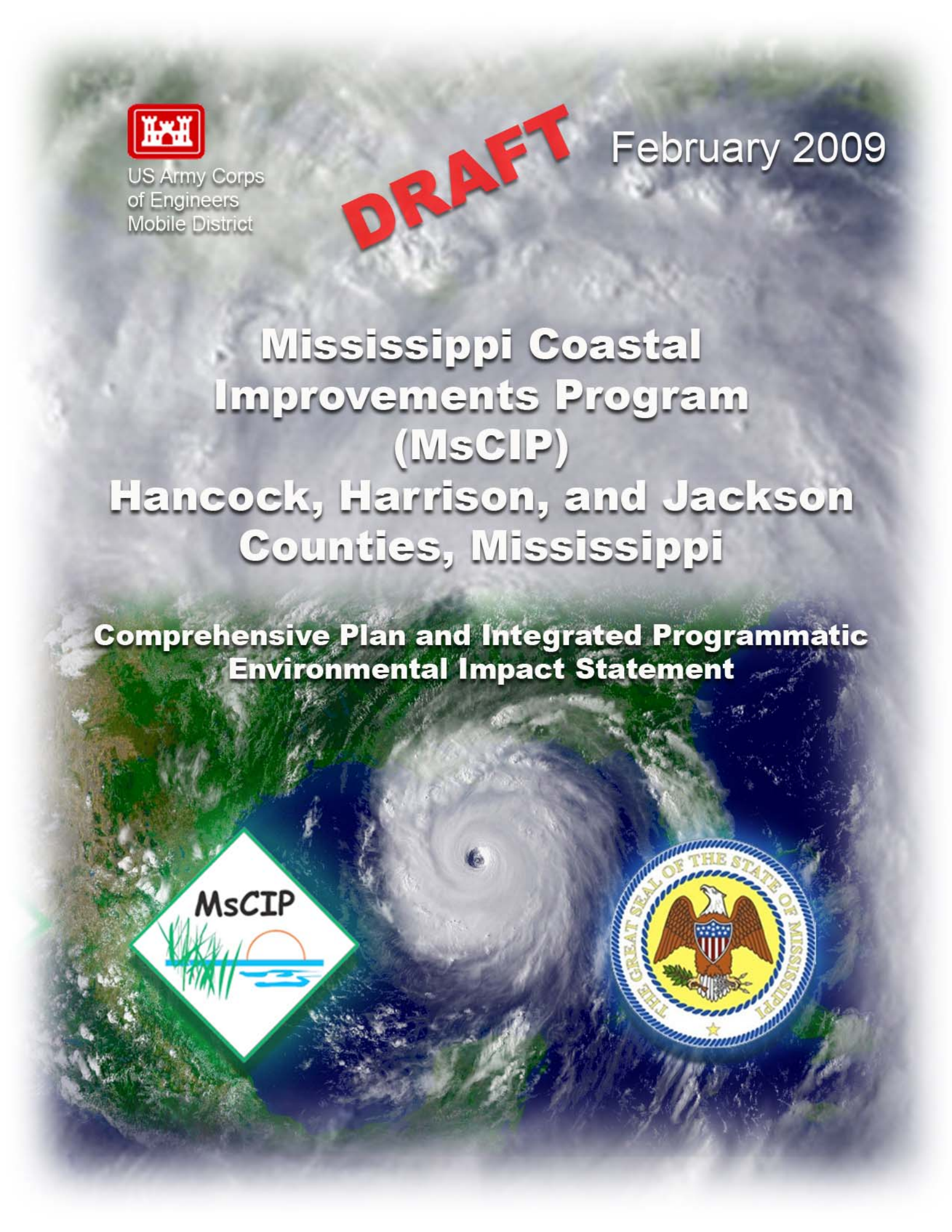
US Army Corps
of Engineers
Mobile District

DRAFT

February 2009

Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

Comprehensive Plan and Integrated Programmatic Environmental Impact Statement



COVER SHEET

Responsible Agency and Lead Federal Agency: U.S. Army Corps of Engineers

Title: Comprehensive Plan and Integrated Programmatic Environmental Impact Statement, Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

Contact: *For information on the* draft *Programmatic Environmental Impact Statement (PEIS) and the related public meetings:*

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The Comprehensive Plan and Integrated Draft Programmatic EIS will be available at: http://www.mscip.usace.army.mil/

Abstract:
This Draft Programmatic EIS analyzes the potential environmental consequences of implementing the tentatively selected features of the Comprehensive Plan in the interests of hurricane / storm damage reduction, ecosystem restoration, erosion control, and saltwater intrusion prevention. A Notice of Intent (NOI) was published in the Federal Register on August 9, 2006, to inform the public of the Corps' intent to prepare an EIS for the MsCIP Comprehensive Plan.

The recommended plan consists of system-wide and site specific structural and non-structural solutions to the problem areas identified in the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005. The other alternatives considered were less effective or efficient solutions to the problems identified in the study. The No Action alternative is also evaluated, per the requirements of NEPA and Corps planning regulations. Implementation of the proposed action would aid in the recovery of coastal Mississippi from the damages caused by the Hurricanes of 2005 (Katrina, Rita, Cindy). The solutions recommended in this report are intended to render the region more resilient and less susceptible to damages resulting from future coastal storm events.

Public Comments:
Prior to preparation of the Draft Programmatic EIS, public involvement was conducted through the publishing of a Notice of Intent in the Federal Register on August 9, 2006 and holding a public scoping meeting on December 19, 2006. Additionally, coordination with resource agencies and the public was conducted through a series of public workshops (see list in Section 1.7.65) and agency coordination letters that solicited comments from agencies and the affected public. The Corps of Engineers considered these comments received by letter and formal statements made at public scoping meetings.

A 45-day comment period on this Draft Programmatic EIS begins with the publication of the U.S. Environmental Protection Agency Notice of Availability in the Federal Register. A public hearing to discuss and receive comments on the Draft Programmatic EIS will be held at a time and location to be announced in the Notice of Availability. Individuals and agencies may present written comments relevant to the Draft Programmatic EIS or request to be placed on the mailing list for announcements and for the Final Programmatic EIS by sending the information to Dr. Susan Rees at the address above. The comments received during the comment period will be considered in the preparation of the Final Programmatic EIS. Late comments will be considered to the extent practicable.

SUMMARY

Problem Statement

The hurricanes of 2005 caused an unprecedented level of destruction within the Gulf Region of the United States, most notably in the states of Texas, Louisiana, and Mississippi. Significant coastal storm events impacting the Gulf Region in 2005 included:

- Hurricane Cindy, which made landfall on the 6th of July near Waveland, Mississippi;
- Hurricane Katrina, which made landfall on the 29th of August on the Louisiana-Mississippi border, and
- Hurricane Rita, which made landfall on the 24th of September between Sabine Pass, Texas and Johnsons Bayou, Louisiana.

Each of these large storm events caused significant damage to the U.S. coast bordering the northern Gulf of Mexico. This series of tremendous storms devastated the physical, natural, and human environments of the region. The impacts of these storms were not only local, but regional, and system wide as well. Homes and businesses, industry, employment, regional economies, environmental resources, and life, health and safety were negatively affected, and a life-changing blow was dealt to residents of the region that has not yet abated. These storms also resulted in significant secondary impacts to the much broader region due to the subsequent migration of the displaced population, wholesale disruption of the region's economy, disruption of the region's infrastructure, and severe impacts on the human, physical and natural resources of the area.

System wide problems identified by the study team, State, County, and City officials, residents, and agency staff, included:

- Hurricane-induced storm surge caused significant damage to structures and infrastructure within the three-county (Hancock, Harrison, and Jackson) MsCIP study area;
- Hurricane-induced storm surge caused significant damage to coastal ecosystems and fish and wildlife resources within the three-county study area;
- Hurricanes induced saltwater intrusion within the Mississippi Sound ecosystem and associated coastal environments; and
- Hurricanes induced erosion of coastal wetlands and coastal infrastructure within the three county MsCIP study area.

Planning and NEPA Process

The Congress of the United States authorized the U.S. Army Corps of Engineers (USACE) in 2005 to initiate two important and related comprehensive planning efforts to address the devastation caused by the coastal storms of 2005:

1. Mississippi Coastal Improvements Program (MsCIP) and
2. Louisiana Coastal Protection and Restoration (LaCPR).

Taken together, these two planning efforts are intended to develop system-wide solutions to assist the multi-state region of the U.S. Gulf Coast in recovering from the devastation caused by the storms of 2005.

This report, the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Programmatic Environmental Impact Statement (hereafter referred to as the

Comprehensive Plan), is intended to identify near and long term strategies to reduce the vulnerability of the region to a recurrence of similar natural disasters. The purpose of this report is to describe the Comprehensive Plan developed for the Mississippi Coastal Improvements Program and, following approval by the Assistant Secretary of the Army (Civil Works), to seek authorization from Congress for implementation of its tentatively selected plan features to assist in the recovery of coastal Mississippi.

The MsCIP was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005. The direction provided by Congress to USACE established the Federal (Comprehensive) Goal for the MsCIP and states (in part):

"… the Secretary shall conduct an analysis and design for comprehensive improvements or modifications to existing improvements in the coastal area of Mississippi in the interest of hurricane and storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resource purposes…"

The USACE has taken a system wide approach in formulating the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan to ensure that both the MsCIP and the Louisiana Coastal Protection and Restoration (LaCPR) efforts are fully coordinated and develop complementary plans for the restoration of the U.S. Gulf coastal region as an integrated system.

In addition, the planning effort has taken a "top down" comprehensive planning approach, beginning with development of a Comprehensive Plan to address the overall water resources problems and opportunities of the region. Building off of the comprehensive identification of problems and opportunities, the planning effort then proceeded to develop site specific problems, opportunities and solutions that contribute to accomplishing the Comprehensive Vision for the restoration and protection of the Mississippi Gulf Coast. The results of this effort are presented in this report and include a comprehensive regional plan that addresses hurricane and storm damage reduction and environmental restoration needs, as well as recommending a variety of site specific projects for either immediate implementation or for further investigation and subsequent implementation.

This draft Comprehensive Plan report contains both tentatively selected plan features for approval of the Comprehensive Plan and for immediate implementation for a variety of water resource development projects that were developed through the comprehensive planning process. The Report also contains options for additional study for those components of the Comprehensive Plan which require additional investigations prior to identifying a specific recommendation for construction.

The Comprehensive Vision for the Mississippi Coastal Improvements Program (MsCIP) is a coastal Mississippi that is more resilient and less susceptible to risk from hurricane and storm surge. Consistent with this Comprehensive Vision and the Federal Goal specified by Congress, this Comprehensive Plan has sought to identify solutions to the hurricane and storm damage, saltwater intrusion, fish and wildlife, erosion, and other related water resource problems of coastal Mississippi. The solutions recommended in this report are intended to render the region more resilient and less susceptible to the recurrence of future coastal storm events. Resiliency (i.e., ability to withstand / survive) to storm events equaling or exceeding the 2005 hurricanes was also an evaluation criteria that was applied to the formulation of projects recommended as part of the Comprehensive Plan.

In response to the Federal Goal, as established by Congress, the following goals were established for the MsCIP by the Corps of Engineers Project Development Team (PDT), cooperating agencies and affected public. The system-wide goals established for this study were developed in clear recognition of the linkages between structural and nonstructural storm damage reduction and ecosystem restoration opportunities. System-wide goals are intended to address the coastal landscape of the entire Gulf Region, including the adjacent area specifically evaluated in the LaCPR

program. MsCIP system-wide goals identified in the Comprehensive Plan effort include the following:

- Identify measures to minimize risk to loss of life and safety caused by hurricane and storm surge;
- Recommend cost-effective measures for restoration of nationally and regionally significant environmental resources within a context of long-term sustainability;
- Recommend cost-effective measures to reduce damages from hurricanes and storms without encouraging re-development in high-risk areas;
- Recommend cost-effective measures to mitigate damages caused by saltwater intrusion into nationally significant ecosystems;
- Recommend cost-effective measures to restore eroded coastal resources as part of a system-wide approach to develop a resilient coastline;
- Identify other water resource related programs and activities integral to the development of a comprehensive system-wide plan.

Tentatively Selected Comprehensive Plan Features

The following components of the Comprehensive Plan are ready for advanced design and implementation. These projects are presented in support of a Record of Decision for construction:

- Coastal Wetland and Forest Restoration
    - Turkey Creek
    - Bayou Cumbest
    - Dantzler
    - Admiral Island
    - Franklin Creek
- Submerged Aquatic Vegetation Pilot Project
- Coast-wide Beach and Dune Restoration on mainland beaches
- Moss Point Municipal Structure Relocation
- Waveland Flood Proofing Pilot Project
- Forrest (Forest) Heights Hurricane and Storm Damage Reduction

The restoration project at Deer Island also has been developed sufficiently for a construction authorization recommendation and is presented in support of a Record of Decision for construction. Should the Corps proceed with this action, additional decisions may be made with regard to additional Deer Island project components at a later date (such as a breakwater and westward expansion of the former Section 204 wetland site). Each of these future decisions will be subject to appropriate documentation to comply with NEPA.

Two other Comprehensive Plan elements are presented in support of construction authorization contingent upon the coordination of additional NEPA documentation. These projects include the High Hazard Area Risk Reduction Plan (HARP) and the comprehensive Barrier Islands Restoration Plan. The HARP provides for purchase of properties located in the high hazard zones of the three coastal counties of Mississippi. Acquisition would be in accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, and would be implemented first in the most high risk areas (approximately 2000 parcels) and initially with

owners willing to sell. Following the generation of site specific data, supplemental NEPA documentation would be presented as necessary to ensure compliance with the appropriate environmental laws and regulations.

Part 1 of the Cost Appendix included Rough Order of Magnitude costs that did not include escalation. These costs were used for initial screening of options. Part 2 of the Cost Appendix includes Total Project Cost Summaries that include escalation based on proposed contract award dates.

Project cost and beneft summaries (not including interest during construction) for the tentatively selected plan elements are shown in Table S-1. These tentatively selected plan elements are evaluated in detail in this report in support for authorization for construction.

Table S-1
Cost and Benefit Summary for Tentative Selected Plans Elements Evaluated in Detail

Tentatively Selected Plan Element	Project Costs* (FY-08)	Annual O&M Costs	Project Benefits
Comprehensive Barrier Island Restoration Plan**	$477,200,000	$0	$17,699,600 annual damages avoided
Mainland Beaches	$23,200,000	$0	More than 30 miles of beach and dune restoration
Forrest Heights Levee	$14,000,000	$114,000	$331,500 annual damages avoided
Admiral Island	$21,700,000	$58,000	123 acres of ecosystem restoration
Turkey Creek	$6,800,000	$47,000	689 acres of ecosystem restoration
Dantzler	$2,200,000	$26,000	385 acres of ecosystem restoration
Bayou Cumbest	$25,400,000	$114,000	148 acres of ecosystem restoration
Franklin Creek	$1,850,000	$11,000	149 acres of ecosystem restoration
Deer Island	$21,400,000	$0	342 acres of ecosystem restoration
Submerged Aquatic Vegetation (SAV) Pilot Project	$900,000	$0	Ecosystem restoration benefits to be determined
High Hazard Area Risk Reduction Program	$187,500,000 to $397,000,000	$75,000	Annual damages avoided $22,000,000 to $33,000,000
Waveland Floodproofing Pilot Project	$4,425,000	$0	Annual damages avoided to be determined
Moss Point Municipal Facility Relocations	$10,800,000	$0	Annual damages avoided to be determined

There are no known HTRW issues, but contingencies were adjusted to account for this eventuality. See Cost Appendix, Part 2 for the Total Project Cost Summaries. * These costs have been rounded and do not include interest during construction. ** The cost for the Comprehensive Barrier Island Restoration Plan includes a contingency based on a Cost Risk Analysis.

This report also supports a recommendation for initiating studies to accomplish the intent of Section 3083 of the Water Resources Development Act of 2007 to design a freshwater diversion project to be located in the vicinity of Violet, LA. The comprehensive goal to be attained through the initiation of these studies would provide sufficient inflows to the western Mississippi Sound area to support oyster reef health and productivity in coastal Mississippi.

- Freshwater Diversion at Violet, Louisiana

There are four system-wide elements of the Comprehensive Plan which require additional investigation and evaluation prior to the recommendation of site-specific plans for construction or implementation. These system-wide elements of the Comprehensive Plan include:

- Long-term High Hazard Risk Reduction Plan (HARP) (additional acquisition of high risk properties over a 30 to 40 year period).
- Additional Damage Reduction Alternatives
- Coastal Mississippi Ecosystem Restoration Program
- Escatawpa River Freshwater Diversion.

A Record of Decision for construction is not being requested for these Comprehensive Plan components, but their potential environmental effects are presented as reasonably foreseeable actions for the consideration of cumulative effects. The environmental effects of these system-wide elements of the Comprehensive Plan are presented in Chapter 4 Environmental Effects.

The environmental effects analysis was conducted on three different levels, which provide various details based on the information available. A more qualitative analysis is conducted for those components of the Comprehensive Plan that require Advanced Study and Design for further project development. Two projects are being recommended for Advanced Engineering and Design and an environmental analysis is conducted using the most information that is available. Supplemental environmental documentation will be prepared for the barrier islands effort and will provide a greater level of detail at that time.

As a result of the diversity of potential projects that have come forth as a part of the Comprehensive Plan, further environmental considerations and analyses will be required prior to projects being implemented. There could be supplemental environmental impact statements to evaluate projects that would result in significant impacts and further environmental assessments for projects that are less complex in nature and do not have significant impacts. During development of tiered NEPA documentation, detailed discussions of potential impacts and any mitigation, if required, will be incorporated as measures and alternatives are being developed.

Provisions for “tiering” of EISs are found in 40 CFR 1502.20 whenever a broad environmental impact statement has been prepared (such as a program or policy statement) and a subsequent statement or environmental assessment would then be prepared on an action included within the entire program or policy. This EIS will serve as the basis from which further required environmental analyses and documentation could be tiered from.

A third level of detailed analyses has been conducted to determine the impacts associated with projects being recommended for construction. It is expected that no further environmental analysis is required prior to the projects being constructed.

Table S-2 depicts the recommended projects and a summary of their environmental effects. Detailed analysis of the environmental effects of alternatives is provided in Chapter 4.

Table S-2

Environmental Effects of Recommended Alternatives

Category of Effects	No Action	Dantzler, Turkey Creek, Franklin Creek and similar Phase II Ecosystem Restoration	Forest Heights Hurricane and Storm Damage Reduction Component	Deer Island Ecosystem Restoration	Bayou Cumbest, Admiral Island, and similar Phase II Ecosystem Restoration	SAV Pilot Project at Bayou Cumbest	Beach and Dune on Mainland and Similar Phase II Ecosystem Restoration	Barrier Island Restoration	Waveland Floodproofing, Housing Relocation Assistance Program (HARP), Moss Point Municipal Relocation Component
Benthos / Terrestrial Invertebrates	Loss of the coastal ecotone habitat, such as barrier islands and beaches.	No impact due to natural recolonization with similar and/or other appropriate species	N/A.	No impact due to natural recolonization with similar and/or appropriate species	Significant positive impact due to restoration of wetland habitat	Significant positive impact due to restoration of exceptional valuable habitat.	No impact.	Filling Camille Cut would change the nature of the species from open water to beach habitat. Littoral zone placement results in minor impact as recolonization would occur over time. Overall significant positive impact to regional benthos with maintenance of salinities in of the Mississippi Sound estuarine conditions.	N/A
Fish	Loss of coastal ecotone such as wetlands and estuarine conditions.	Positive enhancement of water quality of stormwaters.	Some positive impact due to clearing and snagging of Turkey Creek.	Direct positive benefit via improved estuarine functions.	Direct positive benefit via improved estuarine functions.	Significant benefit via replacement of lost critical habitat.	N/A	Overall positive benefit to fishery habitat by maintaining the nutrient-rich, protective habitat in Mississippi Sound that is necessary to sustain the vital food-chain in one of the most productive areas in the U.S.	N/A.
Submerged Aquatic Vegetation	Continue loss to SAVs.	N/A	N/A.	N/A.	Indirect impact associated with overall improvement water quality in areas suitable for natural establishment of SAVs.	Significant positive benefit.	N/A	Restoration of Camille Cut could restore natural conditions conducive to establishment of SAVs. turbidity may adversely impact the flora.	N/A
Marine Mammal Communities	Loss of coastal ecotones could negatively impact.	No change.	No change.	No change.	Benefits community due to limited habitat in urban setting.	Benefits community due to limited habitat in urban setting.	No change.	Benefits community due to limited vital coastal ecotone in the Gulf of Mexico.	No change.
Marine & Coastal Birds	Loss of coastal ecotones could	Provides valuable stopover habitat within the Mississippi Flyway Corridor.	No change.	Provides valuable stopover habitat within	Provides valuable stopover habitat within the Mississippi	N/A	Provides valuable nesting, roosting and breeding habitat.	Provides the first valuable stopover habitat within the Mississippi Flyway Corridor in the Gulf of	No change.

Category of Effects	No Action	Dantzler, Turkey Creek, Franklin Creek and similar Phase II Ecosystem Restoration	Forest Heights Hurricane and Storm Damage Reduction Component	Deer Island Ecosystem Restoration	Bayou Cumbest, Admiral Island, and similar Phase II Ecosystem Restoration	SAV Pilot Project at Bayou Cumbest	Beach and Dune on Mainland and Similar Phase II Ecosystem Restoration	Barrier Island Restoration	Waveland Floodproofing, Housing Relocation Assistance Program (HARP), Moss Point Municipal Relocation Component
	negatively impact.			the Mississippi Flyway Corridor.	Flyway Corridor.			Mexico.	
T&E Species	Loss of coastal ecotones could negatively impact.	Habitat benefits listed species, such as Sandhill Crane.	No change.	Habitat could benefit T&E species.	Habitat could benefit T&E species.	No change.	Habitat benefits nesting, roosting, and breeding of listed species, such as piping plovers and least terns, and is a valuable stopover in the MS Flyway Corridor.	Habitat benefits listed species, such as piping plovers and sea turtles.	No change.
Geology	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.
Meteorology	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.
Soils & Sediments	No impacts.	Restores historical soils.	Adds fill material to existing levee.	Restores historical soils.	N/A	Restores historical soils.	Restores historical soils.	N/A	N/A
Water Quality	Degraded water quality could negatively impact coastal ecotones.	Improves water quality through natural filtration by wetland restoration.	No impacts.	Improves water quality through natural filtration by wetland restoration.	Improves water quality through natural filtration by wetland restoration.	SAVs enhances water quality through natural filtration.	No impacts.	Improves water quality through sustaining estuarine conditions in Mississippi Sound.	No impacts.
Commercial & Recreational Fishing	Loss of coastal ecotones could negatively impact.	N/A	N/A	Restores diverse habitat to juvenile species.	Restores diverse habitat to juvenile species.	Restores SAV habitat to juvenile species.	N/A	Improves habitat through sustaining estuarine conditions in Mississippi Sound.	N/A
Essential Fish & Shellfish Habitats	Loss of coastal ecotones could negatively impact.	N/A	N/A	Restores diverse habitat to juvenile species.	Restores diverse habitat to juvenile species.	Restores SAV habitat to juvenile species.	N/A	Restores valuable essential fish & shellfish habitats for breeding and foraging grounds of species of aquatic resources of national importance.	N/A
Marine Sanctuaries	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.	No impacts.
Cultural Resources	Loss of sites could occur, such as Ft. Massachusetts and	If identified, sites would be avoided and/or impacts minimized.	No impacts.	Identified sites would be avoided.	If identified, sites would be avoided and/or impacts minimized.	No impacts.	Protects sites along the mainland.	Protects sites on the islands and along the mainland.	If identified, sites would be avoided and/or impacts minimized.

Category of Effects	No Action	Dantzler, Turkey Creek, Franklin Creek and similar Phase II Ecosystem Restoration	Forest Heights Hurricane and Storm Damage Reduction Component	Deer Island Ecosystem Restoration	Bayou Cumbest, Admiral Island, and similar Phase II Ecosystem Restoration	SAV Pilot Project at Bayou Cumbest	Beach and Dune on Mainland and Similar Phase II Ecosystem Restoration	Barrier Island Restoration	Waveland Floodproofing, Housing Relocation Assistance Program (HARP), Moss Point Municipal Relocation Component
	French Warehouse.								
Noise	No change.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.
Air Quality	No change.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.	Current levels will resume following construction activities.
Socioeconomics – Utilities	Continue degradation.	Removes destroyed utilities.	No impacts.	No impacts.	Removes destroyed utilities.	No impacts.	No impacts.	No impacts.	Removes destroyed utilities.
Socio-economics – Economy, Demographics, and Environmental Justice	Continue degradation.	No impacts.	Protects env. justice site.	No impacts.	No impacts.	N/A	No impacts.	No impacts.	No impacts.
Socio-economics – Vehicular, Railroad, & Marine Vessel Traffic	Continue degradation.	Removes destroyed infrastructure.	No impacts.	No impacts.	Removes destroyed infrastructure.	N/A	N/A	N/A	Removes infrastructure or protects by floodproofing.
Land & Water Use	No impact.	Converts development to restored habitat.	No impact.	Converts development to restored emergent tidal habitat.	No impact.	No impact.	No impact.	Restores loss habitat.	Removes and/or floodproofs developed areas.
Public Safety	Adverse impacts by future storms.	Protect public.	Protect public.	Protect public.	N/A	Protect public mainland.	Protect public mainland.	Protect public.	The public would benefit by not be in the potential area impacted by future storm events.
Cumulative Impacts	Loss of coastal ecotones, such as barrier islands and beaches.	Restores valuable wet pine savannah habitat.	Protect public infrastructure and env. justice site.	Restores coastal ecotones, protects mainland.	Restores valuable marsh habitat, provides fishery & WQ benefits.	Restores SAV nursery grounds.	Restores coastal ecotone - nesting grounds for coastal birds, protects mainland valuable components.	Restores coastal ecotone - nesting grounds for coastal birds, protects mainland valuable components, provides fishery & WQ benefits.	Protects public safety.

Note: There will be short-term impacts associated with these projects; however it is anticipated that the current conditions would resume to normal, if not, improved.

Public Involvement and Agency Coordination

NEPA is intended to ensure full public participation in the EIS process. Public participation includes effective communication between all Federal, state, local agencies, and tribal governments, and other persons or organizations [i.e. public and non-governmental organizations (NGOs)] that may have an interest in the project. A Notice of Intent (NOI) was published in the Federal Register on August 9, 2006, to inform the public of the Corps' intent to prepare an EIS for the MsCIP Comprehensive Plan. The public was invited to attend a public scoping meeting, a public workshop, and a public hearing to obtain public input and ensure compliance with NEPA. Other methods employed by the MsCIP study team to reach the general public and interested stakeholders included meeting announcements, brochures, news releases to local print and broadcast news media, and a web site. Further public communications include maintaining contact with public officials and agency representatives, ensuring that calls and letters from the public are addressed in a timely manner, and contacting stakeholders through placement of notices of public meetings in stakeholder newsletters. In addition, the EIS will be widely circulated and comments will be requested.

The MsCIP Interim Report effort and this subsequent MsCIP Comprehensive Report and Integrated Programmatic EIS effort have been coordinated with all other agencies tasked with addressing the damages resulting from the hurricanes of 2005. Agencies, educational institutions and interested individuals have been contacted via phone, e-mail, or public notice, to solicit ideas and input to the plan formulation process. Those entities that have chosen to participate have availed themselves of several opportunities to involve themselves in the MsCIP planning process, including Regional Coordination and Public Workshop meetings, interactive problem area identification sessions, and development of measures sessions, via open forums, web-based feedback and participation forums, and less formalized discussions.

Per the Council on Environmental Quality regulations on implementing the National Environmental Policy Act, the Corps, Mobile District requested that a number of State and Federal Agencies accept the status of Cooperating Agency on the Integrated Report and Programmatic Environmental Impact Statement. In response to this request, dated October 30, 2006, the following entities are participating as cooperating agencies:

State:

- Mississippi Department of Archives and History
- Mississippi Department of Environmental Quality, Office of Pollution Control
- Mississippi Department of Marine Resources
- Mississippi Department Of Transportation
- Mississippi Emergency Management Agency
- Mississippi Museum of Natural Science
- Mississippi Secretary of State, Public Lands Division

Federal:

- Federal Emergency Management Agency, Region 4
- Minerals Management Service, Gulf of Mexico Region
- National Oceanic and Atmospheric Administration, National Marine Fisheries Service Southeast Region, , Protected Resources and Habitat Conservation Divisions
- National Park Service
- U.S. Department of Agriculture , Natural Resources Conservation Service

- U.S. Department of Transportation, Federal Highway Administration
- U.S. Environmental Protection Agency, Region 4
- U.S. Fish and Wildlife Service
- U.S. Geological Survey

Local:

- Gulf Regional Planning Commission

In addition, this study effort was accomplished with the active participation of the following additional Federal and state agencies, local governments, and stakeholders in the planning and NEPA impact evaluation process:

- National Aeronautics and Space Agency
- National Weather Service
- Hancock, Harrison and Jackson Counties
- Communities of Bay St. Louis, Biloxi, D'Iberville, Gautier, Gulfport, Long Beach, Moss Point, Ocean Springs, Pascagoula, Pass Christian, and Waveland
- University of Southern Mississippi
- University of New Orleans
- Coastal Restoration Network
- The Nature Conservancy (TNC)
- The Audubon Society
- Sierra Club

Early on, the MsCIP team placed a high value on incorporating public input and active stakeholder listening into the planning process. A chronological overview of opportunities for citizen and stakeholder input during the MsCIP development process is described below:

- Over 60 Federal, State and local government agency representatives and other community leaders from business and industry gathered in Biloxi on April 7, 2006 to identify early needs, opportunities and recommendations for the MsCIP process.
- Public Meetings were held in Harrison, Jackson and Hancock Counties on April 10, 11 and 13, 2006 to examine a broad range of potential coastal protection options and solicit public input on designing comprehensive improvements.
- An online agenda of the April 10-13, 2006 public meetings was posted on April 18, 2006 for displaced coastal residents or those who could not attend the public meetings.
- A second Regional Coordination meeting of governmental, business and industry stakeholders was held April 24 and 25, 2006 in Biloxi. The session probed for missing or overlooked items in the near-term planning process.
- A second round of public workshops was conducted May 1, 2 and 4, 2006 where near-term projects and the screening criteria used to select them were presented.
- A follow-up online workshop was held on May 3, 2006 for displaced coastal residents or those unable to attend public meetings.
- A third Regional Coordination Meeting including government partners, business and industry was held in Biloxi on August 21-22, 2006. Issue-related subgroups for structural, non-

structural, barrier island restoration, and environmental solutions offered specific comments and recommendations.

- A public scoping meeting / workshop was held on December 19, 2006 at the MDMR office in Biloxi to gather public input for the EIS.
- A project web portal was launched in January 2007 enabling user downloads, project team collaboration, and improved communication and coordination.
- Online meetings for structural, nonstructural, environmental, and barrier island working groups took place on February 6 and 9, 2007.
- A public workshop was held on April 5, 2007 to help finalize MsCIP measures for structural, nonstructural, environmental issues, and barrier islands.
- A Risk Analysis workshop was held on July 9 and 10, 2007 at the MDMR office in Biloxi, Mississippi assess stakeholder preferences.
- A follow-up to the Risk Analysis workshop was held on September 10 and 11, 2007.

Additional meetings will be held during the review process for the MsCIP and will be announced widely to encourage maximum attendance and participation.

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1 INTRODUCTION (PURPOSE AND NEED*[1])

The hurricanes of 2005 caused an unprecedented level of destruction within the Gulf Region of the United States, most notably in the states of Texas, Louisiana, and Mississippi. Significant coastal storm events impacting the Gulf Region in 2005 included:

- Hurricane Cindy, which made landfall on the 6th of July near Waveland, Mississippi;
- Hurricane Katrina, which made landfall on the 29th of August on the Louisiana-Mississippi border, and
- Hurricane Rita, which made landfall on the 24th of September between Sabine Pass, Texas and Johnsons Bayou, Louisiana.

During Hurricane Katrina coastal Mississippi was the point of impact of the greatest tidal surge that has hit the mainland of the U.S. in its recorded history. Hurricane Katrina affected over 90,000 square miles (sq. mi.) of the Gulf Coast region and caused almost complete destruction of several large coastal communities, and seriously damaged numerous others.

Each of these large storm events caused significant damage to the U.S. coast bordering the northern Gulf of Mexico. This series of tremendous storms devastated the physical, natural, and human environments of the region. The impacts of these storms were not only local, but regional, and system wide as well. Homes and businesses, industry, employment, regional economies, environmental resources, and life, health and safety were negatively affected, and a life-changing blow was dealt to residents of the region that has not yet abated. These storms also resulted in significant secondary impacts to the much broader region due to the subsequent migration of the displaced population, wholesale disruption of the region's economy, disruption of the region's infrastructure, and severe impacts on the human, physical and natural resources of the area.

The Congress of the United States authorized the U.S. Army Corps of Engineers (USACE) in 2005 to initiate two important and related comprehensive planning efforts to address the devastation caused by the coastal storms of 2005:

- the Mississippi Coastal Improvements Program (MsCIP) and
- the Louisiana Coastal Protection and Restoration (LaCPR).

Taken together, these two planning efforts are intended to develop system-wide solutions to assist the multi-state region of the U.S. Gulf Coast in:

- recovering from the devastation caused by storm events, and
- provide greater resiliency towards future storm events.

This report, the *Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Programmatic Environmental Impact Statement* (hereafter referred to as the Comprehensive Plan) is intended to identify near and long term strategies to reduce the vulnerability of the region to a recurrence of similar natural disasters. The purpose of this report is to describe the Comprehensive Plan developed for the Mississippi Coastal Improvements Program and, following approval by the Assistant Secretary of the Army (Civil Works), to seek authorization from Congress for implementation of its tentatively selected plan features to assist in the recovery of coastal Mississippi (Hancock, Harrison, and Jackson counties).

[1] This document is an integrated report/environmental impact statement, sections marked with an * are required portions of the environmental impact statement.

This report presents information in support of a Record of Decision for construction for a number of ecosystem restoration, storm damage reduction, and multi-purpose projects. Additionally, other projects are developed in this feasibility study which are not presented in support of a Record of Decision for construction, but are addressed as reasonably foreseeable actions for the consideration of cumulative effects. Supplemental NEPA information will be presented in the future as programmatic elements of the Comprehensive Plan are further developed.

1.1 Authorization

The MsCIP was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states:

> *"For an additional amount for "investigations" to expedite studies of flood and storm damage reduction related to the consequences of hurricanes in the Gulf of Mexico and Atlantic Ocean in 2005, $37,300,000 to remain available until expended: Provided, that using $10,000,000 of the funds provided, the Secretary shall conduct an analysis and design for comprehensive improvements or modifications to existing improvements in the coastal area of Mississippi in the interest of* ***hurricane and storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resource purposes*** *at full Federal expense; Provided further, that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project recommendations based upon maximizing net national economic development benefits; Provided further, that interim recommendations for near term improvements shall be provided within 6 months of enactment of this act with final recommendations within 24 months of this enactment."*

The direction provided by Congress to USACE established the Federal (Comprehensive) Goal for the MsCIP as "**comprehensive** improvements or modifications to existing improvements". The USACE has taken a ***system wide*** approach in formulating the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan to ensure that both the MsCIP and the Louisiana Coastal Protection and Restoration (LaCPR) efforts are fully coordinated and develop complementary plans for the restoration and future resiliency of the U.S. Gulf coastal region ***as an integrated system***.

In addition, the planning effort has taken a "top down" ***comprehensive planning*** approach, beginning with development of a Comprehensive Plan to address the overall water resources problems and opportunities of the region. Building off of the comprehensive identification of problems and opportunities, the planning effort then proceeded to develop site specific problems, opportunities and solutions that contribute to accomplishing the ***Comprehensive Vision*** for the restoration and protection of the Mississippi Gulf Coast. The results of this effort are presented in this report and include a comprehensive regional plan that addresses hurricane and storm damage reduction and environmental restoration needs distributed across all three impacted counties. The Comprehensive Plan recommends a variety of site specific projects for either for immediate implementation or for further investigation and subsequent implementation. Comprehensive plan features include non-structural, structural, and environmentally-oriented solutions and plans.

1.2 Study Purpose and Scope

The ***Comprehensive Vision*** for the Mississippi Coastal Improvements Program (MsCIP) is a coastal Mississippi that is more ***resilient*** and less susceptible to risk from hurricane and storm

surge. Webster's dictionary [2] defines resilient as "*a. capable of withstanding shock without permanent deformation or rupture; b. tending to recover from or adjust easily to misfortune or change".* Consistent with this Comprehensive Vision and the Federal Goal specified by Congress, this Comprehensive Plan has sought to identify solutions to the hurricane and storm damage, saltwater intrusion, fish and wildlife, erosion, and other related water resource problems of coastal Mississippi. The solutions recommended in this report are intended to render the region more resilient and less susceptible to damages resulting from future coastal storm events. Resiliency (i.e., ability to withstand / survive) to storm events equaling or exceeding the 2005 hurricanes was also an evaluation criteria that was applied to the formulation of projects recommended as part of the Comprehensive Plan. The pursuit of resiliency for coastal Mississippi communities led to the development of the Lines of Defense concept (see Plan Formulation section), which incorporates natural and manmade features in a comprehensive storm damage reduction plan.

1.3 Study Area Location and Geographic Description

The MsCIP Comprehensive Plan study area consists of the three Mississippi coastal counties: Hancock, Harrison, and Jackson. For planning purposes, these three counties were further divided into sub-units for evaluation and are described in the appendices Also included are the offshore ecosystems of Mississippi Sound and its barrier islands. Areas in Louisiana and Alabama that could be affected by actions considered for improvement to the Mississippi coast will also be discussed, where applicable.

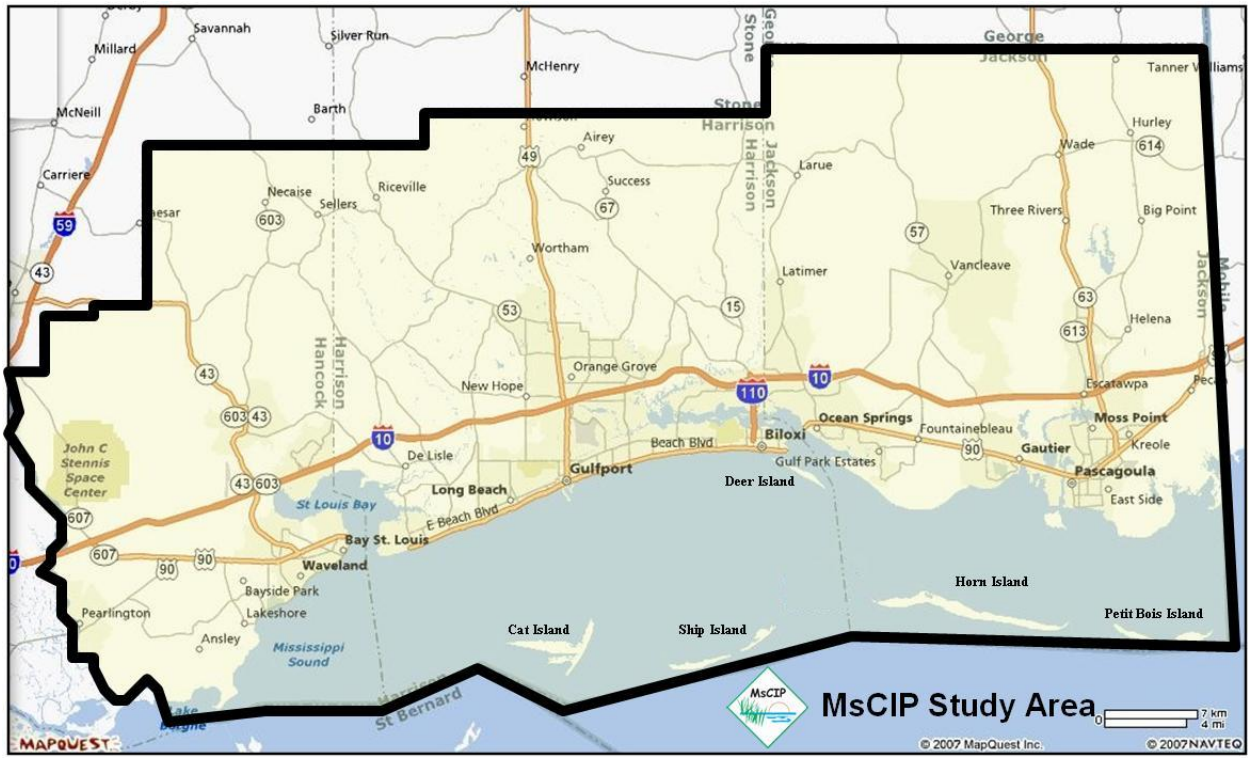


Figure 1-1
The MsCIP Study Area

The 75 mile-long coastal study area is bounded on:

[2] Webster's New Collegiate Dictionary, G. & C. Merriam Company, 1975

- the west by the Pearl River, which follows the boundary with the State of Louisiana until it reaches the Mississippi Sound,
- the east by the Alabama State line, and
- the south by the Gulf of Mexico.

Mississippi Sound is a partially protected body of water averaging 8 to 10 miles wide and separated from the Gulf of Mexico by a series of barrier islands (Cat, Ship, Horn, and Petit Bois Islands). The Gulf Intra-coastal Waterway provides a shallow draft channel (12 feet deep by 150 feet wide) for navigation within Mississippi Sound a few miles from the mainland shore. The mainland shore is broken by the entrances to St. Louis Bay between Bay St. Louis and Pass Christian, and Biloxi Bay between Biloxi and Ocean Springs.

U. S. Highway 90 traverses the area a few miles inland except in Harrison County, where it closely borders the coastline. Two major rivers empty into Mississippi Sound: the Pearl River, which forms the boundary between Mississippi and Louisiana, and the Pascagoula River, which traverses Jackson County and enters the Sound at Pascagoula. Elevations along the coast vary from low-lying marsh reaches at elevations of 1 to 7 feet at the eastern and western extremities to the relatively high ground near shore in the central portion that rises from the beaches at elevation 4 to 6 feet up to over 16 feet within a short distance inland. Major towns along the Mississippi Gulf Coast are, from west to east, Waveland, Bay St. Louis, Pass Christian, Long Beach, Gulfport, Biloxi, Ocean Springs, and Pascagoula. This area is illustrated in Figure 1-1 above.

1.4 Prior Studies, Reports, and Programs

1.4.1 Studies and Reports

In response to the authorization's instruction ***"… that interim recommendations for near term improvements shall be provided within 6 months of enactment of this act…"*** the Chief of Engineers submitted his Interim Report on December 30 2006. The Interim Report recommended the implementation of 15 projects across the coast at a cost of $108 million. A brief summary of the authorized "near-term" construction projects are presented in Table 1-1. These projects are currently in design phase or under construction.

Table 1-1
Authorized Interim Projects

Projects	Purpose	County
Bayou Caddy	Ecosystem Restoration	Hancock
Hancock County Beaches	Ecosystem Restoration & Hurricane & Storm Damage Reduction	Hancock
Hancock County Streams	Flood Damage Reduction & Ecosystem Restoration	Hancock
Jackson Marsh	Ecosystem Restoration	Hancock
Clermont Harbor	Hurricane & Storm Damage Reduction	Hancock
Downtown Bay St. Louis	Hurricane & Storm Damage Reduction	Hancock
Cowand Point	Hurricane & Storm Damage Reduction	Hancock
Long Beach Canals	Flood Damage Reduction	Harrison
Harrison County Beaches	Ecosystem Restoration & Hurricane & Storm Damage Reduction	Harrison
Courthouse Road	Flood Damage Reduction & Ecosystem Restoration	Harrison
Shearwater Bridge	Hurricane & Storm Damage Reduction	Jackson
Gautier Coastal Streams	Flood Damage Reduction & Ecosystem Restoration	Jackson
Pascagoula Beach Boulevard	Hurricane & Storm Damage Reduction & Ecosystem Restoration	Jackson
Upper Bayou Casotte	Flood Damage Reduction	Jackson
Franklin Creek Floodway	Hurricane & Storm Damage Reduction	Jackson

A list of 36 various studies and reports relevant to this study, which have been reviewed and by the study team, is included in the References Section of this report.

1.4.2 Federal Programs Addressing Recovery from Hurricane Katrina

Government, private, and volunteer organizations continue to work closely together to help rebuild the damaged region affected by Hurricane Katrina. The Department of Homeland Security's (DHS)/ Federal Emergency Management Agency (FEMA) acts as the lead Federal agency in the relief, recovery, and rebuilding mission and has implemented various programs to help address the damages. Numerous Federal agencies have accomplished much and continue to provide much needed services in order to help not only get the region back on its feet but also to provide for a stronger and better future for the residents of the Gulf Coast.

The Housing and Urban Development Administration continues to help rebuild damaged housing and other infrastructure through its Community Development Block Grants (CDBG) Program, which is administered through the Mississippi Development Authority. The application of the CDBG

Program to the region affected by Hurricane Katrina represents the largest single housing recovery program in U.S. history. The Federal Housing Administration together with FEMA are providing mortgage and foreclosure relief and counseling for homeowners.

FEMA, Department of Transportation (DOT), U.S. Coast Guard (USCG), and US Army Corps of Engineers (USACE) have restored transportation and shipping and have re-opened ports throughout the region. The U.S. Department of Energy (DOE) and Department of Interior (DOI), Minerals Management Services (MMS) has worked to restore energy and water resources. The Department of Commerce, National Telecommunications and Information Administration has worked to restore communications throughout the region.

The US Department of Agriculture is actively working to rebuild industry and The National Ocean and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS) is assisting local communities in rebuilding Gulf oyster beds while also conducting fisheries monitoring. The Small Business Administration and Department of Commerce continues to implement programs designed to stimulate business redevelopment in the region. The U.S. Department of Labor (DOL) has focused on workforce redevelopment in hurricane-affected Gulf Coast states by investing funds in four primary initiatives that are already helping citizens pursue career opportunities while supporting the revitalization of the Gulf Coast. FEMA, Corps, USCG, and various other agencies are working together to restore the environment and parks.

An estimated 100 million cubic yards of debris have been removed from the region and approximately 1,450 miles of channels have been cleared. NOAA has surveyed and mapped approximately 800 square miles along the Gulf Coast to locate marine debris. In Mississippi alone, US Geological Survey (USGS) teams identified more than 235 sites along residential canals that require marine debris removal. In Mississippi, more than $429 million has been obligated for post-disaster mitigation projects through FEMA's Hazard Mitigation Grant Program. The USEPA along with FEMA and the Corps have contributed to the debris removal mission by providing technical advice and assistance, promoted recycling, and handled the disposal of over 4 million containers of household hazardous waste; assisted in the proper handling and recycling of over 380,000 large appliances (refrigerators, freezers, and air conditioners) and collected and recycled over 661,000 electronic goods to save important landfill space and ensure the reuse of metal components.

In July 2006, EPA completed cleanup of oil and hazardous materials in Mississippi and Alabama, and transitioned responsibility for remaining activities to the states. The Department of Health and Human Services (HHS) continues to help in providing Health Care, Social Services, Food and Education. There are numerous ongoing programs and people everywhere have contributed to the Gulf Coast Recovery and continue to remain committed to the Gulf Coast in time and money. HHS/FEMA continues to work at becoming better prepared in advance of future storms (HHS Website Ongoing Programs).

From the very start, the recovery effort included a large volunteer contingent. The mix of volunteers was widely based consisting of those who were local and from afar, concerned individuals, church and civic organizations and time honored volunteer institutions. The New Waveland Café operated by “hippies” (as affectionately described by locals) from all parts of the US, served three full meals per day to all comers. The Red Cross provided meals on wheel delivering food to the homes of residents. St Paul United Methodist Church and Jesus Christ Baptist Church hosted hundreds of volunteers on their property in huge tent cities complexes. Two years after the storm and with greatly diminished volunteer resources, the East Biloxi Coordination Center and Hope Force International combined the resources of seven volunteer organizations to construct a new home in Biloxi for a senior citizen whose home was destroyed by Katrina.

1.5 Mississippi State Strategy

The Mississippi Department of Marine Resources Coastal Preserves Program was developed in 1992 by authority of the Wetlands Protection Act. The Coastal Preserves Programs objective is to acquire, protect, and manage sensitive coastal wetland habitats along the Mississippi Gulf Coast, therefore ensuring the ecological health of Mississippi's coastal wetland ecosystems. The State currently has title to approximately 30,000 acres of the designated 72,000 acres of crucial coastal wetland habitat within Mississippi's 20 coastal preserve sites.

The Mississippi Emergency Management Agency is currently working with the residents of Bayou Cumbest to purchase property damaged by Hurricane Katrina from willing sellers. The Corps, Mobile District has been closely coordinating with Mississippi Emergency Management Agency to develop its environmental restoration project in conjunction with those purchased properties.

The Governor of the State of Mississippi has developed a Seven-Point Strategy for rebuilding coastal resources of the State. It is anticipated to be an on-going effort over the next 10 to 15 years. The strategy is summarized as follows:

- Implementation of breakwater structures for surge protection (natural surge diffusers, breakwaters, jetties seawalls, etc.);
- Deer Island restoration to pre-1900 footprint with fortification of the south side;
- Barrier Island restoration to pre-Camille conditions;
- Restoration of 10,000 acres of coastal marshes, beaches, and forests;
- Restoration of historical water flow to coastal Mississippi watersheds to provide water quality and quantity critical to estuarine and marine habitats, including efforts to divert freshwater from Louisiana into the Biloxi marshes;
- Restoration of submerged aquatic vegetation (SAVs) in Mississippi Sound; and
- Restoration and enhancement of reef systems in Mississippi waters and adjacent Federal waters (i.e. oysters, nearshore low-profile reefs, and offshore artificial reefs).

1.6 Systematic and Regional Integration with Louisiana Coastal Protection and Restoration (LACPR)

The hurricanes of 2005 affected the entire region of the northern Gulf of Mexico from the panhandle of Florida to the Texas coast causing direct destruction to the immediate coast and its population centers. It also had unprecedented impacts to the much broader region from the subsequent migration of the affected population, wholesale disruption of the region's economy, disruption of the region's educational infrastructure, and untold impacts on the human resources of the region. Although Congress authorized two separate studies with slightly different objectives, the USACE has taken a systematic and regional approach in formulating solutions and in evaluating the impacts and benefits of those solutions. In addition to the regional impacts of the Hurricanes of 2005, the two states share key resource issues including shoreline erosion and barrier island loss, wetlands loss, salinity intrusion, and storm surge and waves. The barrier islands reduce wave energy and help significantly in reducing erosion to the mainland. Wetlands, including marshes and near shore marine and estuarine habitat, are the nursery grounds for the entire marine food chain in the Gulf of Mexico. And, like the barrier islands, they also help to reduce wave energy. Linked to both the degradation and loss of the wetlands and barrier islands is the increase of salinity in the estuarine areas of the Mississippi, Breton, and Chandeleur Sounds. These increasingly scarce areas of the United States require a delicate mix of fresh and salt water to provide habitat for oysters, shrimp, sturgeon, and other fisheries which also provide an important economic source for both states. The

following discusses the efforts undertaken to date by the MsCIP and LACPR teams to consider regional influences as part of the planning effort. A more detailed discussion of these efforts can be found in Appendix K, Plan Formulation, Section 11.

Both LACPR and MsCIP teams are working together to solve these issues at the local, regional, and national levels. Multiple focus groups, public meetings, and regional workshops have been held to make sure that the solutions presented in this report are comprehensive in nature, and also maintain the delicate balance between people and their environment. In addition, both efforts used the same plan formulation strategy, as well as shared the use of the many technical tools required to perform the evaluations. To this end, both teams are considering structural, nonstructural, and coastal restoration measures during the plan formulation. To ensure consistent communication and coordination, both teams have attended critical meetings regarding study goals and objectives, plan formulation, and Agency Technical (ATR) and Independent External Peer (IEPR)Review efforts. All modeling used in both efforts has been well coordinated, and both teams made use of, and jointly coordinated, the efforts of those USACE laboratories, Centers of Expertise, and ATR and IEPR teams involved in these studies. In addition, the development of the Risk Informed Decision Framework (RIDF) has been a joint effort of the two studies.

All potential impacts, both adverse and beneficial impacts, are being considered without regard to geographic boundaries. Any measures which induce adverse impacts must be eliminated from further consideration or their impacts satisfactorily mitigated on a regional basis. Several measures may have beneficial impacts outside specific study boundaries. For example, the diversion of freshwater from the Mississippi River to Lake Borgne via the Violet marsh area could not only reduce saltwater intrusion in the Mississippi Sound south of Hancock County, but it could also provide much needed sediments to the Biloxi marshes of Louisiana. Also, the systematic restoration of the coastal sediment budget and sand transport system along the Mississippi barrier islands could provide benefits to eastern Louisiana.

In both the MsCIP and LACPR studies, the regional influences of several proposed project alternatives on storm surge levels were examined with regional storm surge and wave modeling. The regional surge/wave model was specifically designed with this requirement in mind by having model domains and grid meshes that encompassed both Louisiana and Mississippi, and by developing the models consistently (for example, adoption of similar grid resolution throughout the model domain).

In addition to having a regional-scale and regionally-consistent storm surge/wave model, a regionally consistent definition of the hurricane hazard was also important. A multi-disciplinary team, the Risk Assessment Group (RAG), was assembled by the Corps to characterize the probabilities of different hurricanes that can impact the northern Gulf of Mexico region. Their work fully utilized the best of today's knowledge, data and technology. A significant achievement of the RAG, which supported both the MsCIP and LaCPR work and FEMA's remapping efforts, was the adoption of a unified general coastal flooding methodology that is being applied by USACE and FEMA. The unified approach involves coupled regional storm surge and nearshore wave models, the same approach originally taken by the Interagency Performance Evaluation Task Force (IPET). The RAG developed a number of new insights into the behavior of hurricanes. One notable and extremely important finding was the tendency for all major intense hurricanes to decrease in intensity prior to landfall. The RAG developed a regionally-consistent Joint Probability Method-Optimal Sampling approach (JPM-OS) for defining hurricane probabilities and for calculating probabilities associated with hurricanes having a certain set of characteristics (track, intensity, size, forward speed).

Several alternatives are presently being considered in both the MsCIP and LACPR studies to divert freshwater from the Mississippi River or other sources as a mechanism for promoting a reversal of a historic increase in salinity in the Mississippi Sound/Biloxi Marsh area. The intent of the diversion is to build wetlands, support fresher marshes and improve oyster reef health and productivity thus

enhancing both their economic value and the ecological services they provide. However, the water diverted from riverine sources not only has lower salinity, but usually carries more sediment and nutrients than marine water. Diversions may result in areas of excess nutrients and thus cause algal blooms and eutrophication, greater light attenuation, and changed substrate characteristics, so their system-wide impacts need to be carefully evaluated. Spatially-explicit evaluations of habitat change over large areas are required for such system-wide impacts. Therefore, any proposed diversion alternative will need to be carefully evaluated in order to fully understand the positive and negative aspects of various diversion scenarios.

During the next steps in plan development in the LACPR and MsCIP investigations and or implementation, the joint study teams will collaborate at a Northern Gulf of Mexico integrated systems scale. The purpose of this effort will be to identify common stakeholder agreement on the configuration, performance, and cost of alternatives with a goal of achieving no adverse impacts, increased levels of risk reduction, and coastal restoration in those plans. The LACPR and MsCIP teams will hold joint meetings with stakeholders of the coastal areas in Louisiana and Mississippi to accomplish this task, as follows:

- Explain the process on how the range of alternatives were initially developed in both projects for coastal restoration and risk reduction,
- Present the individual elements and integrated system configurations of the array of developed alternatives that were evaluated through these investigations,
- Describe the performance, costs, and unintended adverse consequences found through modeling simulations of these alternatives,
- Solicit the viewpoints of stakeholders for both studies in joint meeting sessions to identify consensus and differences of opinion on the makeup, performance, and costs of these alternatives,
- Interact with the stakeholders of both studies for screening, refinement, and/or re-formulation of alternatives from a Northern Gulf of Mexico integrated systems scale perspective,
- Conduct iterations of planning and analysis for identifying common agreement on the configuration, performance, and cost of alternatives for attaining no adverse impacts, risk reduction, and coastal restoration, and
- Describe requirements for further alternative plan development and analysis.

1.6.1 Regional Storm Surge and Wave Modeling

Large-scale levee systems; other man-made barriers; restoration of barrier islands that involve substantial increases in an island's cross section, crest elevation or length; or wetland restoration on a massive scale, all have the potential to influence storm surge levels and wave conditions produced by extreme hurricanes on a regional scale. Levees and barriers are intended to protect against storm surge, but they also can cause a build-up of storm surge by obstructing or completely blocking the movement of water that is driven by hurricane-force winds. Barrier islands alter the movement of water toward the coast, providing some blocking action and by forcing the water to move through gaps between islands, an effect that is lessened once the storm surge overtops an island. The enhanced roughness of wetlands can slow the advance of storm surge somewhat, which can cause a small local increase in storm surge seaward of the wetland and slightly reduce the surge landward of the wetland or slow its arrival time slightly. Each of these processes might tend to retard the storm surge propagation in one area; but in the process of slowing the storm surge advance, the movement of water might be slightly redirected toward another location causing a local storm surge increase elsewhere. Natural and man-made protection and buffering features like wetlands and barrier islands do not decrease the mass of water driven into the region by the hurricane winds (mass is conserved); however, they do change the momentum and redistribute the storm surge.

Natural and man-made coastal protection measures can also significantly alter wave conditions during hurricanes, reducing the potential for wave-induced damage along the coastline during elevated storm surge levels. Levees and barriers can completely block wave energy; and barrier islands act to block ocean waves from reaching the mainland coastline or reduce wave energy. Even though the reduction is less, barrier islands greatly reduce ocean wave energy even when the surge has overtopped the barrier island. Wetlands reduce wave energy, although it is difficult to accurately quantify the reduction given the current lack of detailed knowledge about the physics of this process.

In an attempt to address structural effects on surge and waves, a combination of two models has been used. A completely coupled and consistent regional storm surge and wave modeling capability is available to examine the regional influences associated with planned and proposed project alternatives being developed in the LACPR and MsCIP studies, but only from the perspectives of project influences on storm surge levels and wave conditions. The model is based on the coupled ADCIRC-STWAVE models. The regional surge and wave model has been extensively validated using measured data acquired during Hurricanes Katrina and Rita, during the Katrina Interagency Performance Task Force (IPET) and MsCIP and LACPR projects.

This regional modeling capability was applied to examine regional-scale changes to storm surge levels associated with several of the proposed project alternatives, for example the influence of proposed barriers across Lake Pontchartrain on storm surge levels along coastal Mississippi, the influence of widespread Louisiana wetland restoration on storm surge levels in Mississippi, and the influence of Mississippi barrier island restoration on storm surges in Louisiana.

1.6.2 Regional Salinity/Water Quality Modeling

In addition to regional influences on storm surge and waves, construction of large-scale levee systems or other man-made barriers, restoration of barrier islands that might involve increasing an island's footprint or length, or wetland restoration on a large scale, all have the potential to influence water exchanges and current patterns during normal tidal action and typical wind conditions. Such persistent changes to the hydrodynamic regime can alter salinity and water quality regimes leading to changes to habitat.

Wetland restoration measures proposed for construction in the MsCIP study are relatively small-scale features within small estuaries, and the barrier island changes proposed for construction in the MsCIP study do not involve significant changes to the barrier island footprints. Therefore regional-scale influences on salinity and water quality due to these alternatives are not predicted to be significant. Wetland restoration and barrier island restoration at a much larger and widespread scale are being considered in the LACPR study. These restoration measures have the potential to aairly reduce surge and waves, but can also induce significant regional changes in terms of salinity, water quality and habitat. Therefore, further studies in more detail in the future will be needed.

Both the MsCIP and LACPR studies are considering the diversion of freshwater from the Mississippi River or other sources as a mechanism for promoting a reversal of a historic increase in salinity in the Mississippi Sound/Biloxi Marsh area. The intent of the diversions is to build wetlands, support fresher marshes and improve oyster reef health and productivity thus enhancing both their economic value and the ecological services they provide. However, the water diverted from riverine sources not only has lower salinity, but usually carries more sediment and nutrients than marine water. Diversions may result in areas of excess nutrients and thus cause algal blooms and eutrophication, greater light attenuation, and changed substrate characteristics, so their system-wide impacts need to be carefully evaluated. Spatially-explicit evaluations of habitat change over large areas are required for such system-wide impacts.

A regional salinity and water quality model (WQM) (based on CE-QUAL-ICM coupled to the CH3D hydrodynamic model) has been developed covering an area from west of Lake Pontchartrain to east

of Mobile Bay and south beyond the Chandeleur Islands in the Gulf. This model has been extensively validated for the Mississippi Sound region, as part of previous work done by the Engineering Research Development Center (ERDC) and Mobile District. The model has not yet been as extensively validated for the Lake Pontchartrain and Biloxi Marsh areas; however, in light of past experience with the model in numerous studies, it is expected that the current state of the model is yielding reasonable results in this region for the purposes of the "screening-level studies" that have been conducted to date to examine the possible benefits of freshwater diversions.

To more accurately answer detailed questions about changes to salinity and water quality, and to answer them with greater confidence (a level which can withstand a high level of technical scrutiny), additional resolution and model refinement and validation of the WQM, is needed. To answer more detailed questions about how changes in sedimentation, salinity and water quality translate to changes in landscape and habitat, additional model development, testing, and validation will be required. To date, the WQM has been applied to examine freshwater diversions at three locations: (1) diversion from the Mississippi River at Violet, LA, (2) diversion of all of the Escatawpa River flow into Grand Bay, MS, and (3) diversion from the Mississippi River at Bonnet Carre' spillway.

1.6.3 Regional Wetlands Restoration

The LACPR study is considering various restoration alternatives that will provide multiple benefits, particularly ecological benefits. These features have the potential to reduce storm surge and wave action, and the regional implications of these projects will be considered. Landscape features such as wetlands also have the potential to create frictional resistance and affect storm surge even when vegetation is inundated by the storm surge.

The impact of wetland restoration on storm surge at the mainland coast of both Louisiana and Mississippi was assessed with a sensitivity study. The sensitivity study was primarily a qualitative assessment that provides valuable information on trends and relative performance but one should be cautious about making quantitative assessments of surge reduction. It should be noted that the analysis does not consider the morphologic and vegetation cover changes to the wetlands caused by erosion and/or damage to vegetation that occurs during a storm's passage. The analysis also does not consider changes in the structure of the hurricane itself due to landfall infilling phenomenon that may be influenced by landscape features such as wetlands.

In a general sense, the influence of wetland restoration activities on storm surge and waves will be local in nature and relatively small for the types and spatial-scale of wetland restoration that are being considered and proposed in both the LACPR and MsCIP studies. Impacts on waves may be greater than impacts on storm surge, but they are expected to be more local and are not expected to have significant regional influences outside the local area. For example, the wetland restoration proposed in the MsCIP study is local, and will not have significant storm surge or wave influences in Louisiana.

1.6.4 Continued LACPR-MsCIP Northern Gulf of Mexico Planning and Analysis

The LACPR and MsCIP teams continue to collaborate on a number of issues at a regional scale. The LACPR and MsCIP teams will hold joint meetings with stakeholders of the coastal areas in Louisiana and Mississippi during the winter 2008 -spring 2009 timeframe on the diversion of freshwater from the Mississippi River into Lake Borgne and Mississippi Sound.

In its current state, the regional storm surge and wave model has been used to preliminarily examine regional influences and interactions that are created by MsCIP projects which are tentatively proposed for construction in the near-term (1 – 5 years), and selected conceptual LACPR measures with an implementation period yet undetermined. Based on this analysis it is unlikely that any of the

MsCIP tentatively selected plan features would have any negative influences on the region. Some conceptual hurricane and storm damage reduction measures applicable to Louisiana could have adverse impacts on other areas of the region. Should these conceptual measures be considered further, additional detailed analysis would need to be performed to determine the actual level of impact. Together, the MsCIP and LACPR study teams, along with key stakeholder representatives, will evaluate the issue of regional storm surge and wave influences and assess whether or not there is a significant regional influence, and if so jointly decide whether any additional risk is acceptable, whether the project(s) must be modified to lessen the increased risk, or whether the project(s) need to be reformulated.

Other possible structural concepts being tentatively considered for further study under the MsCIP would be subjected to similar detailed analysis to ensure that regional impacts are not caused by a locally beneficial action.

In addition all alternatives that involve large-scale wetland restoration, storm surge barriers, or large-scale levee/floodwall systems will be evaluated for regional influences on salinity, water quality and habitat. The hydrodynamic, water quality, and habitat experts from the MsCIP and LACPR study teams, plus outside peer reviewers for both projects, will make the assessment of which alternatives should be considered and integrated into the regional WQM model for this assessment. As was the case for the regional storm surge and wave model, the WQM model will be applied to examine regional influences of the tentatively selected alternatives in the MsCIP study and the most preferable alternatives that surface in the LACPR study.

1.6.5 Coordination with FEMA

In addition to the significant coordination between the MsCIP and LACPR teams, the teams have also coordinated fully with the Federal Emergency Management Agency (FEMA) to ensure a unified approach in the development of appropriate hurricane and storm damage reduction alternatives. FEMA has different regional offices to manage different areas of the United States. FEMA Region IV serves the state of Mississippi, and FEMA Region VI serves the State of Louisiana. After Katrina, Regions IV and VI began the complex process of updating their Flood Insurance Rate Maps (FIRMS) to include storm surge. FEMA Region VI utilized the Corps, New Orleans District to provide the model for updating their FIRMS, while Region IV contracted with an Architect-Engineer firm for this effort. Both the MsCIP and LACPR teams employed a consistent methodology for storm surge modeling, and coordinated their efforts closely with both FEMA regions. FEMA Region IV's contractor adopted some slight differences in terms of the specifics of their modeling approach; however, the agencies reconciled the differences in water levels generated for Regions IV and VI, and used an averaging technique to achieve a unified approach and result.

1.7 Public and Agency Involvement, Review, and Consultation*

NEPA is intended to ensure full public participation in the EIS process. Public participation includes effective communication between all Federal, state, local agencies, and tribal governments, and other persons or organizations [i.e. public and non-governmental organizations (NGOs)] that may have an interest in the project. A Notice of Intent (NOI) was published in the Federal Register on August 9, 2006, to inform the public of the Corps' intent to prepare an EIS for the MsCIP Comprehensive Plan. The public was invited to attend a public scoping meeting, a public workshop, and a public hearing to obtain public input and ensure compliance with NEPA. Other methods employed by the MsCIP study team to reach the general public and interested stakeholders included meeting announcements, brochures, news releases to local print and broadcast news media, and a web site. Further public communications include maintaining contact with public officials and agency representatives, ensuring that calls and letters from the public are addressed in a timely manner,

and contacting stakeholders through placement of notices of public meetings in stakeholder newsletters. In addition, the EIS will be widely circulated and comments will be requested.

The MsCIP Interim Report effort and this subsequent MsCIP Comprehensive Report and Integrated Programmatic EIS effort have been coordinated with all other agencies tasked with addressing the damages resulting from the hurricanes of 2005. Agencies, educational institutions and interested individuals have been contacted via phone, e-mail, or public notice, to solicit ideas and input to the plan formulation process. Those entities that have chosen to participate have availed themselves of several opportunities to involve themselves in the MsCIP planning process, including Regional Coordination and Public Workshop meetings, interactive problem area identification sessions, and development of measures sessions, via open forums, web-based feedback and participation forums, and less formalized discussions. Active participants in the MsCIP planning process included: NPS, FEMA, USEPA, USFWS, NOAA, USGS, the State of Mississippi, Hancock, Harrison and Jackson counties, the eleven cities along the coast of Mississippi, several educational institutions (i.e. University of Southern Mississippi, and University of New Orleans), and a number of interested individuals.

1.7.1 EIS Scoping Process

NEPA regulations provide for the use of the scoping process to identify and assess reasonable alternatives to Proposed Actions that avoid or minimize adverse effects of these actions upon the quality of the human environment. "Scoping" is used to identify the scope and significance of environmental issues associated with a proposed Federal action through coordination with Federal, state, and local agencies; the general public; and any interested individuals and organizations prior to the development of an EIS. The process also identifies and eliminates from further detailed study issues that are not significant or have been addressed by prior environmental review. Several initial scoping meetings were held between April and August 2006 in conjunction with development of the interim report. A scoping workshop was held in Biloxi, MS, December 19, 2006, to gather public input for the programmatic EIS.

1.7.2 Additional Required Coordination

The proposed plans presented in the MsCIP Comprehensive Report and Integrated Programmatic EIS are very integrated and all encompassing. These efforts are so extensive that additional coordination is anticipated in order to accomplish these proposed plans. The Corps, Mobile District anticipates additional coordination to be necessary with the following entities: NOAA, FEMA, USFWS, NGOs, Universities, and other stakeholders. Internal coordination among USACE elements including ERDC, Mississippi Valley Division, and the New Orleans District will continue throughout the implementation of the comprehensive plan. This additional coordination is necessary to adequately address improvements from a holistic approach.

1.7.3 Study Participants and Coordination

Per the Council on Environmental Quality regulations on implementing the National Environmental Policy Act, the Corps, Mobile District requested that a number of State and Federal Agencies accept the status of Cooperating Agency on the Integrated Report and Programmatic Environmental Impact Statement. In response to this request, dated October 30, 2006, the following entities are participating as cooperating agencies:

State:

- Mississippi Department of Archives and History
- Mississippi Department of Environmental Quality, Office of Pollution Control
- Mississippi Department of Marine Resources

- Mississippi Department Of Transportation
- Mississippi Emergency Management Agency
- Mississippi Museum of Natural Science
- Mississippi Secretary of State, Public Lands Division

Federal:

- Federal Emergency Management Agency, Region 4
- Minerals Management Service, Gulf of Mexico Region
- National Oceanic and Atmospheric Administration, National Marine Fisheries Service Southeast Region, , Protected Resources and Habitat Conservation Divisions
- National Park Service
- U.S. Department of Agriculture , Natural Resources Conservation Service
- U.S. Department of Transportation, Federal Highway Administration
- U.S. Environmental Protection Agency, Region 4
- U.S. Fish and Wildlife Service
- U.S. Geological Survey

Local:

- Gulf Regional Planning Commission

This study effort was accomplished with the participation of the following Federal and state agencies, local governments, and stakeholders:

- National Aeronautics and Space Agency
- National Weather Service
- Hancock, Harrison and Jackson Counties
- Communities of Bay St. Louis, Biloxi, D'Iberville, Gautier, Gulfport, Long Beach, Moss Point, Ocean Springs, Pascagoula, Pass Christian, and Waveland
- University of Southern Mississippi
- University of New Orleans
- Coastal Restoration Network
- The Nature Conservancy (TNC)
- The Audubon Society
- Sierra Club

1.7.3.1 LaCPR Modeling Team

The study team closely coordinated with members of the LaCPR technical team to ensure consistency between modeling efforts, data sources, and results. All hydrodynamic modeling results for the MsCIP project was closely coordinated with the LaCPR team. MsCIP and LaCPR applied an identical hydrodynamic modeling methodology and used consistent grids. The MsCIP storm suite included the storm suite modeled for LaCPR plus additional storms making landfall along and east of the Mississippi coast. The statistical methods applied for both were also consistent.

1.7.3.2 US Fish and Wildlife Service

Pursuant to the Fish and Wildlife Coordination Act of 1934 as amended the U.S. Fish and Wildlife Service (USFWS) has made recommendations to the MsCIP environmental team regarding potential impacts to wetlands, National Wildlife Refuge lands, Coastal Barrier Resource Act units, and fish and wildlife resources. The USFWS assisted in drafting portions of the Environmental Appendix, the environmental framework, and affected environment and environmental consequences sections of the Integrated Comprehensive Report. They also worked jointly with the ERDC team in providing input on the modeling schemes and selection of potential restoration sites.

In their Planning Aid letter dated June 12, 2007, the USFWS recommended that environmental and non-structural measures be utilized wherever practicable and that, minimization and avoidance of impacts should be considered on all projects. In addition, the FWS has prepared a draft Fish and Wildlife Coordination Act Report (FWCAR) that includes incorporation of sediment control measures during construction, maintaining disturbed areas with the use of native vegetation if at all possible, placing restrictive easements or covenants on all preserved and restored project areas, accounting for secondary development and indirect effects associated with projects during advanced design and feasibility studies, incorporation of environmental and non-structural measures in place of hard structures wherever practicable, and minimization and avoidance of impacts should be considered on all project elements. A copy of the FWCAR is included as Section 2 of the Environmental Appendix.

1.7.3.3 National Park Service

The NPS is a *Cooperating Agency* for the MsCIP Integrated EIS, and a NPS staff member was co-located with the MsCIP study team. The Mississippi Sound barrier islands consisting of Petit Bois, Horn, East and West Ship Islands and portions of Cat Island are located within Gulf Islands National Seashore (Seashore), a park unit managed by the DOI/National Park Service (NPS). The National Seashore's purpose is to preserve, protect, and interpret its Gulf Coast barrier island and bayou ecosystem and its system of coastal defense fortifications, while providing for public use and enjoyment in a manner consistent with applicable laws and agency policies. Undeveloped natural resource areas protected by the NPS provide habitat for several endangered species, stop-over habitat for migratory birds, and critical nursery habitat for marine flora and fauna, and serve as an enclave for complex terrestrial and aquatic plant and animal communities that characterize the northern Gulf Coast. The Seashore also contains one of the most complete collections of publicly accessible seacoast defense structures in the U.S., from early French and Spanish exploration and colonization through World War II.

The NPS is mandated to preserve natural conditions and processes, and to preserve cultural resources (see Comprehensive Barrier Island Restoration Plan Appendix for additional detail). Effective management of the barrier islands requires adaptation to the dynamics of these coastal landforms that act as the interface between ocean and land, and bear the impacts of hurricanes, variations in sediment supply, and sea level rise anticipated from global warming.

The long-term erosion and land loss experienced by the barrier islands since the mid-1800's is of major concern to the NPS. The NPS in collaboration with the USACE and other agencies has concluded that proactive management actions are crucial, necessary, and consistent with 2006 NPS Management Policies to restore Ship Island and the barrier island sand transport system and budget affecting Petit Bois, Horn, East and West Ship Islands, and to protect cultural resources threatened by shoreline erosion. The NPS has been extensively involved in the MsCIP planning process, and has closely coordinated with the USACE, USGS, NMFS, EPA, NOAA, USFWS, and MDMR in the development of barrier island restoration options.

1.7.3.4 NOAA/National Marine Fisheries Service

Technical staff of NOAA Fisheries, Protected Resources Division (PRD) and Habitat Conservation Office (HCD) participated in numerous inter-agency on-site and virtual on-line meetings. During these meetings, specific goals of the MsCIP Comprehensive Plan were discussed as well as potential measures and alternatives that would be evaluated. Recommendations concerning marine resources in the area have been a vital part of formulation of these measures and alternatives.

1.7.3.5 Federal Emergency Management Agency, Region 4

All hydrodynamic modeling and the development of stage-frequency curves for coastal flooding was closely coordinated with the FEMA. The numerical modeling methodologies were similar and consistent grids were used by both teams. Results from the FEMA and Corps modeling efforts were generally consistent, with 90% of all results being within +/- 1.0 feet of each other. Final stage-frequency values were established by taking an ensemble average of the Corps and FEMA results, to ensure consistency of end results.

1.7.3.6 U.S. Geological Survey

Technical staff of the USGS participated in numerous inter-agency on-site meetings relative to the restoration of the barrier islands. USGS provided studies on the disposition of the barrier islands and potential sources of high quality sand for beach nourishment. They continue to advance knowledge in these fields through ongoing field studies particular detailed bathymetry around the Mississippi barrier islands and additional geotechnical information.

Natural Resources Conservation Service – Tom please add a short paragraph relative to coordination.

1.7.3.7 Mississippi Department of Marine Resources (MDMR)

Multiple MDMR personnel assisted the MsCIP study team throughout the development of the Comprehensive Report and Integrated Programmatic EIS. MDMR staff worked very closely with the MsCIP study team in the identification and project specific designs of most of the ecosystem restoration sites discussed and evaluated in this report. A more detailed discussion of these environmental restoration sites is located in Environmental Appendix.

1.7.3.8 Mississippi Department Wildlife, Fisheries, and Parks (MDWFP)

The study team has invited participation from technical staff of the MDWFP, through invitations to participate in numerous inter-agency on-site and virtual on-line meetings. During these meetings, specific goals of the MsCIP Comprehensive Plan were discussed, as well as potential measures and alternatives that would be evaluated. Comments from MDWFP were considered and were incorporated into the Comprehensive Report and Integrated Programmatic EIS.

1.7.3.9 Mississippi SHPO

The study team closely coordinated with the Mississippi SHPO regarding assessments of damages to archaeologically significant resources throughout coastal Mississippi. Also, Corps archaeologists provided assessments of potential actions or measures and resulting impacts to the remaining resources. These assessments were coordinated with the Mississippi SHPO for their review, comments, and concurrence.

1.7.4 Coordination, Collaboration and Data-Sharing with NGOs

The study team invited participation from members of NGOs, such as The Nature Conservancy (TNC), The Sierra Club, and The Audubon Society, as well as many other groups throughout the region and the state. Both regional and local members of these organizations have participated in

various stakeholder meetings during which specific goals of the MsCIP Comprehensive Plan were discussed as well as potential measures and alternatives that would allow the Corps to meet stated goals and objectives. Comments from these NGOs have been considered and have been incorporated into the MsCIP Comprehensive Report and Integrated Programmatic EIS.

1.7.5 Coordination, Collaboration and Data-Sharing with Academic Institutions

The study team utilized members of academia, drawing on their research and knowledge of coastal systems. Specifically, members of the University of Southern Mississippi, Gulf Coast Research Laboratory, and Mississippi State University research and development community have participated in the public outreach meetings. Their input has been extremely valuable in efforts to bring the best expertise available to bear on developing this plan for recovery and improvement of coastal Mississippi.

1.7.6 Public Workshops

Early on, the MsCIP team placed a high value on incorporating public input and active stakeholder listening into the planning process. Various styles of public meetings were held. Public workshops included interaction between public participants and technical team members for information gathering. Public meetings were more formal. A Public scoping meeting and a Public hearing is required by NEPA and using these two complementary formats allowed the team to comply with NEPA as well as interact with public participants and local governmental and municipality representatives. A chronological overview of opportunities for citizen and stakeholder input during the MsCIP development process is described below:

- Over 60 Federal, State and local government agency representatives and other community leaders from business and industry gathered in Biloxi on April 7, 2006 to identify early needs, opportunities and recommendations for the MsCIP process. The meeting was designed to solicit input from members. The team developed guiding principle recommendations for the planning process and a list of specific proposals for consideration. Participants were able to view aerial maps of coastal Mississippi, examine the Corps' projects candidates, and attached local comments to coastal maps.
- Public Meetings were held in Harrison, Jackson and Hancock Counties on April 10, 11 and 13, 2006 to examine a broad range of potential coastal protection options and solicit public input on designing comprehensive improvements. Participants interactively indicated their level of agreement or disagreement with a series of prepared questions and statements. Additionally, participants were invited to submit comments via personal computer, comment card or directly to a court reporter during these sessions. A web-based database was launched that permitted public meeting attendees and others to submit comments on the planning concepts presented.
- An online agenda of the April 10-13, 2006 public meetings was posted on April 18, 2006 for displaced coastal residents or those who could not attend the public meetings.
- A second Regional Coordination meeting of governmental, business and industry stakeholders was held April 24 and 25, 2006 in Biloxi. The session probed for missing or overlooked items in the near-term planning process. A county-by-county review of projects and local ratings of these projects provided additional directional guidance.
- A second round of public workshops was conducted May 1, 2 and 4, 2006 where near-term projects and the screening criteria used to select them were presented. Additional public comment was captured via personal computer, comment card and court reporter.

Participants responded interactively to a series of statements and questions exploring preliminary project selection criteria, balance of approach and other perceptions.

- A follow-up online workshop was held on May 3, 2006 for displaced coastal residents or those unable to attend public meetings.
- A third Regional Coordination Meeting including government partners, business and industry was held in Biloxi on August 21-22, 2006. Issue-related subgroups for structural, non-structural, barrier island restoration, and environmental solutions offered specific comments and recommendations to Corps planners and subject matter experts.
- A scoping session workshop was held on December 19, 2006 at the MDMR office in Biloxi to gather public input for the EIS. The workshop format enabled attendees to pose questions to Corps planners and subject matter experts in an informal setting. Participants were offered additional interactive and comment gathering opportunities.
- A project web portal was launched in January 2007 enabling user downloads, project team collaboration, and improved communication and coordination.
- Online meetings for structural, nonstructural, environmental, and barrier island working groups took place on February 6 and 9, 2007. Participants had the opportunity to submit comments and be part of a facilitated discussion.
- A public workshop was held on April 5, 2007 to help finalize MsCIP measures for structural, nonstructural, environmental issues, and barrier islands. A 2-part session enabled participants to interact with Corps planners on emerging planning concepts in the first segment and formally comment on the plan during the second part.
- A Risk Analysis workshop was held on July 9 and 10, 2007 at the MDMR office in Biloxi, Mississippi assess stakeholder preferences.
- A follow-up to the Risk Analysis workshop was held on September 10 and 11, 2007.
- Additional meetings will be held during the review process for the MsCIP and will be announced widely to encourage maximum attendance and participation.

1.7.7 Continuing Outreach

The study team developed an interagency PDT, using lessons-learned after the hurricanes of 2005, and incorporating members from Federal and state resource agencies, state and local governments, members of state academia institutions, and various NGOs. Contacts for special interest groups and various focus groups have been compiled and maintained. The study team has developed and maintains a website dedicated to providing information and receiving comments. The intent is to create a transparent process focusing on the comprehensive, long term protection and sustainability of coastal Mississippi.

1.7.8 Internet Web Site

The MsCIP web sites are located at http://mscip.usace.army.mil/ and also http://meetingroom.groupsolutions.us/.

1.8 Report Organization

This report is organized in the following manner (* indicates report sections required for an EIS):

- Section 1 – Introduction
  - Purpose and Need*
  - Public Involvement and Agency Coordination*
- Section 2 – Affected Environment* (Existing and Without-Project Conditions)
- Section 3 – Plan Formulation (Alternatives and Plans*)
- Section 4 – Environmental Effects*
- Section 5 – Description of Tentatively Selected Comprehensive Plan Components
- Section 6 – Implementation Requirements
- Section 7 – List of Primary Study Team Members and Report Preparers*
- Section 8 – Glossary of Terms
- Section 9 – References*
- Section 10 – Index*
- Appendices
  - Appendix A Environmental
  - Appendix B Economic
  - Appendix C Real Estate
  - Appendix D Non Structural
  - Appendix E Engineering
  - Appendix F Cost Estimating
  - Appendix G Risk Appendix
  - Appendix H Barrier Islands
  - Appendix I Modeling
  - Appendix J Internal Technical Review / External Peer Review
  - Appendix K Plan Formulation

2 STUDY AREA DESCRIPTION (AFFECTED ENVIRONMENT*)

2.1 Study Area and Environmental Setting*

2.1.1 The MsCIP Environmental Framework

The area or the zone where water meets land can be described in various terms – it is a buffer area, the land-water interface, or an ecotone - the edge where the terrestrial ecosystem transitions into the aquatic ecosystem. Critical coastal habitats exist in this ecotone area: swamps, marshes, coastal ridges, coastal forests, littoral zone, dunes, and beaches. These coastal habitats serve as vital breeding areas, nursery grounds, and areas where much of the massive amounts of organic carbon needed to fuel aquatic food chains are produced. These areas capture sediments, nutrients and even contaminants eroded from the uplands before they enter the aquatic system. These areas also absorb wave, tide, and surge energy before impinging upon the upland.

Fundamentally, the Mississippi Coastal Improvements Program (MsCIP) is the framework for the protection, restoration, enhancement and re-establishment of the natural buffering capacities of these coastal habitats. Mississippi's coastal habitat system provides a comprehensive network of areas that are critical both to the environment and to society. The degradation of Mississippi's coastal habitat system has severely impacted the resiliency of the natural and man-made environment to past and future storm events.

During the MsCIP plan formulation process (see full discussion in Section 4), a Lines of Defense (LOD) concept was developed based on existing natural and manmade coastal features. The LOD concept identifies and develops the storm surge reduction potential

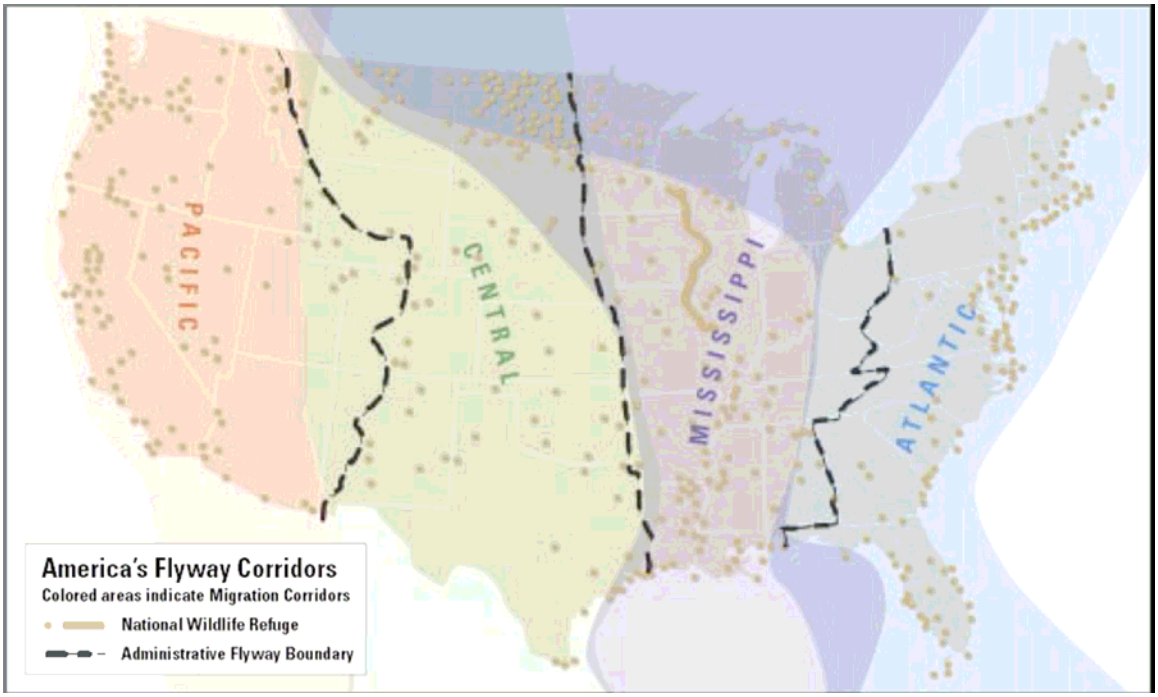
- for natural features such as barrier islands, beaches and dunes, and local topography and
- for existing and potential future manmade features such as roadways, rail beds, seawalls, surge gates, etc.

Each LOD can be enhanced to provide greater storm surge damage reduction benefits. Coastal habitats, such as beaches/dunes and wetlands, provide the first and second LOD against future storms. Barrier islands are the first LOD and the first natural barrier against future storms. The second LOD includes beach and dune habitat along the coastal mainland which provide a natural buffer to storm impacts to the mainland.

2.1.2 General Description of the Study Area

Coastal habitats in Mississippi provide vital ecosystems for fish and wildlife that is found no other place in the world. The annual waterfowl migrations, both spring and fall, are one of the most amazing spectacles in nature. The MsCIP study area falls within the Mississippi Flyway. The longest migration route of any in the Western Hemisphere lies in this flyway. Its northern terminus is on the Arctic coast of Alaska and its southern end in Patagonia. Well timbered and watered, the entire region affords ideal conditions for the support of hosts of migrating birds. The two rivers that mark it, the Mackenzie emptying on the Arctic coast and the Mississippi in the Gulf of Mexico, have a general north-and-south direction, another factor in determining the importance of this route which is used by large numbers of ducks, geese, shorebirds, blackbirds, sparrows, warbler and thrushes. The majority of North American land birds, seeking winter homes in the tropics that come south through the Mississippi Flyway take the short cut across the Gulf of Mexico in preference to the

longer, though presumably safer, land or island journey by way of Texas or the Antilles (Association of Fish and Wildlife Agencies 2008).



Source: USFWS

Figure 2-1
America's Flyway Corridors

Although waterfowl are what most people think of when they hear the word flyway or migration, many other birds migrate as well. Approximately two thirds of the breeding bird species of eastern United States forests migrate to tropical wintering areas in the Caribbean, Mexico, and Central and South America (Keast and Morton 1980). The movement of birds across the Gulf of Mexico each spring and fall is a prominent feature of Nearctic-Neotropical bird migration system (Ramos 1988). From early April through mid-May, the day-to-day consistency of migration across the Gulf of Mexico is rarely interrupted, and then only when strong cold fronts are positioned over the southern Gulf of Mexico (Gauthreaux 1971).

The coastal woodlands and narrow barrier islands that lie scattered along the northern coast of the Gulf of Mexico provide important stopover habitat for Neotropical land bird migrants (Moore et al. 1990). They represent the last possible stopover before fall migrants make a non-stop flight (18-24 hr) of greater than 1,000 km, and the first possible landfall for birds returning north in spring (Moore and Kerlinger 1987). The loss of coastal habitat suitable for forest-dwelling migrants has resulted in severe fragmentation of the remaining habitat, with many woodlands average only a few hectares in area. Development in the coastal zone is likely to continue the fragmentation of stopover habitat in the future (Moore and Simons 1989). Additional pressures following hurricane events, such as Katrina, also results in the loss of more undeveloped lands.

Mississippi Sound is fed from the north by eight coastal mainland watersheds and drainage from the south by tidal exchange from the Gulf of Mexico. From west to east the mainland drainages include: Lake Borgne, the Pearl River, the Jourdan River, the Wolf River, the Tchoutacabouffa River, the Pascagoula River, and Mobile Bay. Combined drainage area from streams and rivers entering the Mississippi estuarine basin is approximately 19,660 square miles (mi^2). The Pearl River and

Pascagoula River drainage areas far exceed those of Biloxi and St. Louis Bays. Pascagoula River has a drainage area of 9,400 mi^2 with an average discharge of 15,185 cubic feet per second (ft^3/s). Pearl River drains 8,700 mi^2 and has an average discharge of 12,890 ft^3/s. The combined drainage area for rivers emptying into Biloxi and St. Louis Bays is 1,400 mi^2 with an average discharge of 2,790 ft^3/s (NMFS 1998). It is within this brackish estuarine water that several species of fish, classified as aquatic resources of national importance, thrive from the shallow waters to the deep sea 70 miles offshore.

The influx of rivers creates a salinity gradient within the Sound (Priddy et al. 1955). Both east-west and north-south gradients occur in the Sound in addition to vertical gradients. Generally, positive salinity gradients exist from the mainland seaward and vertically, surface to bottom (GMFMC 1998). Surface salinity is influenced by the discharge of freshwater from large rivers and is reduced during periods of higher flow in late spring and early summer (Thompson et al. 1999). Temperature follows expected salinity trends. Levels of dissolved oxygen are usually above lethal limits.

The Pascagoula and Pearl Rivers, Bayou Casotte, and Biloxi Bay are the primary sources of nutrients entering the Mississippi Sound. The temporal and spatial variability of estuarine salinity is dependent on water supply, evaporation, and mixing, and also management, which includes the direct influence of activities, such as water withdrawal for inland irrigation projects and diversions, and the indirect effects of global climate change. Oysters grow faster in areas with fluctuating salinities within their normal ranges, compared to constant salinity (Pierce and Conover 1954). Oyster reefs of commercial importance are sub tidal and form aggregates that cover thousands of acres of the Mississippi Sound. The aerial extent of oyster reefs in Mississippi is estimated at 10,000 to 12,000 acres, of which over half is located in the western Mississippi Sound south of Pass Christian.

The eighty-mile-long body of water north of the string of five barrier islands is the Mississippi Sound, a large dynamic estuary extending from Mobile Bay in Alabama on the east to Lake Borgne in Louisiana to the west. Mississippi Sound is located within the very center of what fisheries biologists term the Fertile Fisheries Crescent. The Gulf of Mexico produces 28 to 30 percent of the total fishery products of the United States. Gunter (1963) showed that between 1936 and 1962, production from the Gulf of Mexico increased at a rate of 7 times its former production, with the shrimp fishery being the most valuable in the country. The Fertile Fisheries Crescent has been called “the core of the Gulf’s $800 million fishing industry.” Mississippi Sound forms a major part of the Fertile Fisheries Crescent within the northern Gulf of Mexico.

The Fertile Fisheries Crescent can be divided into three sections, the West Florida Shelf, The Mississippi-Alabama Shelf and the Louisiana-Texas Shelf. The Mississippi-Alabama Shelf extends from the DeSoto Canyon westward to the Mississippi River Delta. Sediments within this area range from more carbonate in the eastern part to mostly terrigenous nearer the Mississippi River Delta. Bottom features within the area are small peaks of cemented together sediments called “pinnacles”, dense fields of reef-like mounts, and low ridges that run parallel to shore. Also located within near shore waters are hard bottoms and rock outcroppings.

Recent studies have determined of the total fishes found within the northern Gulf of Mexico, excluding the southern Florida reef habitats, approximately 1,200 species, almost 400 species are found within the Mississippi-Alabama Continental Shelf. The Mississippi Sound estuary plays a key role in these numbers by providing prime habitat for various life stages of red snapper, tuna, redfish, Spanish and king mackerel, grouper, speckled trout, jack crevalle, cobia, amberjack, marlin, and various species of sharks. Mississippi Sound’s productivity is unequalled in the Gulf which makes it ideal for avid sport fishermen, commercial fishing, and local recreational use. Biloxi, Mississippi, located in the center of Coastal Mississippi was once known as “The Seafood Capital of the World” and in 1910 canning factories located here shipped over 15 million cans of oysters, more than any place else in the world.

The fishing industry contributed $1.1 billion to the state's economy prior to the devastation by Hurricane Katrina. According to Mississippi Department of Marine Resources, during a five-year average before the storm, Mississippi shrimp accounted for five to seven percent of all the shrimp landings in the U.S. The commercial seafood industry which includes the harvesting, processing and distribution of all seafood products created a total economic impact of $900 million in 2003. The total ex-vessel value of commercial landings amounted to $46 million while the total plant-gate value of commercial seafood production was $338 million in 2003. The recreational fishing industry which includes saltwater and freshwater fishing produced a total economic impact of $463 million in 2001 and $1,306 million in 1996 (ASA).

2.1.3 General Impact of Recent Hurricanes

The destruction caused by the hurricanes of 2005 came in two forms: the wind and tidal action of the hurricane itself. When Hurricane Katrina struck the Gulf Coast, it was a Category 3 hurricane; it had been as high as Category 5 as it moved through the Gulf of Mexico. The hurricane was also massive, which meant that these intense winds were spread over a wide area – in fact the entire Gulf Coast. The same forces that flooded parts of New Orleans damaged or destroyed wetlands along the Gulf Coast. Barrier islands took the initial damage. Wetlands suffered less from wind damage than from flood waters that dumped saltwater, trash, and toxic chemicals into the fragile ecosystems. When saltwater is introduced into a freshwater habitat it kills the vegetation – i.e. valuable wet pine savannah habitat.

A hydric soil is one that is defined as "a soil formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part." (Federal Register, 1994) Since the soils of these areas formed under hydric conditions due to the proximity of water, the historic spatial extent of the coastal wetlands can be estimated by the presence of these hydric soils. Analysis through GIS shows that 76% of all of the houses seriously damaged (damage estimated as greater than 90%) by Katrina, as defined by FEMA, were also located in areas mapped as hydric soils or areas composed of dredged material from adjacent channels. This correlation is an additional demonstration that the importance of restoring the coastal habitats extends beyond ecological interests into insuring the well-being of the human population.

Disturbance of soils and vegetation, such as vegetation covered by trash or complete removal of trees and/or marsh grasses, in coastal wetlands has resulted in the introduction and colonization of exotic species. The destruction of wetlands and coastal habitat occurred in a sensitive area for birds. As previously discussed, the northern Gulf Coast is a stopping point for birds in migration; it also serves as nesting ground for many species of terns and other water birds. Damage to the barrier islands was particularly bad for the nesting species; nests the following couple of years were lower for several species. The endangered Mississippi Sandhill Crane and a number of other threatened birds occur in the area. Twelve important bird areas lay in Hurricane Katrina's path: two in Florida and ten on the northern Gulf Coast. The hardest hit bird areas were the Breton NWR and the Gulf Islands National Seashore.

The habitats of several endangered species in the northern Gulf region were altered by the hurricanes. The endangered Alabama beach mouse has lost several acres of primary and secondary dunes that serve as habitat, and has lost scrub forest habitat, where it finds prey, to saline ocean waters. Along the Alabama coast, some nesting sites for the endangered Kemp's ridley sea turtle have been destroyed, and forested areas have been blown down in the Noxubee National Wildlife Refuge in Mississippi, where the listed redcockaded woodpecker has habitat.

The Gulf Coast states are significantly forested and are major producers of lumber and plywood. The U.S. Department of Agriculture Forest Service estimated 19 billion board feet of timber damaged on over 5 million acres in Mississippi, Alabama, and Louisiana. This would translate into an estimated

$5 billion loss in potential timber revenues according to the Forest Service. The forested area damaged represents 30% of the total timberland in the affected region, 90% of which occurred on non-federal lands. Eighty percent of the damage occurred in Mississippi. The Mississippi Forestry Commission issued a news release estimating that 1.3 million acres of forestland in the state had been damaged, with commercial timber valued at about $1.3 billion; urban tree damage in Mississippi was estimated at $1.1 billion.

The Gulf Coast where Hurricane Katrina struck is an especially important center of commercial and recreational fishing, producing 10% of the shrimp and 40% of the oysters consumed in the U.S. Further, commercial shrimpers fishing out of or delivering to Alabama, Mississippi, and Louisiana ports account for almost half of all U.S. shrimp production. Hurricane Katrina has destroyed or severely damaged fishing boats and processing and storage facilities throughout this area. The impact of Katrina on fish populations, habitat, and their viability for consumption was significant.

2.2 Significant Historic, Existing and Future (Without-Project) Resources*

2.2.1 Physiography, Geology

The Mississippi coast is situated in the Outer Coastal Plain Mixed Forest Province Ecoregion according to the USDA's *Description of the Ecoregions of the United States* (USDA 1995). Along the coast, flat coastal plains generally have gentle slopes and local relief of less than 100 feet. Water bodies of the area are typically characterized as sluggish streams, marshes, lakes, and swamps.

There are two major physiographic regions in the Mississippi coastal region. The Gulf Coast Flatwoods form an irregular belt through the southern half of the three-county region. This belt consists mainly of wet lowlands and poorly drained depressions, with some higher, adequately-drained areas. The second physiographic region, the Southern Lower Coastal Plain, is rolling and gently undulating interior uplands. Elevations range from sea level along the coast in Hancock, Harrison, and Jackson Counties to about 420 feet above sea level in the far northern areas of the coastal region. The slope of the land surface is generally oriented to the south. The area is underlain by a thick sequence of sedimentary deposits dipping to the south and west.

The coast of Mississippi is composed of sedimentary rocks and sediments deposited between the Cenozoic era and Quaternary period. Sedimentary layers of Pliocene, Miocene, Oligocene, and Eocene age currently found in the coastal Mississippi area consist of clay, silt, sand, gravel, and limestone. All these formations dip to the south-southwest. The geologic formations exposed on the surface of the Mississippian Gulf coast are up to 100 feet thick and consist of alluvium and terrace deposits (Otvos 1998). The Biloxi Formation, the Prairie Formation, and the Gulfport Formation were all deposited during this time. The Biloxi Formation was deposited during a period of rising sea level in marine and brackish water both nearshore and offshore. This formation is not exposed at the surface, except along the banks of the Industrial Seaway in Gulfport where it has been exposed from excavation. It ranges in thickness from 15 feet in Harrison County up to 120 feet in Jackson County, and consists of clay, fine sand, and sandy clay with abundant fossils. Both shells and microscopic foraminifera are found, and these fossils are used to identify the deposition environment (Oivanki 1998). The Prairie Formation, ranging from 15 to 40 feet thick, was deposited in river channels and inter-channel swamps. It is composed primarily of sands and muddy sands with petrified tree trunks and organic matter, and is visible along the Industrial Seaway road cut in Harrison County. The formation underlies the wide, generally flat coastal plain immediately north of the coastal marshes and beaches on the coast. The city of Bay St. Louis is built on the high sandy bluffs of the Prairie Formation (Oivanki 1998). The Gulfport Formation is a sand unit that was deposited during a time of sea level decline, following the highest sea level stage of the Pleistocene epoch. It forms the high ridge upon which the coastal cities of Pass Christian, Gulfport, and Biloxi are built. The coastal

Mississippi beaches are regularly replenished with sand dredged from the Mississippi Sound, and the source for much of this sand is the Gulfport Formation (Otvos 1998).

The physiography and geology of coastal Mississippi were largely unaffected by the hurricanes of 2005; however, saltwater intrusion into sediments and water bodies as a result of inundation during Hurricane Katrina in particular, has been evident. The storm surge associated with Katrina brought saltwater into many freshwater features that would not normally be impacted by saline waters. The level of saltwater intrusion by inundation caused die-off of many species, only some of which have re-grown by this late date. Die-off of trees impacted by saltwater was particularly severe on the barrier islands, which to-date, have never recovered. While much of the saltwater is no longer present in soils or rocks within the study area, its effect on vegetation has not been reversed in many areas. Measures to address die-off of vegetation in areas impacted by saltwater intrusion are addressed in later sections of this report and appendices.

Saltwater intrusion into the estuarine environment of Mississippi Sound is an issue related in only a limited fashion, to geology and soils, and measures to address saltwater intrusion resulting from human intervention was, in this study effort, investigated as a study in its own right, the results of which will be discussed further in this report, and in the separate Environmental Appendix.

2.2.2 Relative Sea Level Rise

The Corps planning guidance, specifically Appendix E, Section IV, Paragraph E-24 of the Planning Guidance Notebook (ER 1105-2-100), requires that potential relative sea level rise should be taken into consideration for coastal or estuarine projects at the feasibility level of study and recommends, given the uncertainty of future sea level rise estimates, preference be given to developing strategies that are robust over the entire range of potential sea level rise rates versus those that perform well only over a limited range of potential sea level rise rates.

Systematic long-term tide elevation observations suggest that the elevation of oceanic water bodies is gradually rising and this phenomenon is termed ‘sea level rise.’ The rate of rise is neither constant with time nor uniform over the globe. In addition to elevation of oceanic water bodies, however, is the gradual depression of land surface along the coast of Mississippi, referred to as “subsidence”, which becomes an additional factor in the relationship between the land’s elevation over time, and that of changing sea levels. Because the coast of Mississippi is affected by both subsidence and global sea level rise (adjusted for local conditions), these factors combine (and are referred to in this analysis) in a single element of “relative” sea level rise. Relative sea level rise (RSL) at a given location, then, is simply the change in mean sea level at that location with respect to an observer standing on or near the shoreline.

Historically, relative sea level rise has been determined by fitting a linear relationship to monthly mean or annual mean sea level, either of which is computed from tide gage observations. The slope of the fitted line gives the rate of sea level rise at the location of the tide gage. The computed rate includes the rate of subsidence or uplift of the location upon which the tide gage is founded, and thus the computed RSL rates may be extended locally or regionally to areas with similar geotechnical and tidal conditions.

Project performance in this study effort was evaluated for both an extrapolation of the observed historic rate plus subsidence, which resulted in a rate over a 100-year planning horizon of approximately two feet of relative sea level rise, and also for a rate higher than that historically observed, as suggested by the Intergovernmental Panel on Climate Change, equivalent to approximately 3.4 feet over an assumed 100-year planning horizon [Intergovernmental Panel on Climate Change (IPCC) 2001]. In addition, sensitivity analysis was also conducted by use of an alternate 50-year planning horizon.

Additional detail on relative sea level's effect on environmental resources, ecosystem restoration measures, potential structural and non-structural damage reduction measures, costs, and other factors, are contained in following sections of this report, and in the Engineering Appendix.

2.2.3 Climate

Coastal Mississippi is located in a region characterized by humid subtropical conditions. The coastal area of Mississippi exhibits temperate winters and long, hot summers, with rainfall fairly evenly distributed throughout the year. However, the coast is also subject to periods of both drought and flood, and the climate rarely seems to truly exhibit "average" conditions. Prevailing southerly winds provide moisture sufficient to maintain high humidity. Normal mean annual temperatures range from approximately 66 degrees at Pascagoula, to approximately 68 degrees at Gulfport. Temperatures routinely exceed 100F each year, and freezing temperatures reach the Gulf coast almost every winter (Mississippi State Climatologist 2006).

2.2.3.1 Hurricanes and Storm Surge on Mississippi Coast

The northern Gulf of Mexico, particularly that area between Mobile Bay to just west of the Mississippi River, is uniquely situated in regards to the formation and landfall for Atlantic tropical cyclones. Influencing factors include the circulation and bathymetry of the Gulf, the offshore topography of the northern Gulf Coast, and the abundant warm waters of the Gulf. Over 40 tropical cyclones have made landfall between Mobile Bay, Alabama and eastern Louisiana in the period 1800 – 2005. Two of these storms, Camille in 1969 and Katrina in 2005 were the largest storms to impact the southeastern US.

Abnormally high water levels along the coasts are typically associated with the passage of hurricanes. Many factors contribute to the magnitude of hurricane storm surge. Storm intensity is but one of many. The effect of waves, rainfall, sea level variations, and coastal topography are a few of the others (Harris 1963). Unfortunately, hurricane size and duration are often overlooked. Certainly, this was a major "lesson learned" with regard to Hurricane Katrina. Hurricane Katrina was an unusually large Gulf hurricane, perhaps the largest in two hundred years or more. By contrast, Hurricane Camille (August 1969), the previous standard for destructive hurricanes on the Gulf Coast, was a much smaller but extremely intense tropical cyclone which made landfall in almost the exact same locale. With sustained winds of 190 miles per hour (mph), Camille created a swath of destruction in the communities of Bay St. Louis, Waveland, and Pass Christian, Mississippi. However, a 25- to 30-foot tidal surge was confined to a small area near and east of the center; much smaller than that of Katrina. The levees at New Orleans were not breached during that event, but were overtopped during Hurricane Betsy in 1965. To the east, a storm surge of 15.5 feet was recorded at Biloxi. Conversely, Hurricane Katrina, packing 120 mph sustained winds at landfall, produced an unprecedented massive and devastating 24-foot storm surge at Biloxi, with record surge levels extending from well west into Louisiana to Mobile, Alabama. The historical record is replete with similar, but much smaller examples. Large, slow moving hurricanes such as the New Orleans storms of 1915, 1947, and Betsy in 1965 produced much higher tidal surges than the small Category 3 Hurricane Elena, which directly hit Biloxi in September 1985.

Examination of Figure 2-2 illustrates the magnitude of Hurricane Katrina in comparison with other hurricane and high tidal events (based on a plot of each year's highest tidal/water level elevation) of the last approximately 123 years (1882-2005), at the Biloxi tidal gauge. Hurricane Katrina exceeded all previous events in damage, adjusted to 2006 dollars, and only the infamous Galveston hurricane of 1900 exceeded the death toll of Hurricane Katrina, despite the advanced warnings given.

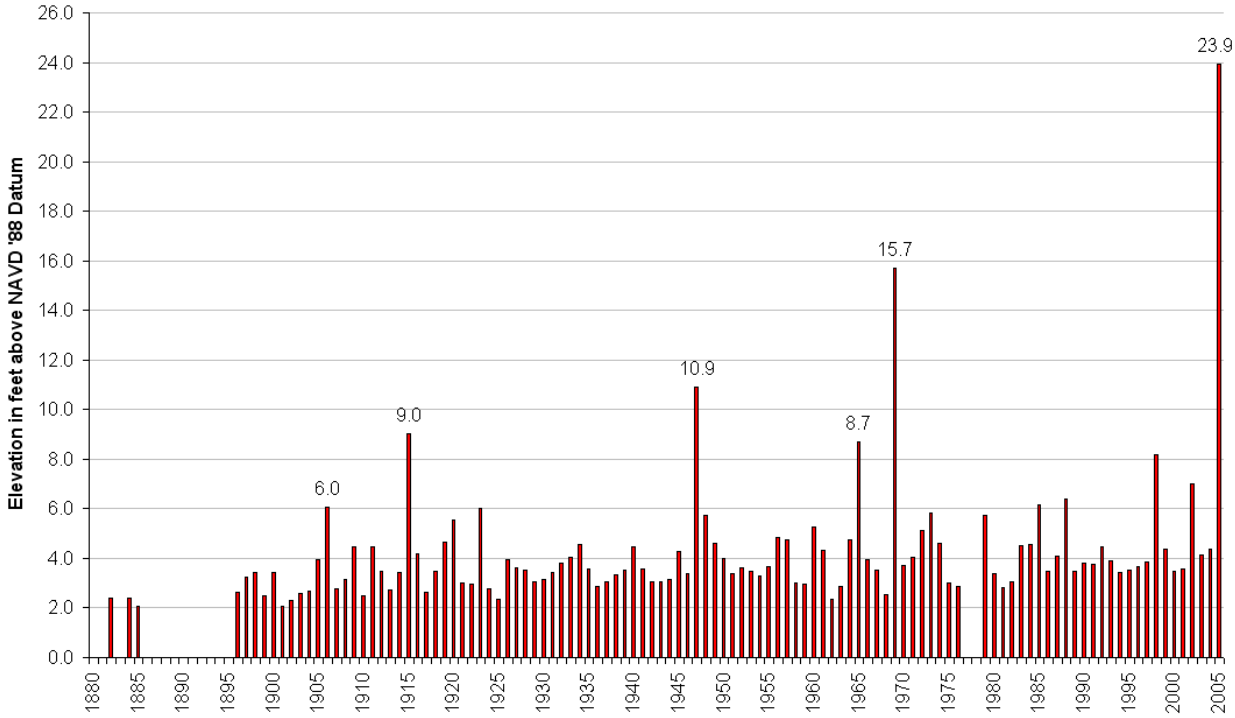


Figure 2-2
Maximum Annual Stage at Biloxi, MS Gage

2.2.3.2 Precipitation/Rainfall

Average annual rainfall ranges from approximately 65 inches at Biloxi and Gulfport, to approximately 67 inches at Pascagoula. Locally violent thunderstorms are a threat on an average of 60 days each year (Mississippi State Climatologist 2006). The area has been struck by at least eight hurricanes since 1895, and as of 2005 has been affected by 51 tropical disturbances (including hurricanes) since 1915.

2.2.4 Hydrology and Hydraulics

The coast of Mississippi is governed by often large volumes of rainfall, delivered on a very flat landscape. Principal rivers discharging to Mississippi Sound include the Pearl and Pascagoula Rivers; the Escatawpa River flows into the Pascagoula River at Pascagoula. Other principal rivers discharge into either Bay St. Louis or Biloxi Bay, which are connected to Mississippi Sound. The Wolf and Jourdan Rivers flow into Bay St. Louis, and the Biloxi and Tchoutacabouffa rivers flow into Biloxi Bay. River patterns meander broadly through this flat and often marshy landscape, and often display abandoned “oxbows” and off-channel wetlands. Numerous bayous are also interspersed within these coastal bays and along the Mississippi Sound shoreline. Many of these bayous have been heavily modified over the years by development and conversion for commercial, residential, industrial, or recreational purposes.

The landscape is generally low-lying on the eastern and western ends of the Mississippi Coast, with higher ground in the middle. The great majority of the ground surface south of Interstate-10, which crosses the state within five to ten miles of the coastline, is below 25 feet above mean sea level, with the preponderance of the area below 15 feet in Jackson and Hancock counties and in the bay and riverine margins of Harrison County.

The occurrence of large rainfall and/or hurricane events in coastal Mississippi may normally cause extensive flooding, although nothing in the modern record has ever approached the severity of inundation caused by Hurricane Katrina. Rain-induced riverine flooding in the larger coastal river basins does not generally coincide with hurricane surge, though torrential tropical storm and hurricane rainfall can exacerbate flooding due to surge in the smaller coastal basins. Flooding may also be exacerbated by sediment and debris blockage of channels, culverts, bridges, and canals.

Numerous channels, culverts, bridges, and outfalls were impacted by sediment and debris displacement and deposition as a result of the hurricanes of 2005. Much of the debris has subsequently been removed, but much remains within coastal wetlands, creeks, and bayous, and continues to impair the hydrologic and ecologic functions of the larger ecosystem.

2.2.5 Coastal Processes

Coastal processes evident in coastal Mississippi include waves, tides, littoral currents, and severe storm events. These natural factors are the primary ones affecting coastal morphology, but coastal processes are also influenced by water depth, coastal subsidence, and man-made structures.

The study area includes the Mississippi Sound, which extends approximately 12 miles south of the coastline to where it intersects with the barrier islands. These barrier islands reduce the penetration of long swells arising out of the Gulf of Mexico, resulting in reduced wave energy within the Sound. The wave height is relatively low, with a mean tidal range of only 1.47 feet.

Beaches along the Mississippi coast extend for over 26 miles from about Bay St. Louis in the west to Pascagoula in the east. Many of these beaches are periodically replenished with sand. The Belle Fontaine headland in Jackson County is considered to be the only remaining natural beach on the Mississippi mainland coast. The beach is formed by natural sand deposition provided from longshore currents. However, as residents in the area have armored coastal areas to protect their homes, the natural sand source has been altered and the beach is now suffering from sand deficiency (Oivanki and Suhayda 1994). Beaches serve as both an environmental resource and as an absorber of surge and wave energy. The Gulf Coast is generally considered to be a low-energy area except during the hurricane season (Thurman 1991). Natural changes to the coastline are episodic, associated with major storms and flooding events. High energy, short duration storm events, such as hurricanes and tropical storms, are particularly devastating to the Mississippi coast where storm frequency is high and ground elevation is relatively low.

High waters and wave action associated with such severe storms are known to remove sand dunes from their given locations and displace large amounts of sand. Other less obvious properties and processes that can have an impact on the coastline include type, wind induced currents, tidal flow, channel bathymetry, and residual tidal circulation. The natural coastal erosion rate for Mississippi is only about 2 inches per year, but may ebb and flow in many areas.

The majority of groins, jetties, breakwaters, and seawalls found along coastal Mississippi were significantly damaged or completely destroyed during Hurricane Katrina. Plans for reconstruction of these features are underway and in some cases, reconstruction has begun, some of these being projects that were recommended for construction in the Interim Report. It is expected, through various funding mechanisms, most of these features will be reconstructed as originally designed or slightly modified.

The unprecedented storm surge from Hurricane Katrina caused substantial losses to the barrier islands due to erosion. The vast majority of eroded land has not recovered, nor have the resources associated with that land. Dune systems were severely damaged or in some cases flattened. Interior forests were stripped of much of the undergrowth which consists of shrub and herbaceous layers (MDMR 2006). Many trees, dune grasses and herbaceous shrubs were killed and have not

returned. Over 30,000 structures were significantly destroyed (50 %or more), with another 15,000 to 25,000 suffering moderate to minimum inundation damage.

Hurricane Katrina deposited unknown quantities of debris in coastal Mississippi marshes, covering well over 1,000 acres several feet deep. Debris fields extend well into the adjacent maritime forests covering approximately 835 acres. Smaller areas of debris deposition exist along the entire coast of Mississippi (MDMR 2006).

Overall, the footprint of the mainland shoreline along coastal Mississippi appears to have changed very little as compared to pre-Hurricane Katrina conditions; however, the elevation of the shoreline was severely eroded in some areas, such as Bay St. Louis. Sand and soil was lost along the entire coastal Mississippi shoreline (MDMR 2006).

2.2.6 Environmental Resources

The primary study area consists of the three coastal counties comprising the State of Mississippi: Hancock, Harrison, and Jackson counties, and the coastal (offshore) ecosystem including its barrier islands. This area ranges in elevation from sea level to about 30 feet. The essentially flat to gently undulating, locally swampy Coastal Lowlands are underlain by alluvial, deltaic, estuarine, and coastal deposits and merge with the fluvial-deltaic, plains of the streams of the area. This portion of coastal Mississippi has been classified as an alluvial coast, a terraced, deltaic plain. According to the Cowardin et al (1979), *Classification of Wetlands and Deepwater Habitat of the United States*, there are five major wetland and deepwater systems, four of which are found within coastal Mississippi. They include marine, estuarine, riverine, and palustrine wetland systems. Further details on ecological resources and fish and wildlife can be found in the Environmental Appendix, *Chapter 1 Coastal Mississippi Environment*.

2.2.6.1 Ecological Habitats

The marine system consists of the open ocean overlying the continental shelf and its associated high energy coastline. Within coastal Mississippi, the marine system is the area along the Gulf of Mexico front south of the barrier islands. It is comprised of the intertidal beachfront of the barrier islands along the Gulf of Mexico, and subtidal habitat which consists of the unconsolidated sandy or silty water bottoms. Estuarine systems within coastal Mississippi consist of deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open partly obstructed or sporadic access to the open ocean and in which ocean water is occasionally diluted by freshwater runoff from the land. Mississippi Sound consists of both sub-tidal and inter-tidal estuarine systems.

Riverine systems are bounded on the landward side by upland, by the channel bank, or by wetlands dominated by trees, shrubs, and persistent emergents. Cowardin et al (1979) divides the riverine system into four sub-systems: tidal, lower perennial, upper perennial, and intermittent, two of which are found in coastal Mississippi. These include freshwater tidal marsh and lower perennial emergent wetlands.

The palustrine system includes nontidal wetlands dominated by trees, shrubs, and persistent emergents. It also includes small, shallow, permanent or intermittent waterbodies, such as ponds or coastal plain depressional wetlands. Coastal Mississippi is interlaced with a rich and diverse complex system of vital wetlands that provide floodwater storage, groundwater recharge, water filtering and purification systems, as well as wildlife habitat that include Pine Savannahs, headwater slopes (Bayhead Drain), swamps, and ephemeral pools.

Numerous problems have been identified that impact the sustainability and productivity of coastal Mississippi wetland habitats. Freshwater newly emergent marshes are formed in pro-grading deltas that depend on flooding waters to supply their nutrient needs. One of the challenges facing the sustainability of the freshwater marsh is a lack of sediment from upstream. Lack of sediment also hampers natural accretion and causes further erosion and subsidence. Coastal Mississippi also has

a problem with invasive species colonizing within areas that have been altered in some form or fashion due to man's disturbance. The majority of the coastal preserve systems have been invaded with these invasive species which continue to out-compete the native species, heavily depended on by native fauna. Also, pollutants cause eutrophic conditions, harm plants and wildlife. A more comprehensive discussion of the *Ecological Habitats* is been provided in the Environmental Appendix.

2.2.6.2 Fish and Wildlife

Many species of invertebrates and vertebrates make up the various fauna population along the Gulf coast. Invertebrate populations in Mississippi Sound and the nearshore area of the Gulf of Mexico transfer energy through the coastal food web. Microscopic estuarine zooplankton live throughout the water column with limited mobility. Zooplankton includes such organisms as copepods, protozoans, chaetognaths, pteropods, tunicates, ctenophores, and siphonophores. Larval stages of benthic forms and eggs and larval stages of many fish species are often interspersed throughout zooplankton. Many important commercial species feed upon zooplankton.

Vittor and Associates (1982) investigated the macrofauna of Mississippi Sound and selected areas in the Gulf of Mexico. Over 532 taxa from offshore Mississippi and Alabama and 437 taxa from the Mississippi Sound were identified. Densities of individuals varied from 910 to 19,536 individual/ yard^2 for the offshore and 1,200 and 38,863 individual/ yard^2 for the Sound area. Abundance of macrofauna is temporal with greatest densities occurring from fall to spring.

Oyster production in Mississippi depends on public reefs managed by the Mississippi Department of Marine Resources (MDMR). The State of Mississippi accounts for about 13% to 17% of Gulf oyster landings. Reefs are located along the coast across the entire state with the largest reefs near the western boundary. According to a 1966 survey by W.J. Demoran, there were 9,934 acres of oysters. At that time, there were 582 acres of planted oyster beds. Additional acreage has been planted. A few small areas of oyster bottom have been leased for private development; however, production from these areas has been negligible. There have been considerable annual variations in size of productive areas due to natural environmental fluctuations, such as freshwater flow into the oyster beds. Many of Jackson County's most productive areas have been closed to harvest due to increased pollution associated with coastal development.

Many commercially important species of crustaceans are harvested in Mississippi Sound and the nearshore of the Gulf of Mexico. Brown shrimp (*Penaeus aztecus*) is the main shrimp species harvested by commercial fishermen in the Gulf of Mexico and is the most important commercial species in the Mississippi Sound and Mobile Bay area. White shrimp and blue crab are also harvested within the study area. In addition to those commercial species, there is a very diverse community of crustaceans within Mississippi Sound and adjacent waters including a wide variety of forms and habitat preferences. Epibenthic crustaceans dominate the diet of flounder, catfish, croaker, porgy, and drum. A description of the EFH and managed species are included in the Environmental Appendix, Section 1.5.

Christmas and Waller (1973) reported 138 fish species in 98 genera and 52 families taken from areas across Mississippi Sound. The major fisheries landed along the Mississippi Gulf coast are anchovies, menhaden, mullet, croakers, shrimp, and oyster. Jackson County, primarily the ports of Pascagoula and Moss Point, receives greater than 85% of all Mississippi landings, including all industrial fish (menhaden), 95% of the mullet, trout, and red snapper, and 74% of the croaker landed (Corps 1992).

Coastal wetlands of Mississippi Sound, St. Louis Bay, Biloxi Bay, Pascagoula Bay, and the tidal Pascagoula River provide the resource base for commercial and marine recreational fishing and tourism in Mississippi. The dockside value of commercial fish landings in Mississippi was almost $42 million in 1995. Recreational fisheries also play an important role in the state's economy. In 1991,

500,000 people spent more than $236 million fishing in Mississippi's waters, generating almost $14 million in state sales tax, resulting in $131 million in earnings, and supporting more than 8,000 jobs. Approximately one-quarter of the recreational fishing occurs in coastal waters. Communities, such as Moss Point, Pascagoula, Gautier, Ocean Springs, Biloxi, Long Beach, Gulfport, Pass Christian and Bay St. Louis, all depend on fishing to support their local economies.

Coastal Mississippi supports an array of reptiles, amphibians, birds, and mammals. Reptiles and amphibians found in the area include snakes, turtles, lizards, toads, frogs, salamanders, and crocodilians. Coastal Alabama and Mississippi have a great diversity of reptiles including 23 species of turtles, 10 species of lizards, 39 species of snakes, and the alligator. Eighteen species of salamanders and 22 species of frogs and toads are indigenous to the coastal region.

Mammals found within the area include marsupials, moles and shrews, bats, armadillos, rabbits, rodents, carnivores, even-toed hoofed mammals, and dolphins. Mammals occur within all habitats of the system, using underground burrows, the soil surface, vegetative strata, the air, and the water for feeding, resting, breeding, and bearing and rearing young. There are 57 species of mammals found in the area. Several species of mammals include the raccoon, river otter, gray fox, striped skunk, mink, whitetailed deer, bottlenose dolphin, beaver, possum, and nine-banded armadillo. A number of whales are known to occur offshore Mississippi and Alabama and occasionally are sighted within Mississippi Sound.

Over 300 species of birds have been reported as migratory or permanent residents within the area, several of which breed there as well. Shorebirds include osprey, great blue heron, great egret, piping plover, sandpiper, gulls, brown and white pelicans, American oystercatcher, and terns. Birds of the area eat a great variety of foods, are also food to many predators, and exhibit a diversity of nesting behaviors.

2.2.6.3 Federal T&E Species and Their Critical Habitats

Coastal Mississippi is home to 19 federally listed T&E, or candidate species. Federally listed species known to occur within the project area are shown on Table 1.4.1-1. Several other T&E species, listed by NOAA, PRD, are known from marine habitats in the Gulf of Mexico. These species are blue whale (*Balaenoptera musculus*), finback whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), Sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), hawksbill sea turtle (*Eretmochelys imbricata*), and leatherback sea turtle (*Dermochelys coriacea*). These T&E marine species might be occasional visitors to the project area.

Table 2-1
Federally Listed Rare T&E Species

Common Name	Scientific Name	Status	County	Habitat
Alabama red-bellied turtle	*Pseudemys alabamensis*	LE	Harrison, Jackson	Submerged aquatic vegetation in brackish coastal rivers; freshwater reaches
Black pine snake	*Pituophis melanoleucus ssp. lodingi*	C	Harrison, Jackson	Fire-dependent, upland longleaf pine forests
Brown pelican	*Pelecanus occidentalis*	LE	Hancock, Harrison, Jackson	Feeds over water in coastal areas, nests on small islands.
Eastern indigo snake	*Drymarchon corais couperi*	LT	Harrison, Jackson	Fire-dependent, upland longleaf pine forests
Gopher tortoise	*Gopherus polyphemus*	LT	Hancock, Harrison, Jackson	Fire-dependent, upland longleaf pine forests
Green sea turtle	*Chelonia mydas*	LT	Hancock, Harrison, Jackson	Shallow coastal waters with SAV and algae, nests on open beaches.

Common Name	Scientific Name	Status	County	Habitat
Gulf sturgeon,	*Acipenser oxyrhynchus desotoi*	LT	Hancock, Harrison, Jackson	Migrates from large coastal rivers to coastal bays and estuaries
Inflated Heelsplitter	*Potamilus inflatus*	LT	Harrison	Soft, stable substrata in slow to moderate currents of tributaries and large rivers
Kemp's Ridley sea turtle	*Lepidochelys kempii*	LE	Hancock, Harrison, Jackson	Nearshore and inshore coastal waters, often in salt marshes
Loggerhead sea turtle	*Caretta caretta*	LT	Hancock, Harrison, Jackson	Open ocean; also inshore areas, bays, salt marshes, ship channels, and mouths of large rivers
Louisiana black bear	*Ursus americanus luteolus*	LT	Hancock, Harrison, Jackson	Bottomland hardwood forest; frequently ranges into other habitats
Louisiana quillwort	*Isoetes louisianensis*	LE	Hancock, Harrison, Jackson	Small blackwater streams with sand and gravel substrate and forest cover
Manatee	*Trichechus manatus*	LE	Hancock, Harrison, Jackson	Fresh and salt water in large coastal rivers, bays and estuaries.
Mississippi gopher frog	*Rana capito sevosa*	LE	Harrison, Jackson	Fire-dependent, upland longleaf pine forests; open, ephemeral upland pools
Mississippi sandhill crane	*Grus canadensis pulla*	LE	Jackson	Wet pine savannah
Pearl darter (Pascagoula River System)	*Percina aurora*	C	Jackson	Rivers and large creeks with sand and gravel bottoms and flowing water.
Piping Plover	*Charadrius melodus*	LT	Hancock, Harrison, Jackson	Barrier islands and coastal beaches
Red-cockaded woodpecker	*Picoides borealis*	LE	Harrison, Jackson	Fire-dependent, upland longleaf pine forests
Yellow-blotched map turtle	*Graptemys flavimaculata*	LT	Jackson	Rivers and large creeks with habitat suitable for basking

LT = listed threatened, LE = listed endangered, C = candidate for listing, PE = proposed endangered
Source: Mann, 2000. Bald eagle was delisted from threatened in August 9, 2007.

2.2.7 Water Quality

Mississippi Department of Environmental Quality (MDEQ) monitors the water quality of surface water throughout the state. Water quality assessments are made from this information that give general characterizations of water body health. The state's most comprehensive assessment report is found in the Federal CWA Section 305(b) Water Quality Inventory Report.

Water Quality Assessments are technical reviews of physical/chemical, bacteriological, biological, and/or toxicological data and information to determine the quality of the state's surface water resources. Monitoring data are compared to the "State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters" in order to make decisions on whether a water body is supporting or not supporting its designated uses such as aquatic life support, water contact recreation, fish/shellfish consumption, and drinking water. Detailed discussion on water quality can be found in the Environmental Appendix.

2.2.8 Hazardous, Toxic, and Radioactive Wastes

Due to the extent and large number of real estate parcels associated with the environmental, non-structural and structural measures along with the potential realignment of the structural aspects of this project, no site-specific preliminary assessments have been performed to identify the possibility of hazardous waste. For tentatively selected plan features that include further study or construction,

these studies will be conducted during the next phase of work. A limited number of preliminary assessments were completed during the Interim Project phase of work, but the extent of these assessments only covered the limited area designated for these projects. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

2.2.9 Cultural and Archaeological Resources

Significant cultural resources as defined by the NHPA are those sites that are considered eligible for or are included in the National Register of Historic Places (National Register). These sites are known as historic properties. Historic properties can include buildings or other standing structures; historic or prehistoric districts (such as the historic districts in Biloxi and Ocean Springs); archaeological sites such as Indian mounds or other remains of prehistoric life; objects such as statues or paintings; or sunken vessels. Traditional cultural properties can also be considered significant cultural resources because of their traditional religious or cultural importance to an Indian tribe or other traditional community.

Properties, such as cemeteries or buildings that are less than 50 years old are usually not considered eligible for the National Register, but there are exceptions. For example, certain buildings associated with the Cold War are considered so important to our history that they are eligible for the National Register.

Along the Mississippi Gulf Coast, historic properties can be roughly defined within two categories. The categories are the built environment (standing structures) and archaeological sites. The vast majority of historic properties listed on the National Register are those of the built environment. To date 62 standing structures, 14 historic districts, and one ship have been listed. Fort Massachusetts and the French Warehouse sites are cultural resources found within Gulf Islands National Seashore on Ship Island. Fort Massachusetts has survived many hurricanes, including the most recent one – Hurricane Katrina. Many more standing structures are considered eligible for the National Register, but have not been formally nominated. These are also considered potential historic properties. Historic districts have been designated in Biloxi, Ocean Springs, and Bay St. Louis.

In contrast, very few archaeological sites have been formally nominated to the National Register. However, numerous sites still meet the criterion of definition as historic properties. These include prehistoric earthworks and mounds, shell middens, village sites, and historic occupation areas including extinct town sites. Currently over 200 recorded archaeological sites are considered potential historic properties.

In addition to National Register eligible properties, the Mississippi Coast also contains several National Historic Landmarks and designated Mississippi Landmarks. These include Beauvoir and the Mullato Bayou prehistoric earthworks.

The vast majority of historic and prehistoric sites are found along the immediate coastal strand and adjacent to estuarine systems. Preference for well drained, sandy soils adjacent to water sources is apparent. Coast wide survey work performed by both state (Giliberti n.d.) and private researchers (Blitz and Mann 2000) have found a distinctive focus on the immediate coastal and estuarine locations. Unfortunately, the geographic placement of these resources has made them extremely vulnerable to destruction from continued occupation and development, as well as vulnerable to the effects of tropical storms and hurricanes.

Modern development along the Mississippi coast has affected both archaeological sites and standing structures, including individual structures and historic districts in the project area. Key issues are soil disturbance and construction. Soil disturbance affects archaeological sites, and construction of new buildings and associated infrastructure can affect the view shed and “feel” of a historic building or district or cause demolition or alteration of historic buildings.

From the early 1970s to the present, construction in the project area has greatly increased. In fact, more development and construction has occurred in the three counties that are part of the project area than anywhere else in the state. Land use studies show that between 1972 and 2000 both medium-density and high-density urban land use areas increased by more than 90 percent in the study area; overall, developed land use increased by almost 70 percent during that period (MARIS 1992, 2000; USGS 1972; USGS and USEPA 1992). This sizeable increase in developed land is caused in part by the casinos and related infrastructure, residential, and commercial construction. The development involves large areas of soil disturbance, which destroys archaeological sites.

Previous archaeological and architectural studies along the Mississippi Gulf Coast have documented the destruction caused by natural forces, most notably hurricanes. Standing structures are often the most dramatic and visible witnesses to this destruction. However, prehistoric and historic archaeological sites are also extremely vulnerable. Shell middens, found along the immediate shoreline and within coastal marshes and estuaries, often are flipped and re-deposited by the storm surge and wave action of hurricanes. This effectively destroys much of the value of the sites. Sites such as Indian villages and historic town sites such as those along the bluff on Bay St. Louis can also be destroyed by such wave action. In addition, post storm activities offer many more mechanisms for site destruction. These include clearing of timber by use of skidders and other heavy equipment, debris removal, and reconstruction. The destructiveness of these activities is well documented from the years following hurricane Camille which struck the area in 1969.

Hurricane Katrina has been documented to have destroyed a vast majority of the standing historic properties within Hancock County, and a large number of those within Harrison and Jackson Counties. The size and strength of the storm surge has also undoubtedly had as much destruction on archaeological sites. Post hurricane activities have further impacted the remaining historic properties.

Protection from the immediate and post-effects of hurricanes should be considered as beneficial to cultural resources. While some historic properties may be adversely affected by protection plans, long term prevention of damage should be considered a positive measure for historic properties, in particular standing structures.

2.2.10 Socio-Economics

2.2.10.1 Land-Use and Land Cover

Land-use describes what is practiced, permitted, or planned. Land cover, an increasingly important attribute of land-use, describes what is physically on the ground. It is defined as the type of material that covers the earth's surface at a specific location at a specific time. Land-use is the manner in which human beings use a specific tract of the earth's surface. Land cover can change dramatically in a short period while land use remains the same. A field that had a land cover of wheat in May, for example, might be bare soil in August, though the land use remains agricultural.

In 2000, natural vegetation covered 82% of the three coastal counties. Forest, scrub-shrub/cutover/barren, and emergent wetlands were the predominant natural cover types. Developed land covered about only 8% of the counties. More than half of the developed land was medium-density urban land, 27% was high-density urban land, and the rest was transportation infrastructure (roads, streets, bridges). Impervious surfaces covered approximately 4% of the three-county region. The largest concentrations of developed land were near the coast along Highway 90 and south of Interstate-10.

In 2000, natural cover accounted for 84% of Hancock County's total acreage. Forest, scrub-shrub/cutover/barren, and emergent wetland were the predominant natural cover types. Developed land accounted for 5% of the county, and the rest was primarily transportation infrastructure and high-density urban land. Impervious surfaces covered slightly more than 2% of the county. Most of

Hancock County's developed land is medium-density urban land and is in the coastal areas of Waveland, Clermont Harbor, Lakeshore, and Bay St. Louis south of U.S. Highway 90; the NASA Test Site complex in the western portion of the county; and the area between Interstate-10 and Bay St. Louis.

In 2000, natural vegetation covered 78% of Harrison County. Most of the natural areas were in forest, scrub-shrub/cutover/barren, and emergent wetlands. Developed land acreage accounted for 11% of the total land area. About half of the developed areas were medium-density urban land, and the remainder was either high-density urban land or transportation infrastructure. Impervious surface area covered 5% of the county in 2000. Developed land in Harrison County is primarily concentrated along the coastal strip between Pass Christian and Biloxi, the area straddling U.S. Highway 49 between Gulfport and Interstate-10, just north and west of the intersection of Interstate-10 and U.S. Highway 49, and north of Big Lake and the Back Bay of Biloxi and D'Iberville. Approximately two-thirds of this area is medium-density urban land and one-third is high-density urban land or transportation infrastructure, particularly in the cities of Gulfport and Biloxi.

In 2000, natural cover accounted for 84% of the land in Jackson County. Forest, scrub-shrub/cutover/barren, and emergent wetland were the most abundant natural cover types. Developed land acreage constituted 7% of the county's land area. About half of the developed land acreage was medium-density urban land and the rest was high-density urban land and transportation infrastructure. Impervious surfaces covered 3% of the county. Developed land in the county is primarily concentrated along the coastal strip between Ocean Springs and Pascagoula south of U.S. Highway 90. Most of the high-density urban land is concentrated in Pascagoula.

POST-HURRICANE KATRINA

Hurricane Katrina damaged tens of thousands of acres in Coastal Mississippi. Coastal Mississippi was subjected to intense winds and salt spray affecting hundreds of acres of standing trees, wetlands, and other vegetation and it is still unknown at this point how much will survive. The Mississippi Forestry Commission estimated that 60% of the coastal forests have been lost. The MDMR estimates 2,500 acres of state owned coastal preserve lands have suffered moderate to severe tree damage. Hurricane Katrina completely obliterated a 2-block zone along the entire Mississippi coastal shoreline and severely crippled the area located north to Interstate-10. Tens of thousands of uninhabitable or completely obliterated homes, thousands of small businesses, dozens of schools and public buildings have been ruined and remain unusable still. The highways, arterial roadways, ports, railroads, and water and sewer systems have suffered varying degrees of destruction and some suffered complete destruction.

Plans are being developed to address rebuilding and redevelopment within coastal Mississippi. Governor Haley Barbour introduced a commission focused on redevelopment of coastal Mississippi and several design charettes and public meetings were held in order for smart growth to occur. Destroyed and damaged infrastructure is being reconstructed and business owners and homeowners, through federally funded disaster relief funds, loan programs, and small business loan programs, are beginning reconstruction. Many residents of coastal properties are in the process of rebuilding their homes and some of those have already moved into the residences. Environmental restoration and hurricane protection programs are in initial planning stages, which should result in analysis of potential protection and redevelopment projects. In summary, rebuilding efforts in some areas of coastal Mississippi are quickly in motion while there are still some whole communities that have yet to rebuild.

2.2.10.2 Historic (Pre-Hurricane Katrina) Population Trends

The 1950-2000 population levels and growth for the U.S., Mississippi, the three-county study area, and each county are presented in Table 2-2. During this fifty year period, the population of the three-county study area grew by 186.6 percent. This is 5.6 times the Mississippi percentage

population growth of 33.2 percent and 2.2 times the U.S. percentage population growth of 86.0 percent for the same timeframe. The three-county area accounted for 32.7 percent of the nominal population growth for Mississippi from 1950 to 2000.

Table 2-2
1950-2000 Population Levels and Growth (in thousands)

	U.S.	Mississippi	Study Area	Hancock County	Harrison County	Jackson County
1950	151,326	2,179	127	12	84	31
1960	179,323	2,178	189	14	119	56
1970	203,212	2,217	239	17	134	88
1980	226,546	2,521	301	25	158	118
1990	248,710	2,573	312	32	165	115
2000	281,421	2,903	364	43	190	131
50 Year Nominal Change	130,095	724	237	31	106	100
50 Year Percentage Change	86.0%	33.2%	186.6%	258.3%	126.2%	322.5%

Source: U.S. Census Bureau, 2000 Census

2.2.10.3 Existing (Post-Hurricane Katrina) Socio-economic Conditions

Population: The 2000-2005 population level and growth estimates for the U.S., Mississippi, the three-county study area, and each county are displayed in Table 2-3. The July 1, 2000 to July 1, 2005 timeframe is the most recent before Hurricane Katrina made landfall in late August of 2005. During this five year period, the population of the three-county study area grew by 2.86 percent. This is 1.4 times the Mississippi percentage population growth of 2.10 percent and 0.6 times the U.S. percentage population growth of 5.06 percent. The three-county study area accounted for 17.4 percent of the nominal population growth for Mississippi from 2000-2005. The three-county study area is one of the more densely populated areas in Mississippi. Hancock County has a lower population density than Harrison County or Jackson County.

Table 2-3
2000-2005 Estimates of Population Levels and Growth

	U.S.	Mississippi	Study Area	Hancock County	Harrison County	Jackson County
July 1, 2000	282,216,952	2,848,634	364,863	43,283	189,699	131,881
July 1, 2001	285,226,284	2,856,108	366,362	43,944	189,512	132,906
July 1, 2002	288,125,973	2,863,091	367,498	44,607	189,996	132,895
July 1, 2003	290,796,023	2,874,171	367,790	45,166	189,189	133,435
July 1, 2004	293,638,158	2,892,668	372,885	45,821	192,129	134,935
July 1, 2005	296,507,061	2,908,496	375,304	46,546	193,187	135,571
5 Year Nominal Change	14,290,109	59,862	10,441	3,263	3,488	3,690
5 Year Percentage Change	5.06%	2.10%	2.86%	7.54%	1.84%	2.80%

Source: U.S. Census Bureau, Population Division

The 2000-2004 population changes for the U.S., Mississippi, the three-county study area, each county, and major cities within each county are displayed in Table 2-4. The city with the greatest nominal or percentage population growth in the study area from 2000 to 2004 is Gautier with population growth of 5,172 persons or 44.28 percent.

Table 2-4
2000-2004 Urban Growth and Distribution

	2000	2004	2000-2004 Nominal Change	2000-2004 Percentage Change
U.S.	281,421,906	293,655,404	12,233,498	4.35%
Mississippi	2,844,658	2,902,966	58,308	2.05%
Three-County Area	363,988	373,762	9,774	2.69%
Hancock County	42,967	45,933	2,966	6.90%
Bay Saint Louis	8,209	8,293	84	1.02%
Waveland	6,674	7,120	446	6.68%
Harrison County	189,601	192,393	2,792	1.47%
Biloxi	50,644	50,115	-529	-1.04%
D'Iberville	7,608	7,757	149	1.96%
Gulfport	71,127	71,850	723	1.02%
Long Beach	17,320	17,258	-62	-0.36%
Pass Christian	6,579	6,758	179	2.72%
Jackson County	131,420	135,436	4,016	3.06%
Gautier	11,681	16,853	5,172	44.28%
Ocean Springs	17,225	17,698	473	2.75%
Pascagoula	26,200	25,865	-335	-1.28%

Source: U.S. Census Bureau, Population Division

Racial Distribution: Table 2-5 shows the racial distribution for the U.S., Mississippi, each county in the study area, and also includes the racial distribution for the major cities in each county as of 2000.

Table 2-5
2000 Population Racial Distribution (percent)

	White	Black	Hispanic	Asian	American Indian	Other	Multiple Races
U.S.	75.1	12.3	12.5	3.6	0.9	5.5	2.4
Mississippi	61.4	36.3	1.4	0.7	0.4	0.5	0.7
Hancock County	90.2	6.8	1.8	0.9	0.6	0.3	1.1
Bay Saint Louis	80.2	16.6	1.7	1.1	0.4	0.2	1.4
Diamondhead	95.3	1.8	2.9	0.9	0.4	0.5	1.1
Pearlington	77.6	20.4	1.4	0.1	0.4	0.1	1.4
Shoreline Park	94.6	2.0	1.9	0.3	1.0	0.3	1.7
Waveland	85.4	11.2	2.0	1.5	0.5	0.5	0.9
Harrison County	73.1	21.1	2.6	2.6	0.5	0.9	1.7
Biloxi	71.4	19.0	3.6	5.1	0.5	1.4	2.4
D'Iberville	78.2	11.4	2.6	7.0	0.4	0.9	2.1
Gulfport	62.2	33.5	2.6	1.3	0.4	0.5	1.6
Long Beach	87.5	7.4	2.3	2.6	0.4	0.7	1.4
Pass Christian	65.9	28.2	1.7	3.5	0.6	0.6	1.2
Jackson County	75.4	20.9	2.1	1.6	0.3	0.7	1.1
Escatawpa	80.5	17.6	0.6	0.7	0.3	0.1	0.7
Gautier	68.2	27.7	3.2	1.3	0.5	0.9	1.4
Moss Point	28.0	70.6	1.0	0.2	0.2	0.4	0.6
Ocean Springs	87.7	7.0	2.5	2.6	0.4	0.7	1.5
Pascagoula	67.2	29.0	3.9	1.0	0.2	1.7	1.0

Source: U.S. Census Bureau, 2000 Census

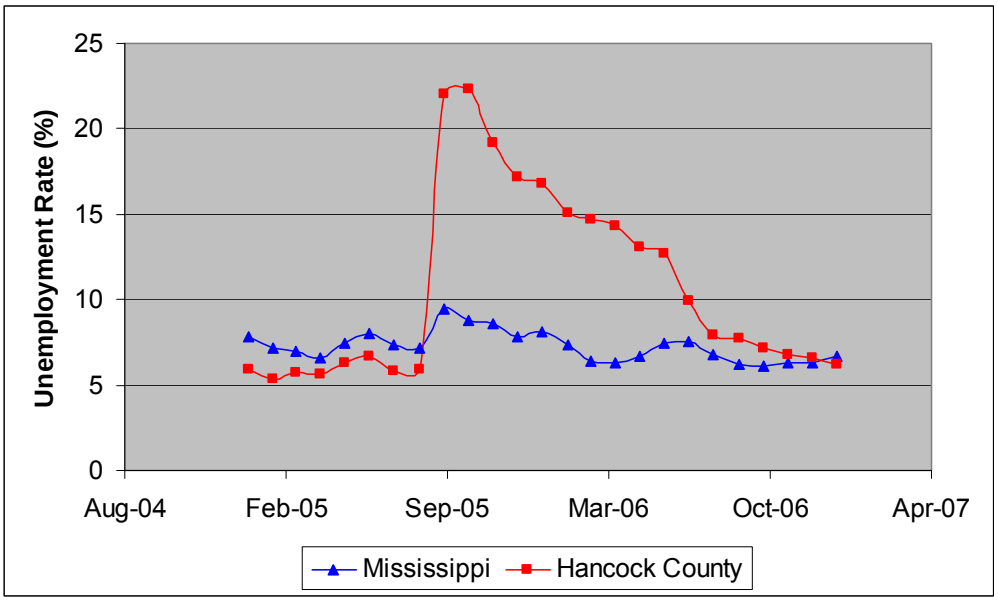
Employment Distribution: The 2002 distribution of employment by major sectors for Mississippi, the three-county study area, and each county is shown in Table 2-6. Approximately 5.4% of Mississippi's Professional and Technical employment could be found in Hancock County in 2002. Hancock County is home to the John C. Stennis Space Center. The Stennis Space Center, with over 4,600 employees is NASA's primary center for rocket propulsion testing. Harrison County is a popular vacation destination for its beaches and casinos. Harrison County accounts for 26.9 percent of Mississippi's employment in the arts and 20.0 percent of Mississippi's employment in food and accommodation services. Jackson County features Pascagoula Harbor. In 2004, 66.7 percent of Mississippi's waterborne commerce volume and 1.3 percent of U.S. volume moved through Pascagoula Harbor. Pascagoula Harbor's annual volume increased 44% from 1986 to 2004. Northrop Grumman Ship Systems' Ingalls Operations, with over 10,000 employees, can also be found in Jackson County. Jackson County accounted for 8.8 percent of Mississippi's employment in manufacturing.

Table 2-6
2002 Employment Distribution by Major Sector

	Mississippi	Study Area	Hancock County	Harrison County	Jackson County
Manufacturing	182,822	21,500	1,000	4,500	16,000
Wholesale	35,316	2,963	251	2,112	600
Retail	135,838	18,698	1,586	11,548	5,564
Real Estate	9,665	1,585	131	1,084	370
Professional & Technical	29,023	5,205	1,555	2,050	1,600
Administration	46,115	5,821	1,280	3,211	1,330
Education	1,678	204	20	100	84
Health & Social Care	131,976	17,549	500	12,429	4,620
Arts	9,292	2,700	100	2,500	100
Food & Accommodation	109,405	27,523	2,114	21,822	3,587
Other Services	22,180	3,558	176	2,067	1,315

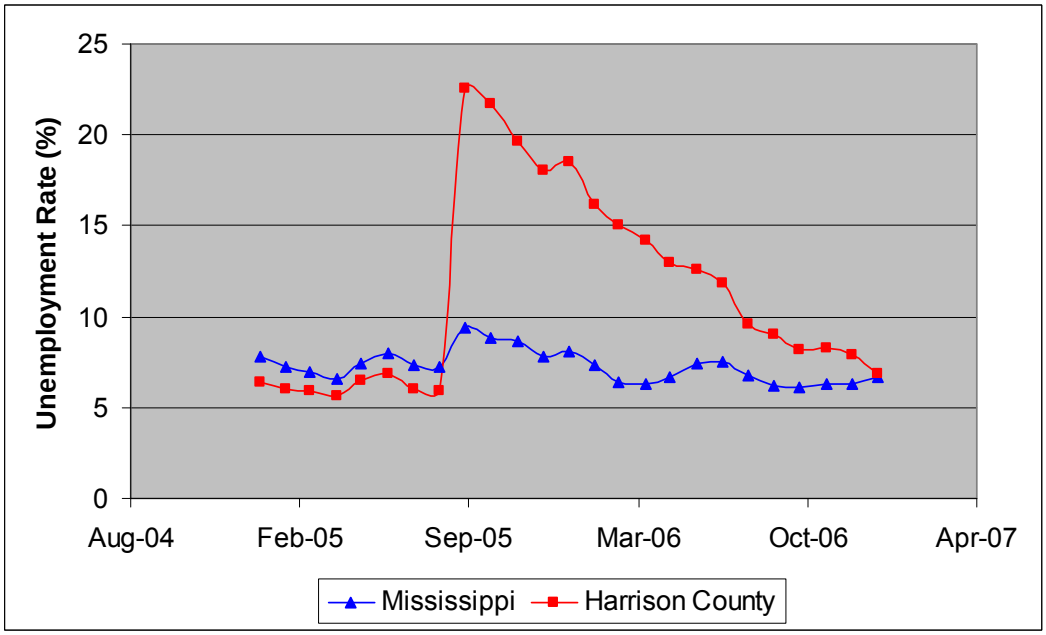
Source: U.S. Census Bureau, 2002 Economic Census

Unemployment: The non-seasonally adjusted unemployment rates for Mississippi and each county in the study area from January 2005 to January 2007 are displayed graphically in Figures 2-3, 2-4, and 2-5. Unemployment rates within the study area increased dramatically following Hurricane Katrina, but have since recovered to roughly pre-Katrina levels.



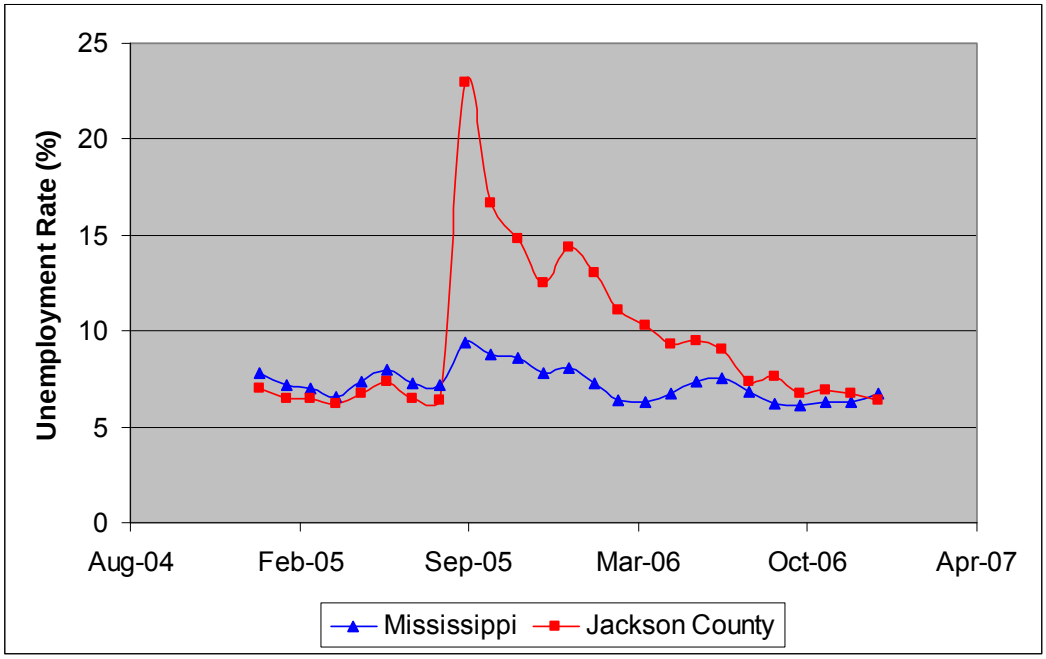
Source: Bureau of Labor Statistics

Figure 2-3
Non-Seasonally Adjusted Unemployment Rates for MS and Hancock County



Source: Bureau of Labor Statistics

Figure 2-4
Non-Seasonally Adjusted Unemployment Rates for MS and Harrison County



Source: Bureau of Labor Statistics

Figure 2-5
Non-Seasonally Adjusted Unemployment Rates for MS and Jackson County

Income and Poverty: Median income and poverty levels for the U.S., Mississippi and each county in the study area for 2004 are displayed in Table 2-7. Each of the three counties in the study area had a higher median income and a lower poverty rate than that of Mississippi in 2004.

Table 2-7
2004 Median Income and Poverty Levels

	Median Income	Nominal Poverty	Poverty Rate
U.S.	$44,334	37,039,804	12.7%
Mississippi	$34,278	549,224	19.3%
Hancock County	$36,285	7,737	16.6%
Harrison County	$35,576	31,809	16.9%
Jackson County	$40,418	20,256	15.0%

Source: U.S. Census Bureau, Small Area Income & Poverty Estimates

2.2.11 Transportation

The Mississippi Gulf Coast has two deep draft harbors, Gulfport and Pascagoula, and many other shallow draft channels, such as Pass Christian and Biloxi. Although there are some smaller airports throughout coastal Mississippi, the Gulfport-Biloxi International Airport is the only passenger airport accepting major commercial airlines. Stennis International Airport, located 8 miles north of Bay St. Louis, is used by NASA. The Mississippi Gulf Coast is served by three (3) railroads including two Class I railroads. These railroads are CSX Transportation Railroad, Kansas City Southern (KCS) Railroad, and Port Bienville Railroad. CSX is a Class I railroad serving the developed portion of the Mississippi Coastal Area. Its main lines traverse most of the region's municipalities. The 94-mile CSX track has an east-west orientation and serves as a major connection between the deepwater ports in New Orleans and Mobile. KCS Railroad is the second Class I railroad serving the study region. Its main line has a north-south orientation extending approximately 69 miles northward from the Port of Gulfport through Harrison, Stone, and Forrest (Forest) (Forest) Counties. The Port Bienville Shortline Railroad is a Class III railroad with 9 miles of track owned and operated by the Hancock County Port and Harbor Commission. It serves the Port Bienville Industrial Park and connects with the CSX southwest of Waveland.

2.2.12 Community Infrastructure and Municipal Services

This analysis considers the state of infrastructure as they currently exist, post-Katrina. The geographical region evaluated for utilities encompasses coastal Mississippi, which includes Hancock, Harrison, and Jackson Counties.

2.2.12.1 Water Supply

Approximately 88 community water systems provide potable water to the tri-county area of the Mississippi Gulf Coast. The water they provide is available for residential, commercial, industrial, and agricultural use, including landscape irrigation, and it is delivered by a system of wells, water distribution piping, and water storage tanks that together make up the water supply infrastructure of coastal Mississippi. All of these systems rely on groundwater as their sole source of supply for drinking water, although in Jackson County surface water is used for industrial end use. The inland portions of the three-county region are largely without public water systems. Throughout the entire state of Mississippi, increased pumping rates has altered the natural groundwater flow direction. The natural groundwater flow direction is from the groundwater to the streams and rivers. As the water tables have fallen, the flow direction has reversed, with water from the rivers and streams recharging the groundwater.

2.2.12.2 Waste Water

In coastal Mississippi's three counties, 49.5 percent of Hancock County, 18.9 percent of Harrison County, and 27.0 percent of Jackson County do not have access to a public wastewater system. Those who are not connected to a public wastewater system employ on-site treatment, which consists of either package plants or septic tanks/drain fields. Package plants are small, self-contained wastewater treatment facilities built to serve a developed area, such as a subdivision or a school. Septic tanks and drain fields, typically installed at individual households, collect wastewater in an underground tank and slowly release the treated water to a drain field where it is absorbed and filtered by the surrounding soil (USACE, Mobile District, 2000).

The wastewater treatment facilities in the Three-County Region treat more than 45 million gallons of wastewater each day. Hancock County treatment facilities treat approximately 3.00 million gallons per day (MGD), Harrison County facilities treat 29.3 MGD, and Jackson County facilities, including Pascagoula and Escatawpa, treat 12.0 MGD (Peterson, 1999).

2.2.12.3 Storm Water

The City of Biloxi uses a variety of management techniques and systems to control storm water. The city requires developers to install storm water drainage facilities designed to control runoff quantity, but does not require specific storm water quality control measures (USACE, Mobile District, 2000). Storm water from Biloxi is discharged into two surface water sources—the Back Bay of Biloxi and the Mississippi Sound. There are four major runoff areas in the city: in East Biloxi, the storm water runoff flows south from Howard Avenue to the Mississippi Sound; in West Biloxi, south of Pass Road, the runoff flows south to the Mississippi Sound; in West Biloxi, north of Pass Road, the runoff flows south to the Back Bay of Biloxi; and in North Biloxi, the storm water drains south to the Back Bay of Biloxi (USACE, Mobile District, 2000).

The City of Gulfport's storm water drainage system has endured numerous problems during the past few years, as parts of the city, particularly in the Orange Grove area, have experienced both street and house flooding. Numerous improvement projects in the last few years have eliminated the house flooding problem, but the street flooding remains. The city has developed a storm drainage master plan that addresses the needs to eliminate any storm water-related flooding in the Gulfport and Orange Grove areas.

Jackson County and each municipality within the county have adopted a storm water plan that addresses the capabilities and requirements of the various storm water systems. In February 2003, Jackson County submitted a Phase II Storm Water Program to the EPA that addressed the following issues: a) General non-point source pollution; b) Raw sewage; c) Solid waste dumping; d) Illegal disposal of wastes; e) Lack of erosion and sediment controls; and f) Impaired water bodies and TMDL programs.

The Storm Water Program includes procedures to provide public education, public involvement, illicit discharges detection and elimination, construction site runoff controls, post-construction runoff controls, and pollution prevention/good housekeeping.

2.2.12.4 Solid Waste Disposal and Collection System

The State of Mississippi regulates three categories of non-hazardous solid waste landfills: Municipal Solid Waste Landfills that receive household waste and other types of Subtitle D material, such as commercial and industrial solid waste and non-hazardous sludge; Class I Rubbish Sites that accept construction and demolition (C&D) debris, brick, concrete, asphalt, natural vegetation, furniture, sawdust and wood shavings, plastic, and metal; and Class II Rubbish Sites that accept natural vegetation, brick, concrete, and asphalt (USACE, Mobile District, 2000). Permitting for a solid waste facility is handled by the MDEQ Permitting Board.

There is one permitted municipal solid waste landfill in the Three-County Region and seven Class I rubbish sites for construction-related waste. The Pecan Grove Landfill and Recycling Center, operated by Waste Management, Inc., receives approximately 90 percent of the total solid waste stream produced in the three coastal counties. The landfill is located in Pass Christian.

3 PLAN FORMULATION (ALTERNATIVES AND PLANS*)

3.3 Introduction

The MsCIP applied the six step planning process described in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G, 1983). This planning process is more fully specified in Corps of Engineers' Engineering Regulation ER 1105-2-100 (the Planning Guidance Notebook, 22 April 2000).

The comprehensive nature of the congressional authorization was interpreted as a mandate to assess all aspects of storm related risk reduction measures including storm damage reduction, erosion reduction, ecosystem restoration, and saltwater intrusion in coastal Mississippi. Additionally, the study language specifically directed that the report "will recommend cost-effective projects", and furthermore, that the report "shall not perform an incremental benefit-cost analysis...and shall not make project recommendations based on maximizing net national economic development [NED] benefits". In response to the direction by Congress to develop a Comprehensive Plan, plan formulation was conducted from a "big picture" perspective which included consideration of many broad scale conceptual approaches to the identified problems and opportunities. The tentatively selected features resulting from this planning effort constitute a Comprehensive Plan containing a combination of programmatic ecosystem restoration features, programmatic storm damage reduction features, and a number of large and small scale tentatively selected plans that could be implemented immediately.

This Plan Formulation section of the report presents the results of extensive public outreach to stakeholders and residents used to identify problems and opportunities and to identify measures which would be appropriate for implementation in coastal Mississippi. This section of the report presents summaries of detailed technical information used in

- the analysis of existing and future without-project conditions,
- the development of problem-solving measures, and
- used in the analysis, evaluation, comparison, screening, and selection of alternative plans.

The selected plans resulting from the plan formulation process are presented as tentatively-selected recommendations. These tentatively-selected recommendations include recommended immediate actions and projects that would assist in the recovery of the physical and human environments, and recommended further studies and longer term programmatic actions required of a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

As mentioned above, the MsCIP team used the Corps planning process. This is compliant with the NEPA study process which compares and contrasts measures and alternatives for a full range of anticipated impacts and effects. The Corps planning guidance requires that impacts and effects be evaluated in a "System of Accounts" framework. The four evaluation accounts were established by the Principles and Guidelines (1983) to facilitate evaluation and display of effects of alternative plans. EC 1105-2-409, Planning in a Collaborative Environment (31 May 2005) also reemphasized the use of the four accounts in conducting Corps water resource feasibility studies as a means of ensuring that Federal water resources projects are planned and implemented in a collaborative manner with other Federal, state and local programs. Other information that is required by law or that will have a material bearing on the decision making process has been included in the accounts to organize information on effects. Briefly, the categories of effect considered under each of the four accounts include the following:

(a) The National Economic Development (NED) account displays changes in the economic value of the national output of goods and services.

(b) The Environmental Quality (EQ) account displays non-monetary effects on significant natural and cultural resources

(c) The Regional Economic Development (RED) account registers changes in the distribution of regional economic activity that result from each alternative plan. Evaluations of regional effects focus on plan induced changes in regional income, employment, output and population.

(d) The Other Social Effects (OSE) account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts. Examples of effects categorized under the OSE account include: urban and community impacts; life, health, and safety factors; displacement; long-term productivity; and energy requirements and energy conservation.

Hurricane Katrina's disastrous impact upon the Gulf Coast served as a very sobering wakeup call for how the nation has prepared for natural disasters and where we have accepted risk. As a result, the Corps has developed a set of "12 Actions for Change" that it now focuses on to transform its priorities, processes and planning practices. These actions will be used to guide the Corps' ongoing and future work, and ensure that the organization is adaptable, flexible and responsive to the needs of the nation.

The "12 Actions for Change" fall within three overarching themes: Effectively implement a comprehensive systems approach; communication; and reliable public service professionalism. The actions are grouped as follows:

Effectively Implement a Comprehensive Systems Approach: Comprehensively design, construct, maintain and update engineered systems to be more robust, with full stakeholder participation.

1. Employ integrated, comprehensive and systems-based approach
2. Employ risk-based concepts in planning, design, construction, operations, and major maintenance
3. Continuously reassess and update policy for program development, planning guidance, design and construction standards
4. Employ dynamic independent review
5. Employ adaptive planning and engineering systems
6. Focus on sustainability
7. Review and inspect completed works
8. Assess and modify organizational behavior

Communication: Effective and transparent communication with the public, and within the Corps, about risk and reliability.

9. Effectively communicate risk
10. Establish public involvement risk reduction strategies

Reliable Public Service Professionalism: Improve the state of the art and the Corps' dedication to a competent, capable workforce on a continuing basis. Make the commitment to being a "learning organization" a reality.

11. Manage and enhance technical expertise and professionalism
12. Invest in research

Among the investigative teams that contributed to the development of the "12 Actions for Change" through their analysis in the aftermath of hurricanes Katrina and Rita were the Corps-commissioned Interagency Performance Evaluation Task Force, the American Society of Civil Engineers, the National Science Foundation-sponsored team led by UC-Berkeley, and Louisiana State University.

Hurricane Katrina demonstrated the need to be prepared and ready to broadly integrate the Corps' many mission capabilities. The '12 Actions for Change' provide a common organizational framework to help meet that objective.

The MsCIP study team embraced these actions throughout the planning process. The study team used a systems-based approach to develop comprehensive plans that were integrated across Corps' mission areas, as well as other local, state, and Federal agency projects and programs. The MsCIP also reassessed and sought policy changes to accommodate the never before seen devastation along the Mississippi Gulf Coast, and used a very dynamic independent and external review process. Alternatives were developed using adaptive planning and engineering systems and focused on sustainability of the environment and communities along the coast.

The organization of the MsCIP team allowed for flexibility across the traditional Corps' hierarchy, as well as incorporating team members from other agencies. This cooperative atmosphere created an organizational behavior allowing team members to focus on innovative and effective solutions to the problems with which they were tasked.

The MsCIP also developed and employed risk-based concepts which engaged stakeholders and allowed for informed decision making. The MsCIP planning process made extensive use of public and agency involvement, which introduced ideas, provided feedback, and gave first-hand accounts of the damages suffered as a result of the disaster. In an effort to demonstrate reliable public service professionalism, the public, state and local government input received at public workshops was also used to identify the degree of importance placed on environmental issues and to give indication of the likely Locally-Preferred Plans, should those be pursued as options to more cost-effective tentatively selected plan features, consistent with Federal guidelines.

Finally, the results of the planning process (as expressed in the Systems of Accounts tables):

- identify cost-effective solutions,
- provide the best choices based on an extensive set of criteria, and
- identify the trade-offs made during the evaluation of alternatives.

The System of Accounts tables present the culmination of technical analyses, public input, and systematic evaluation. The selected alternatives stand out in their ability to fulfill the Congressional authorization and the needs of the nation.

3.3.1 The Federal Planning Process - Overview

Plan formulation for the Comprehensive Plan employed the six step planning process discussed in Corps of Engineers' Engineering Regulation 1105-2-100 (also known as the "Planning Guidance Notebook"). The six step planning process employed in the development of the Comprehensive Plan is displayed in Figure 3-1.

One departure from the traditional six step process was specifically directed by Congress for the MsCIP Comprehensive Plan:

"…Provided further, that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall

not make project recommendations based upon maximizing net national economic development benefits…"

As a result, Steps 4, 5, and 6 employed cost effectiveness, rather than benefit-cost analysis, as the measure of economic effectiveness of alternative plans. Also, final plan selection was not subject to the limitation of recommending the NED plan without a specific waiver from the Secretary of the Army.

Steps in the plan formulation process include:

1. The specific problems and opportunities to be addressed in the study are identified, and the causes of the problems are discussed and documented. Planning goals are set, objectives are established, and constraints are identified.

2. Existing and future without-project conditions are identified, analyzed and forecast. The existing condition resources, problems, and opportunities critical to plan formulation, impact assessment, and evaluation are characterized and documented.

3. The study team formulates alternative plans that address the planning objectives. A range of alternative plans are identified at the beginning of the planning process and screened and refined in subsequent iterations throughout the planning process.

4. Alternative project plans are evaluated for effectiveness, efficiency, completeness, and acceptability. The impacts of alternative plans will be evaluated using the system of accounts framework (NED, EQ, RED, OSE) specified in the Principles and Guidelines and ER 1105-2-100.

5. Alternative plans will be compared. Contributions to National Economic Development (NED) will be used to prioritize and rank alternatives. The public involvement program will be used to obtain public input to the alternative identification and evaluation process.

6. A plan will be selected for recommendation, and a justification for plan selection will be prepared.

The Planning Guidance Notebook (ER 1105-2-100, dated 22 April 2000) states that "water and related land resources project plans shall be formulated to alleviate problems and take advantage of opportunities in ways that contribute to study planning objectives and, consequently, to the Federal objective" (page 2-1). Unlike traditional Corps planning reports, which are required to recommend only the project that maximizes net economic benefits (the Federal objective), this study was guided by unique authorizing language, that included the mandates that the study analysis, "…*shall not perform an incremental benefit-cost analysis...and shall* not *make project recommendations based on maximizing net national economic development* [NED] *benefits*..", but "*...shall recommend a cost-effective project*...". Cost-effectiveness is determined by comparison of estimated implementation costs to the level of benefits each alternative would provide.

Plan formulation has been conducted for this Feasibility Study with a focus on achieving the Congressional mandate to recommend a cost effective project consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. NED benefits were calculated and used in the cost-effectiveness analysis where appropriate, for example in the evaluation of damage reduction measures. Plan formulation also considered all effects, beneficial or adverse, to each of the four evaluation accounts identified in the Principles and Guidelines (1983): NED, EQ, RED and OSE.

3.3.2 The MsCIP Comprehensive Plan – The Planning Process

The USACE has taken a ***system wide*** approach in formulating the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan to ensure that both the MsCIP and the Louisiana Coastal Protection and Restoration (LaCPR) efforts are fully coordinated and develop complementary plans for the restoration of the U.S. Gulf coastal region ***as an integrated system***.

In addition, the planning effort has taken a "top down" ***comprehensive planning*** approach, beginning with development of a Comprehensive Plan to address the overall water resources problems and opportunities of the region. Building off of the comprehensive identification of problems and opportunities, the planning effort then proceeded to develop site specific problems, opportunities and solutions that contribute to accomplishing the ***Comprehensive Vision*** for the restoration and protection of the Mississippi Gulf Coast. The results of this effort are presented in this report and include a comprehensive regional plan that addresses hurricane and storm damage reduction and environmental restoration needs, as well as recommending a variety of site specific projects for either for immediate implementation or for further investigation and subsequent implementation.

This draft Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Report and Integrated Environmental Impact contains both a Comprehensive Plan and a variety of water resource development projects that were developed through the comprehensive planning process. The Report also contains options for additional study for those components of the Comprehensive Plan which require additional investigations prior to identifying a specific recommendation for construction.

The planning process utilized in the MsCIP study was a highly iterative process. Multiple iterations of the six planning steps were required due to the fact that new problems or data were constantly being identified during the planning process as feasibility level investigations were conducted. Additionally, the development of large scale plans, such as "Lines of Defense" (LOD), brought new problems and opportunities to light, which needed to be included into the planning process.

The following is an outline providing additional details of the MsCIP planning process (*with sub-steps or iterative steps italicized*). Figure 3-1, which graphically depicts the process, was used at public meetings. The traditional Corps' planning process was supplemented with tasks that allow for the consideration of the stakeholders acceptability of risk in evaluating and comparing measures or alternative plans. This can be seen in steps 5 e-g below and in the figure on the following page.

1) Identify Problems and Opportunities
    a. *Further refine Problems and Opportunities as new information becomes available*
    b. Identify Constraints
        i. *Further refine Constraints as new information becomes available*
2) Inventory and Forecast Resources
    a. *including multiple Future Without-Project Scenarios to account for uncertainty in future development and sea level rise*
3) Preliminary Measures Developed for Each Problem Area
    a. *followed in later iterations by formulation of true alternative plans*
4) Evaluation of Effects of Measures
    a. *followed in later iterations by Alternative Plans*
5) Comparison of Measures
    a. followed in later iterations by comparison of Alternatives

b. Measure Screening by Traditional Initial Screening Criteria - Technical, Environmental and Economic Feasibility

i. followed in successive iterations by screening by progressively more rigorous criteria

c. Refinement of Measures - Employs Data at Higher Level of Detail

d. Development of evaluation metrics, units of measure, etc.

e. "Weighting" of evaluation metrics by residents of coastal Mississippi

f. Risk-Informed Decision-Making with Refined Data

g. *Presentation of measure and/or alternative plans, including benefits, costs, risks and consequences to decision-making population*

6) Selection and Presentation of Tentatively Selected Plans.

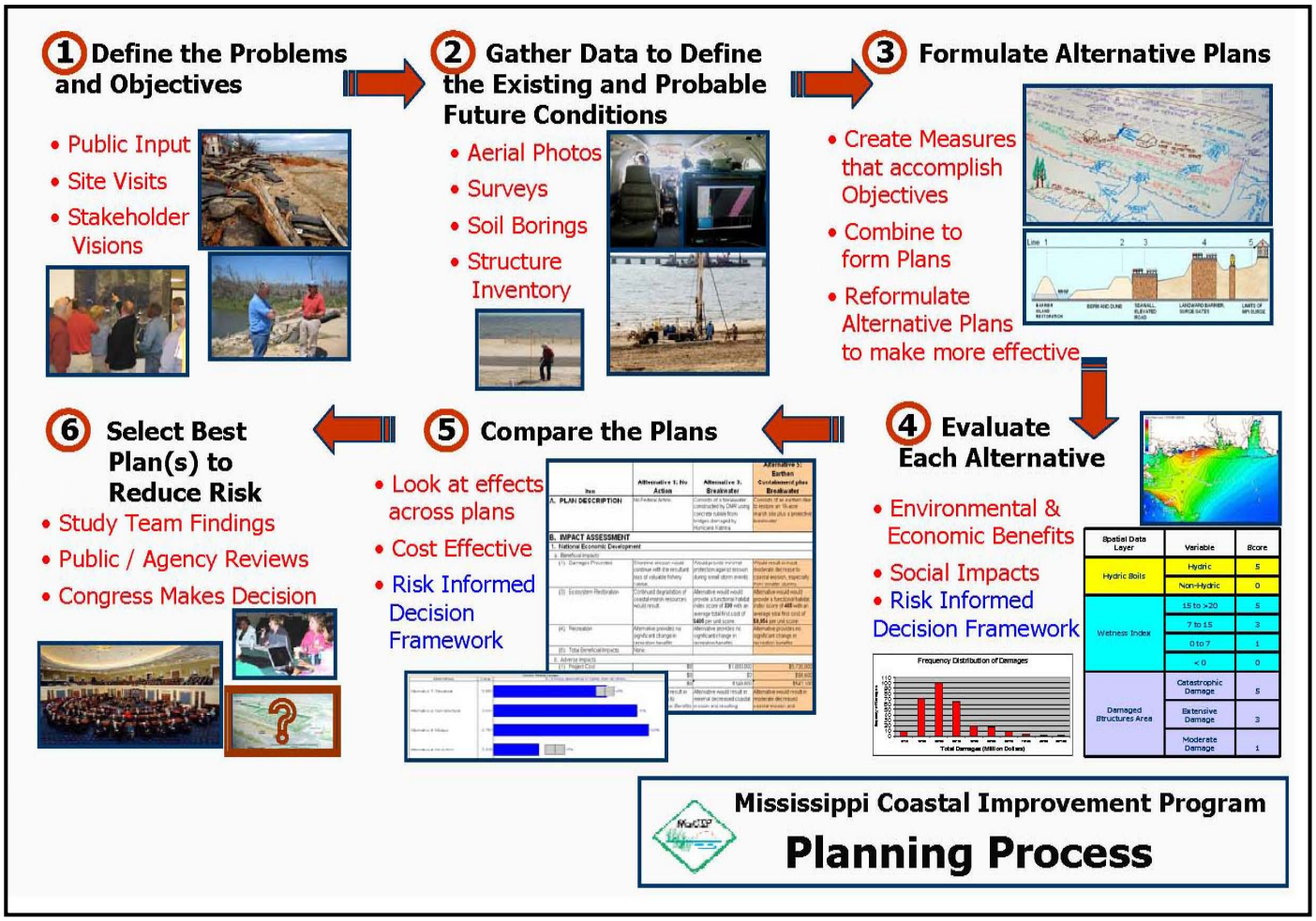


Figure 3-1
MsCIP Planning Process

The planning process depicted in Figure 3-1 is described in this chapter through a series of discussions concerning measures, preliminary alternatives, and final alternatives. Measures are the building blocks of alternatives. Preliminary alternatives which meet the planning criteria are developed further into final alternatives. Recommendations are selected from the list of final alternatives. Measures, preliminary alternatives, and final alternatives each go through a process of

development, evaluation, comparison, and screening (or selection in the case of final alternatives). In the following sections, the development, evaluation, comparison, and screening of measures is discussed in sections 3.6 through 3.9. Preliminary alternatives are developed, evaluated, compared, and screened in sections 3.11 through 3.14. Final alternatives are developed, evaluated, and compared in sections 3.15 through 3.18. The selection of recommended alternatives is presented in section 3.20.

3.3.3 Addressing Risk and Uncertainty

The MsCIP team used standard conventions and definitions used in risk assessment, although some leeway was incorporated into the overall use of risk terminology, due to the on-going use of certain terms, such as "risk", in ways that are much broader than those in the risk assessment arena might use them. The broadest use of the term "Risk", as used in the MsCIP study, could be characterized as the potential for negative outcomes, under certain action and no-action conditions, both now and in the future. The public uses this term to refer to their own personal risks, be it risks to their health, income, residences, cultural integrity, or community, and thus, the MsCIP team had to adopt this convention. The MsCIP team also had to similarly use this term to characterize risks of environmental outcomes, such as functional damage to ecosystems, loss of species (or multiple species) integrity and survival, and many other negative outcomes. Because the public and stakeholders had to understand the nature of their risks and potential consequences for a large range of possible future conditions that by their nature were, in many cases, only qualitatively defined, the use of "risk" in this broader framework was by necessity, adopted.

"Risk ", in a narrower definition also used in the MsCIP study, could be defined as the probability of a certain outcome, under certain conditions. An example of this would be the probability (5% in any given year, for example) of a certain damage level, expressed in dollars ($10,000,000, for example), occurring in the event of a certain-sized hurricane-caused surge and wave depth and extent event. This could be expressed both as a probability of a certain outcome given a certain event, but can also be expressed as a sum of damages expected under a range of events, such as an average of all damages expected, over a time horizon such as fifty years, were nothing to be done to prevent those damages.

Risk, or the probability of certain events or outcomes, was more readily defined for some type of outcomes, such as hurricane-caused surge and wave depth, than for other types of outcomes, such as human reactions, or the number of deaths caused, by an oncoming hurricane. For some factors, probabilities were defined quantitatively; in many other cases, they could only be estimated qualitatively, as a range of possible outcomes.

In addition to addressing risk and uncertainty in the technical analyses conducted for this Feasibility Study the MsCIP planning process incorporated three additional aspects of risk and uncertainty:

- stakeholder weighting of potential negative consequences of planning measures;
- alternative projections of post-Katrina re-development; and
- alternative projections of future sea-level rise.

Please see the Risk Appendix, for more information on how the MsCIP team incorporated risk into the planning process.

3.3.3.1 Stakeholder Weighting of Consequences

The Corps' Engineering and Research Development Center (ERDC) developed an evaluation tool for the MsCIP team to address public preferences concerning potential negative consequences of alternatives. The evaluation tool was developed through "weighing-in" of the public and agency personnel preferences, which reflected the factors most important to them, in deciding what might be

done to address identified problems. Most notable among these potential negative consequences were impacts to population, environmental recovery and preservation, cultural, aesthetic and historic resources, and other factors. The evaluation tool is often referred to as the Risk-Informed Decision Framework (RIDF), and is described in detail in the RIDF Appendix.

3.3.3.2 Accommodating Uncertainty in Future Re-Development Through Scenario Testing

Given the magnitude of the long-term rebuilding effort in Hancock, Harrison, and Jackson Counties, two re-development scenarios were identified. The first scenario assumes the full redevelopment of structures as existed pre-Hurricane Katrina to exactly what they were before the storm (i.e. if a structure was a residence before it will rebuild as a residence, a condominium will rebuild as a condominium, etc.). The second scenario also assumes full re-development of the study area to its pre-Katrina levels, with the exception that commercial and multi-unit housing development would dominate the coastline. This scenario is based on observations of re-building efforts in other counties and states along the Gulf Coast and Florida Panhandle following Hurricane Ivan in 2004. Those re-development efforts suggest that a large portion of the beach front areas may re-develop to condominium structures. In addition to condominiums, Mississippi law has changed since hurricane Katrina, now allowing for casinos to be built within 100 feet of the Mississippi Sound (with certain restrictions).

3.3.3.3 Accommodating Uncertainty in Future Sea Level Rise Through Scenario Testing

Analysis of historical data suggests a relative sea level rise of approximately nine inches along the Mississippi coast during the 20th century. Relative sea level rise is what an observer standing on the shoreline over a long period would observe, which includes the combined effects of land subsidence (or uplift) and the rise of sea level in and of itself. For the last twenty five years, the climate change community has also been arguing that sea level rise will accelerate in the 21st century, though to date, there is no clear confirmation that acceleration is actually taking place.

It is important to recognize that sea level has been rising, and it's prudent (and required by USACE regulations) to recognize the uncertainties inherent in sea-level rise projections. Given the long term nature of this phenomenon, future sea level rise was projected over a 100-year period. However, because the period of analysis specified by ER 1105-2-100 for Corps water resource projects of this type is 50-years, two alternative future without project condition scenarios were developed based on potential sea level rise conditions over a 50 year time period:

- expected (i.e. moderate, or 'central value') relative sea level rise of about 2 feet; and
- high relative sea level rise of about 3.4 feet.

3.3.3.4 Most Probable Future Scenario

Numerous outputs are examined according to these alternative scenarios, including equivalent annual damages, damages reduced, and the annual probability of a surge level being exceeded.

Overall, six alternative without-project condition scenarios were developed to address the uncertainty concerning coastal redevelopment in Mississippi and future sea level rise:

- Scenario 1 is a residential redevelopment with no relative sea level rise over the 50-year period of analysis.
- Scenario 2 is a mixed residential and commercial redevelopment with no relative sea level rise,

- Scenario 3 is a residential redevelopment with a maximum relative sea level rise depending on location of 2.0-feet over the period of analysis,
- Scenario 4 is a mixed residential and commercial redevelopment and a maximum relative sea level rise of a 2.0-foot,
- Scenario 5 is a residential redevelopment with a relative sea level rise depending on location of 3.4-feet, and
- Scenario 6 is a mixed residential and commercial redevelopment with a maximum relative sea level rise depending on location of 3.4-feet.

Extensive analysis was conducted on the six future without-project scenarios. This analysis is documented in the Economics and Engineering Appendices. The result of the analysis is that future without-project Scenario 3 is the most probable without-project future condition. The combination of pre-Hurricane Katrina redevelopment with a moderate sea-level rise of 2.0 feet was determined to be adequate for reporting and communicating the impacts of the comprehensive plan components being tentatively recommended for construction. The remainder of this document is based on the most probable future scenario, which is Scenario 3.

3.4 Identifying Problems and Opportunities

The first step in the Federal water resources planning process is the identification of problems and opportunities. Problems are the undesirable, negative conditions that will be addressed by the planning study. Opportunities express the desirable conditions that could be achieved in the future. The identification of problems and opportunities for the MsCIP employed a “top down” approach, beginning with identifying comprehensive problems and opportunities at the system wide level. Once this was accomplished, the study team, with input from the interested public, used these system wide problems and opportunities as an organizing principle to identify and define site specific problems and opportunities throughout the study area.

Input on identifying problems and opportunities, were solicited from, and then discussed, with members of the public, state, local, and other Federal agencies, representatives of industry and commerce, and resource agencies concerned with study area resources, at the series of open meetings, at individual meetings, and through other open forums. The meetings also included web-casts intended on reaching those that could not physically attend one of the in-field meetings.

3.4.1 Public and Agency Involvement

Public and agency involvement was integral to the planning process. The Corps’ first step in the planning process was to canvass local residents of Hancock, Harrison, and Jackson counties to understand the needs and perspective of the local population. Canvassing was followed by presentations, workshops, and focus groups which provided input into identifying problems and opportunities, and later helped to guide the formulation and selection of measures, alternatives, and plans. Exhibit 3-1 presents a synopsis public and agency involvement in the planning process.

Exhibit 3-1

- Teams canvassed 3 counties – talked to local residents
- Public Input sessions – 194 problems/opportunities
- Local Government Presentation sessions – presentation of preliminary measures
- Regional Coordination meetings
    - Broke out into focus groups based on interest
    - Follow-up focus groups, conference calls, web-cast, emails
- ERDC support in development of multi-criteria decision analysis method
- Multi-criteria decision analysis
    - Assessed variety of options
    - Developed a spreadsheet based method
    - First round Stakeholder Group meetings to refine definitions and prioritize evaluation metrics
        - Groups identified by interest
            - Fed agencies
            - State and local agencies
            - Business leader
            - NGO's
            - Possible other
    - Second round Stakeholder Group meetings
        - Further refinement of metrics
            - Testing understanding and usability by the stakeholders
            - Introduction of weighting of measures
    - Third round Stakeholder Group meeting
        - Presentation of table so that stakeholders could see application of metrics to actual measures
            - Cluster analysis identified how weights were grouped
            - Weights, which indicate stakeholder preferences, were summed by group to be used in plan selection

3.4.2 Problems

The plan formulation process began during the Interim Phase of the study, with development of a comprehensive list of problem areas. These are documented in the Coastal Mississippi Interim Report. Each of the system wide problems identified were related to one of the five comprehensive areas of: a) hurricane storm damage, b) coastal zone erosion, c) damage to fish and wildlife resources, d) saltwater intrusion, and e) other water related resource issues, which are described in more detail in the following sections.

3.4.2.1 Hurricane Storm Damage Problems

Hurricane and storm damage was a system wide problem for the three county MsCIP study area. These system wide problems were identified and described in numbers 1 through 5 and are a function, or aggregate, of more localized problems throughout the study area, which are depicted in numbers 6 and 7. In order to identify the problems associated to more site specific areas, the three county MsCIP study area was delineated into 54 planning sub-units which are depicted in Figure 3-

2. The 54 planning sub-units were created based on hydrodynamic and economic characteristics. They represent areas to which localized hurricane storm surge problems are reasonably consistent throughout. For a detailed explanation of the planning sub-units see the Economic Appendix.

Hurricane-induced storm surge damage includes:

- Over 238 deaths and other serious injury to human health and safety within the three-county (Hancock, Harrison, and Jackson) MsCIP study area,
- Significant damage (50-percent or more destroyed) to over 32,000 structures and their contents within the three-county (Hancock, Harrison, and Jackson) MsCIP study area;
- Moderate to minimal damage to an additional 25,000 to 30,000 structures and their contents within the three-county (Hancock, Harrison, and Jackson) MsCIP study area;
- Damage to business and industry resulting in a significant loss to regional output within the three-county (Hancock, Harrison, and Jackson) MsCIP study area;
- Significant increase in the unemployment to well over twenty-percent within the three-county (Hancock, Harrison, and Jackson) MsCIP study area;
- Significant damage to structures in planning sub-units 1, 2, 3, 4, 5, 6, 7 and 38 in Hancock County…planning sub-units 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, and 39 in Harrison County…planning sub-units 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 51, 52, 53, and 54 in Jackson County;
- Significant damage to public infrastructure in the population centers of Pearlington (sub-unit 6) , Bay St. Louis (sub-unit 2), Long Beach (sub-units 8, 9, and 10), Gulf Port (sub-units 11, 12, 13, 14, and 15), Biloxi (sub-units 16, 17, 18, and 20), Ocean Springs (sub-units 21 and 22) , Belle Fontaine (sub-unit 26), Gulf Park Estates (sub-unit 27), Pascagoula (sub-unit 52), and Moss Point sub-unit 51) as well as other more rural areas.

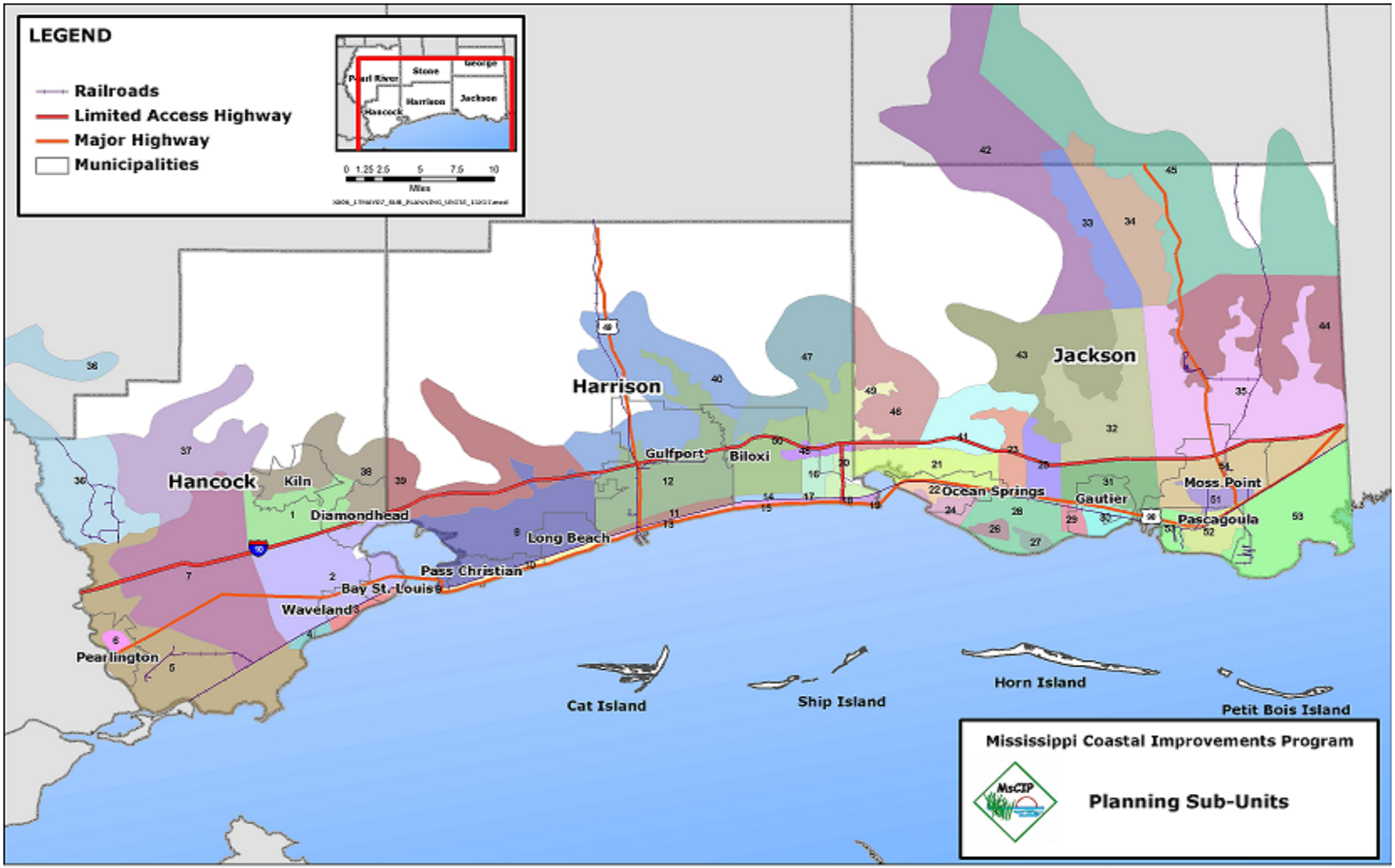


Figure 3-2. Planning sub-units and municipalities for the MsCIP Study area.

3.4.2.2 Coastal Zone Erosion

Hurricanes have induced erosion of coastal wetlands and coastal infrastructure within the three county study area, including:

- Mississippi Sound seagrass habitat loss, which coincides with areas where rapid coastal erosion and massive long-term movement of sand have occurred;
- The Belle Fontaine natural beach and dune system, located along in the central portion of Coastal Mississippi, which is the only natural beach remaining, has experienced severe erosion to a point that it is virtually non-existent; and
- Hurricane Katrina completely submerged the entire barrier island chain, segmenting several of the islands and causing significant erosion

3.4.2.3 Damage to Fish and Wildlife

Hurricane-induced storm surge caused significant damage to coastal ecosystems and fish and wildlife resources within the three-county study area. For example, in coastal wetland preserves and areas identified in the State's wetland restoration initiative the storm surge removed large areas of vegetation in some areas and other areas were filled in with sediment and debris. The sites that had the vegetation removed experienced extensive exotic vegetation propagation, which has out-competed native species. Prior to the hurricane these sites provided valuable habitat, which has now been severely degraded by exotic species. Sites destroyed by hurricane distributed debris and sediment were found then to be either completely covered by thick debris fields, or to have been filled in with sediment to elevations not suitable for re-colonization of native species.

Coastal wetland preserve and state wetland initiative areas which have been severely degraded by hurricane-induced storm surge include Wachovia (1200 acres), Ansley (900 acres), LaFrances (45 acres), Gulf Island National Seashore (Petit Bois, Horn, Ship and Cat Islands in Jackson, Harrison and Hancock Counties) (7000 acres), Dantzler (900 acres), Admiral Island (123 acres), Deer Island (450 acres), DuPont (650 acres), and Pascagoula River Marsh (11,500 acres).

Specific examples of ecosystem damage include:

- Admiral Island (123 acres) Extensive debris fields washed in from Bayou Lacroix during Hurricane Katrina. Approximately 10 acres are covered in a mat of crushed houses, boats, and other debris.
- Wachovia (1200 acres) experienced significant marsh debris and scour from storm surge. However, the scoured areas appear to be forming high quality open-water habitat evident by a high level of dragon fly activity and breeding. The debris is predominantly natural material, mostly the marsh "rolled up" from the scoured areas. Much of the remainder of the tract is forest and savannah, which has suffered wind damage in the form of downed trees and vegetation. This has increased fuel loads and complicated access across the property. The increase in fuel loads is significant because the fuel loads at Wachovia were already high. Invasive species, particularly Chinese tallow, are now present site.
- Ansley (900 acres) - The site is primarily marsh, which has experienced limited scouring. There are significant debris fields within the marsh that extend into the forested areas. Pine timber fared relatively well but hardwoods were heavily damaged. There are significant invasive infestations, primarily Chinese tallow tree.
- Barrier Islands - Hurricane Katrina and other recent storms have over washed all barrier islands in the Northern Gulf causing severe erosion, severely damaging or destroying facilities and resources, depositing massive amounts of debris, degrading habitats, and setting the stage for rampant infestations of noxious, invasive plant and animal species.

- Deer Island (450 acres) - During Katrina, Deer Island lost a significant amount of sand beach and dunes. Related to this, a large number of slash pine trees were killed with mortalities approaching 100% near the east end. The loss of these trees will lead to more catastrophic erosion in the future.

- Danzler property (900 acres) was further from Katrina's core and suffered less direct wind and tidal surge damage than many of the other Coastal Preserves. However, serious long term consequences are anticipated due to the distribution of Chinese tallow tree propagules across the site.

- Pascagoula Marsh System - Katrina left the Pascagoula marsh system exposed to an explosion of invasion exotic species. Gaps left by vegetation loss and disturbances in hydrology regimes will increase the recruitment and growth of such exotic species. The two species that are of the greatest concern are Salvinia molesta (Giant Salvinia) and Sapium sebiferum (Chinese tallow). Disturbed areas often support dense, nearly monospecific colonies of Phragmites australis common reed which is becoming a greater threat to native species population.

3.4.2.4 Saltwater Intrusion

The western area of coastal Mississippi to suffer greatly from increased saltwater intrusion; especially hit hard are oyster resources and coastal marshes.

- Historic oyster reefs located within western Mississippi Sound have declined from lack of freshwater flows resulting from increased saltwater intrusion. Oyster predators, thriving in salty waters, destroy the beds.

- Hancock County marshes, located within the western portion of coastal Mississippi, have suffered increased saltwater intrusion as well as lack of sediment.

Following identification of these system wide problems, the study team, in conjunction with an extensive public involvement program, compiled a list of site specific problems in each of the three counties, organized according to the four problem classifications identified above. A detailed listing of site specific problems is provided in the Plan Formulation Appendix. Table 3-1 presents a synopsis of system-wide and county problems and related needs identified by stakeholders during the workshops and public meetings. These problems and related needs are the basis for the plan formulation process.

Table 3-1
Examples of Stakeholder Input: Coordination with Local Communities

Stakeholder Identified Problems	Stakeholder Identified Needs
• Loss of life and human injury due to ineffective communication • Insufficient capacity at storm shelters	• Coastal Mississippi Hurricane Evacuation Plan
• Storm surge damages and environmental degradation due to development in low lying areas	• Wetland Area Buyouts
• Erosion and intrusion of salt water	• Barrier Island Restoration • Restore or enhance Mississippi Oyster Reefs • Freshwater Diversion
• Erosion and storm damage	• Widen beaches, jump start dunes (Hancock, Harrison, and Jackson Counties)
• Storm surge flooding caused damage to structures and infrastructure	• Provide protection for public facilities • Surge gates along Biloxi and St Louis Bays • Seawalls, levees and ring levees (Forrest Heights Levee, etc.) • Hurricane and Storm Damage Reduction at population centers (Gautier, Ocean Springs, etc.) • Floodproof Existing Infrastructure
• Storm surge caused sedimentation in wetland areas	• Restore wetland functions (Grand Bay Swamp, Hancock County Marsh, etc.) • Restoration of Pine Savannah • Complete snagging and clearing to increase flood water conveyance

3.4.2.5 Other Water Resource Problems

In addition, hurricane-caused problems were also investigated in a series of on-going site investigations conducted in partnership with local representatives, to ensure a complete grasp on the nature of all identified problems, and to ensure development of a full range of suitable measures and plans to deal with the identified problems. Categorical hurricane-caused problems identified by the study team, State, County, and City officials, residents, and agency staff included numerous problems which are typically addressed by agencies other than the Corps of Engineers. These problems concern issues such as hurricane education, warning, and evacuation; municipal infrastructure; and inland transportation infrastructure. Development of the Comprehensive Plan for coastal Mississippi includes problems to be addressed by the Corps of Engineers and by other agencies. Recommendations included in the Comprehensive Plan would necessarily include actions to be taken by agencies other than the Corps of Engineers.

3.4.3 Opportunities

Comprehensive, ***system-wide opportunities*** were identified during the MsCIP planning process to guide the development and evaluation of solutions to the region's water resource problems. An overall theme of Comprehensive Plan opportunities is not merely to reverse the harm done by the hurricanes of 2005, but as importantly to promote the long-term future sustainability of physical, human, and environmental resources within the study area. Comprehensive, system-wide opportunities include:

- Assist in sustainable redevelopment of hurricane damaged physical, environmental, and human resources within the MsCIP study area;
- Reduce the susceptibility of residential, commercial, and public structures and infrastructure to hurricane induced storm damages within the three-county (Hancock, Harrison, and Jackson) MsCIP study area;
- Assist in the recovery and long-term sustainability of coastal wetlands that support important fish and wildlife resources within the study area;
- Accelerate the recovery and assist in the long-term sustainability of maritime forest environments that suffered hurricane induced damages;
- Restore barrier island environments that suffered hurricane induced storm damages in a manner that promotes long-term sustainability of their fish and wildlife resources;
- Reduce saltwater intrusion within the Mississippi Sound coastal environment;
- Assist in the recovery of coastal ecosystems and infrastructure damaged by erosion during the hurricane events of 2005 and support programs that promote long-term erosion reduction and limit erosion potential during future hurricane events.

Because of the massive scope of opportunities associated with each problem area or site, for all problem areas and sites identified as fitting within the mandate given the study team and the authorities provided the Corps, details on opportunities associated with each site are discussed in more detail in the discussion on each site or problem area, as well as the Plan Formulation Appendix. For storm damage reduction and erosion control formulation and screening processes, these discussions are contained in the Engineering Appendix. For ecosystem restoration and saltwater intrusion reduction formulation and screening processes, these discussions are contained in the Environmental Appendix. The results of each evaluation and screening process are summarized in following sections of this chapter.

3.5 Planning Goals and Objectives

In response to the Federal Goal, as established by Congress, the following goals were established for the MsCIP by the Corps of Engineers Project Development Team (PDT), cooperating agencies and affected public. The system-wide goals established for this study were developed in clear recognition of the linkages between structural and nonstructural storm damage reduction and ecosystem restoration opportunities. System-wide goals are intended to address the coastal landscape of the entire Gulf Region, including the area specifically evaluated in the LaCPR program. MsCIP system-wide goals identified in the Comprehensive Plan effort include the following:

- Identify measures to minimize risk to loss of life and safety caused by hurricane and storm surge;
- Recommend cost-effective measures for restoration of nationally and regionally significant environmental resources within a context of long-term sustainability;

- Recommend cost-effective measures to reduce damages from hurricanes and storms without encouraging re-development in high-risk areas;
- Recommend cost-effective measures to mitigate damages caused by saltwater intrusion into nationally significant ecosystems;
- Recommend cost-effective measures to restore eroded coastal resources as part of a system-wide approach to develop a resilient coastline;
- Identify other water resource related programs and activities integral to the development of a comprehensive system-wide plan.

The system-wide objectives established for this study provide specific targets to measure progress towards achieving the comprehensive goals outlined above. Projects formulated as part of the Comprehensive Plan were evaluated based on their ability to contribute to achieving the targets established in these objectives. System-wide objectives include the following:

- Reduce loss of life caused by hurricane and storm surge by 100%;
- Reduce damages caused by hurricane and storm surge by $150M-$200M annually,per coordination with state and local interests based on knowledge of damages from previous hurricane
- Restore 10,000 acres of fish and wildlife habitat including coastal forests, coastal wetlands, wet pine savannah, submerged aquatic sea grasses, oyster reefs, and beaches and dunes by the year 2040;
- Manage seasonal salinities within the western Mississippi Sound such that optimal conditions for oyster growth (surrogate for other aquatic resources, 15 ppt during summer months) are achieved on an annual basis by 2015;
- Reduce erosion to barrier islands, mainland, and interior bay shorelines by 50%;
- Create opportunities for collaboration with local, state, and Federal agencies to facilitate implementation of programs and activities that maximize the use of resources in achieving the comprehensive goal.

3.6 Planning Constraints

There are a number of issues that constrain the development of certain potential measures that might be used to address the identified problem set. Planning constraints are limited to laws and regulations that constrain the planning process. Among these include:

- Measures developed must not negatively impact the resources within the NPS's Gulf Islands National Seashore, particularly with respect to the agency's 2006 Management Policies as well as from those constraints created by inclusion of Horn and Petit Bois Islands as Wilderness Areas;
- Measures developed must avoid, minimize, or mitigate any negative impacts to T&E species identified as residing within areas potentially impacted by study recommendations;
- Measures developed must comply, to the maximum extent practicable, with State of Mississippi Coastal Management Plan;
- Measures developed must meet the guidelines for maintenance of State Water Quality standards;
- Measures must comply with provisions of the Clean Water Act (CWA);

- Measures must comply with provisions of the National Historic Preservation Act (NHPA);
- Measures must comply with the Clean Air Act (CAA);
- Measures must comply with the Endangered Species Act (ESA);
- Measures must comply with the Coastal Barrier Resources Act (CBRA);
- Measures must comply with the Environmental Justice and Protection of Children Executive Order;
- Measures must be consistent with the Magnuson-Stevens Fishery Conservation and Management Act as amended by the Sustainable Fisheries Act of 1996.

3.7 Preliminary Screening of Public Input

Following the initial identification of problems, problem areas, and potential opportunities resulting from the Public Input Sessions, a preliminary screening analysis was conducted. The goal of the preliminary screening was to select items for further consideration which:

- Were caused or exacerbated by the hurricanes of 2005;
- Could not recover without intervention;
- Were consistent with the areas of investigation identified in the Congressional Authorization (storm damage reduction, erosion, fish and wildlife preservation [ecosystem restoration], saltwater intrusion, or related water resource issues;
- Were significant ecosystem resources (scarcity of resource), from a national or regional perspective;
- Were technically or environmentally feasible
- Were not already being addressed by others.

In keeping with the comprehensive nature of the investigation, no attempt was made to restrict items to those that were solely within the Corps' authority to implement. To facilitate future coordination of the comprehensive planning effort, the team did attempt to identify the most likely entity to take the lead role in addressing each item. The complete list of problems, problem areas, and opportunities screened as part of this process are shown in the Plan Formulation Appendix, including which entity would be the most likely responsible agency / actor. Examples of opportunities that can be performed by others include:

- FEMA updating the Coastal Mississippi Hurricane Evacuation Plan to reflect lessons learned during hurricane Katrina;
- Forming a monitoring network, that will survive and function throughout a major storm, to provide data that is critical to emergency managers. This could be accomplished through an update of FEMA's "Integrated Public Alert and Warning System";
- Considering the use of "brown water" systems to minimize demand on ground and surface waters and limit saltwater intrusion. This could possibly be accomplished by the U.S. Environmental Protection Agency;
- Inspecting and Rehabilitating Wastewater and Piping Systems within the three coastal Mississippi counties. This could possibly be accomplished by a State Regional Water and Wastewater Authority;

- Repairing the breach on the West end of Deer Island. This is being accomplished through the Corps' Flood Control and Coastal Emergencies Program;
- Reopening the Highway 90 bridges as quickly as possible. This was accomplished by the Mississippi Department of Transportation, and;
- Utilize the old HW 90 bridge rubble as artificial reef material. This was accomplished by the State of Mississippi DOT.

Other problem areas and suggestions are being accomplished through the MsCIP Interim projects, or are carried forward for consideration in the Comprehensive Plan.

3.8 Development of Measures

After narrowing the list of problems, the MsCIP study team developed potential problem-solving measures. Measures are defined simply as "a feature or activity at a particular site". The initial measures were developed independently within the structural, environmental, and nonstructural sub-teams, and then later evaluated to determine their role within a Comprehensive Plan. Measures were further developed at each of the Regional Coordination, agency, and public workshops.

3.8.1 Development of Storm Damage Reduction and Erosion Reduction Measures

Examples of measures developed for storm damage reduction were supplied by the study team, agencies, and public, and included:

- Levees, seawalls, or embankments (barriers to surge);
- Gates, berms, and breakwaters (barriers to surge);
- Elevating structures (elevation above inundated area);
- Acquisition and removal from high-risk areas (removal from high-risk inundation zones);
- Zoning and Building Code modification (removal of the most damageable or critical infrastructure or services from highest risk areas);
- Floodplain Management (removal of the most damageable or critical infrastructure or services from highest risk areas);
- Moving back from the shoreline (removal of the most at-risk development, most damageable or critical infrastructure, or services from highest risk areas);

Examples of measures for erosion reduction, supplied by the study team and public, included:

- Placement of additional sand;
- Placement of harder erosion-control features, such as shell materials, construction debris, rubble, stone, geo-textiles;
- Supply of additional sand to littoral zone / island sediment budget;
- Reduction of sand-robbing activities in the near-shore or barrier island zones.

3.8.2 Development of Ecosystem Restoration, Preservation of Fish and Wildlife and Saltwater Intrusion Reduction Measures

Examples of measures for ecosystem restoration and fish and wildlife preservation, supplied by the study team and public, included:

- Acquiring and restoring currently undeveloped lands;
- Restoring previously degraded wetlands;
- Removal of sediment and/or debris choking streams and estuaries;
- Re-grading to historic conditions and topography;
- Preserving habitats to reduce fragmentation;
- Removal of invasive species;
- Removal of dead vegetation, deadfalls, and other vegetation that interferes with natural functions;
- Planting of native species in areas in which those species were killed by the hurricanes; and
- Filling of drainage channels that interfere with natural functions.

Examples of measures for saltwater intrusion (seawater encroachment into a freshwater body) reduction, supplied by the study team and public, included:

- Reallocation of freshwater supply by re-regulation of reservoirs and
- Diversion of freshwater sources to direct more freshwater into areas of critical need.

Development of measures was also based on consideration of potential benefits and the potential negative outcomes it might cause (i.e., induced flooding). All of the structural measures were also developed in such a way that they could be laid out as either stand-alone concepts, or as components of a multi-featured plan for a given area (i.e., structural, nonstructural, or ecosystem restoration plan).

3.9 Evaluation of Measures

Each problem area or site and its associated measures were evaluated to determine

- the level of effort required for more detailed development of site specific solutions,
- the need for additional data and more rigorous technical analyses (such as detailed modeling),
- the need for more site specific environmental analysis in order to project potential positive and negative environmental impacts, and
- other factors which are required for informed decision making.

Evaluation at this preliminary phase of study was based on discussions between study team members and technical experts, and on the results of preliminary modeling, such as storm surge modeling or calculations of ecosystem benefits.

3.9.1 Evaluation of Hurricane Storm Damage Reduction (HSDR) and Erosion Reduction Measures

Early evaluation indicated many areas of the coast that are not highly developed, and other areas that contain significant obstacles to formulation of structural measures. It was found to be extremely difficult in many areas to employ structural measures to reduce damages because of environmental concerns and the location of structures. Other areas, such as portions of Harrison County, are more appropriately addressed by structural measures because the entire coastline is densely developed

with a lesser degree of environmental resource concentration. Many outlying areas were found to require individual structural means to achieve storm damage reduction.

Review of the coastline in Mississippi using aerial photographs, topographic maps, LIDAR surveys, and storm inundation data revealed that natural topography could play a major role in forming storm barriers. Other features such as the offshore barrier islands, extensive beaches in many areas, and existing beach-front roadways were also determined to have a substantial role in potential damage reduction. The modeling also indicated that the high ground followed by the CSX Railway crossing the entire state near the coast, functioned as a barrier to surge during Katrina, and thus, should be considered as a potential inland barrier during future events.

Review of the inundation maps generated during the surge modeling of Katrina and other events also indicated that the extensive low-lying areas associated with two bays that extend inland from the coast would require more refined methods than a simple barrier, to solve the surge inundation issue. It was apparent that any continuous storm protection systems would have to consider these as breaks in the line. Closing off rivers and bays with surge gates have been used in Europe to protect inland areas and different designs of gate structure were evaluated and considered in the development of comprehensive plans for coastal Mississippi.

Almost all problem areas or sites along the Mississippi coastline were found to have environmental considerations that required adjustment or modification to structural measures to address those concerns. However, in Jackson County, the Pascagoula River system separates the city of Pascagoula from most of the coast to the west. This river system with its vast marshes areas is one of the last major free-flowing rivers in the southeast, and has numerous environmental resource concerns. In the western portion of the state, extensive marshes along with the Pearl River separate Mississippi from Louisiana. In addition to these environmental concerns, other technical issues also made structural damage reduction in these areas problematic.

3.9.2 Evaluation of Ecosystem Restoration and Saltwater Intrusion Reduction Measures

The MsCIP team used several environmental models to help evaluate the performance of potential ecosystem restoration measures. These models included:

- A Mississippi and Alabama Gulf Coast Tidal Fringe Hydrogeomorphic model (HGM);
- A Wet Pine Savannah HGM;
- A Fish Habitat Index (FHI) Model for Evaluation of Coastal Maritime Forest/Beach-Dune Habitat; and
- A Geographic Information System (GIS) based Spatial Decision Support Model (SDSS) for Wetland Restoration.

The HGM and FHI models are discussed in more detail in the Environmental Appendix.

The SDSS model related areas of hydric soils and other factors to the long-term survivability of a wetlands resource. The model scales and combines multiple GIS layers to identify and evaluate potential wetland restoration sites within the three coastal counties. The results of the model were used in conjunction with local expertise to evaluate potential wetland restoration areas.

The results of the HGM modeling were used for evaluating tidal fringe wetlands and wet pine savannah habitats. The tidal fringe HGM model was also used to evaluate impacts to tidal fringe wetlands that would result from HSDR measures such as levees. These functional assessments helped to determine mitigation requirements for unavoidable wetland impacts by structural components of a comprehensive plan. Likewise, the wet pine savannah HGM allowed the team to assess impacts to wet pine savannah habitats at various environmental restoration sites.

Evaluation of saltwater intrusion reduction methods involved the investigation of freshwater diversion measures at several locations. These measures would divert freshwater from the Mississippi River or other sources to reverse recent increases in salinity in the Mississippi Sound/Biloxi marshes. Reduced salinity would support fresher marshes and oyster reef health and productivity, thus enhancing both their economic value and the ecological services they provide.

The evaluation of diversion measures was conducted through a water quality model (WQM). This model predicted water quality constituents, including nutrients, phytoplankton, dissolved oxygen, temperature, salinity, and underwater light intensity to assess relative changes from a baseline condition.

More detailed information on these models can be found in the Environmental Appendix

3.10 Comparing Measures

Once a measure for an area was determined to contribute to the overall comprehensive plan, it was then compared to other measures developed for that site or problem area. Again, comparison at this phase of study was based on discussion between study team members and technical experts, to determine the *relative* potential damage reduction or environmental output achievable, and problems encountered or solved, particularly in comparison with the "No-Action" Plan.

Comparison of structural and non-structural damage reduction measures, and erosion control measures, was conducted by comparison of their relative ability to reduce damages, with consideration given as to their potential environmental mitigation requirements or negative impacts, potential costs, and other potential issues. Comparison of ecosystem restoration measures, and saltwater intrusion measures, was conducted by comparison of their relative ability to achieve the desired environmental output as compared to the "No-Action" Plan, relative to their potential costs.

3.11 Screening Measures

3.11.1 Screening Criteria

After the measures were developed and evaluated, they were screened based on the inter-disciplinary study team's understanding of each site's potential to meet a variety of criteria and its contribution to the comprehensive plan. Each measure/problem area combination had to meet the following criteria:

- Technical feasibility (i.e., will a given measure provide a sound technical solution to the identified problem(s)?);
- Environmental feasibility (i.e., will a given measure provide a sound solution to the identified problem(s), without creating environmental resource problem of its own?), and;
- Some potentially cost-effective measures for the identified problem area.
- Does not induce development (e.g., building a levee around undeveloped land)
- Does not induce flooding (e.g., creating a barrier that moves more water into an area, thereby increasing flood damages.

In addition, for ecosystem restoration or saltwater intrusion reduction, the site or problem area had to be identified as having:

- no ability to either heal on its own, unaided by human intervention, or;
- national and/or regional significance in regards to the type of ecosystem it represents;
- the need for assistance to restore vital hydrologic links;

- the potential need to manually remove blockages created by hurricane-deposited debris that was impacting function;
- the potential need to remove excess sediment deposited by the hurricanes that had changed the nature of the land's surface and resulted in degraded function and value;
- the potential need to remove invasive species that had entered the area since the hurricanes and caused displacement of native plant species (and potentially wildlife depending on native species), degrading function of the ecosystem; or
- the potential need for planting of native species vital to restoration of a significant ecosystem and restoration of its functions and values.

3.11.2 Screening Results

The purpose of the screening process is to "weed out" unproductive measures, or those that do not meet the planning objectives. Application of the screening criteria resulted in the removal from further consideration of a large number of less significant areas, and many areas that the study team determined were capable of recovery on their own or did not contribute to the overall comprehensive plan. Preliminary analysis indicated that there were many solutions or measures that were *obviously* cost-prohibitive, unequivocally environmentally damaging, or simply technically infeasible.

Due to the large number of measures involved, and the fact that initial evaluation and screening was done on a case-by-case basis by the study team in the field or in discussion held for each site, no detailed discussion of each measure/problem area combination is contained here, although numerous preliminary measures and their evaluation, comparison, and screening are referenced in the Engineering and Environmental appendices.

The list of ecosystem measures and areas to be considered for more detailed analysis was narrowed to the following comprehensive aspects:

- Restoration of barrier islands. Includes entire restoration of the MS barrier islands including littoral placement, re-vegetation, and restoration of Submerged Aquatic Vegetation.
- Restoration of dune habitat. Using dune barriers along the MS coast as either an ecosystem restoration measure, or in combination with dune use as a storm damage reduction barrier.
- Reduction of saltwater intrusion by restoring fresh water flows from the Escatawpa, Pearl, and Mississippi Rivers.
- Restoration of coastal Mississippi wetlands and forests by evaluating historical wetland areas, frequently flooded populated areas, and current wetland and forest areas degraded by the storms of 2005.

Many types of structural and nonstructural protection measures were also reviewed. Some examples of the types of measures that were screened out due to a lack of technical or environmental feasibility are identified below and depicted in Figure 3-3. These measures were discussed with the stakeholders as to why they were screened. For example, the idea of considering offshore breakwater measures came up often in stakeholder and public workshops. The study team determined that while breakwaters may reduce some of the wave energy, they would not significantly reduce flood damages resulting from storm surge, and would have significant environmental and navigation impacts. For these reasons, which were discussed with the stakeholders, the measure was screened from further consideration.

- Inflatable barriers,
- Concrete sidewalks or roadways that could be rotated upwards to form a seawall,
- Sliding panel gates, and

- Offshore breakwaters.
- Contiguous Barrier Island 'Wall'
- Galveston type Seawall

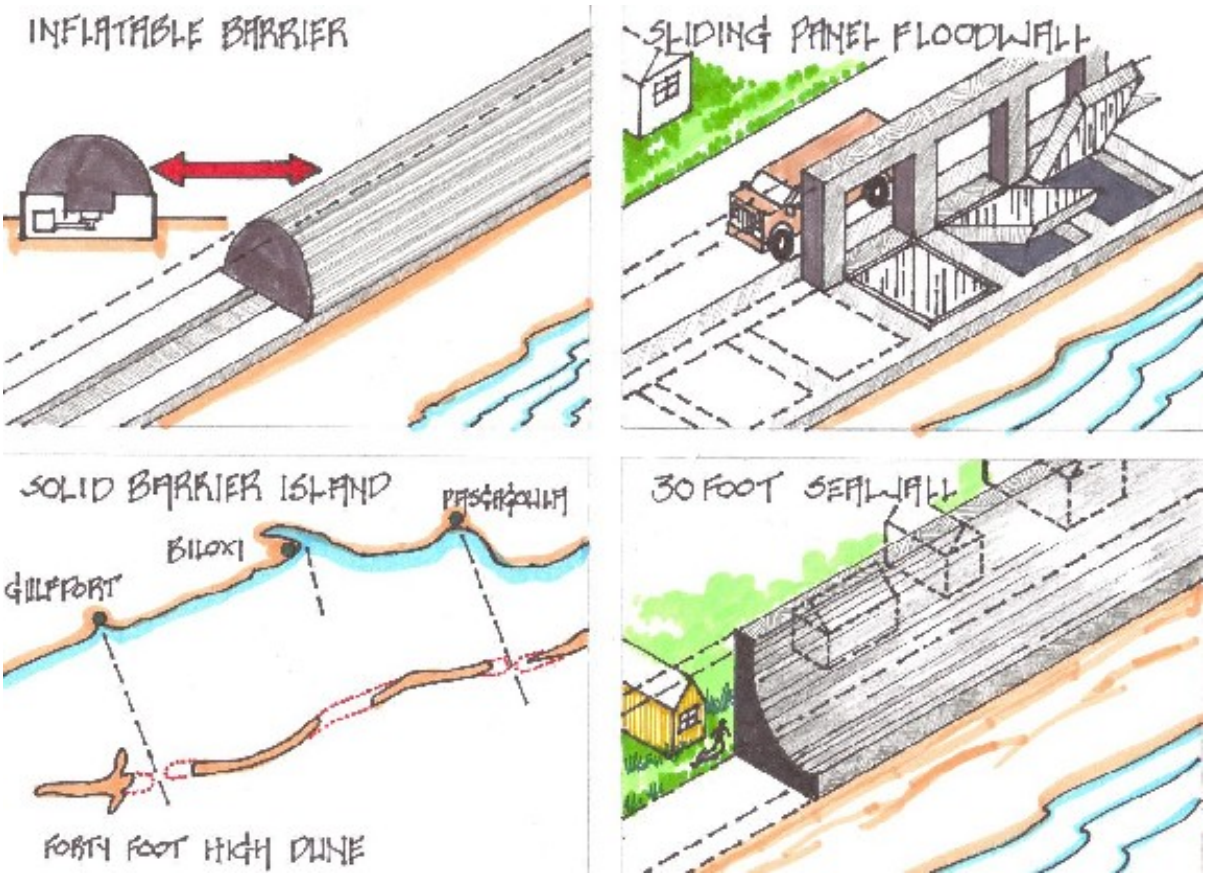


Figure 3-3
Preliminary Damage Reduction Measures Screened Out

Due to the relatively low elevations, type of construction, and the nature of storm surge throughout the coastal area, several preliminary nonstructural measures were also screened from further evaluations. These include:

- Elevating structures on fill material are not allowed in VE zones, which includes most of the area where these type of measures would be considered.
- Dry floodprofing of residential structures only provides protection up to 3 feet and does not makes sense in this area because most of the structures at "high risk" were destroyed, could be more safely elevated or removed from future surge events.
- Likewise, wet floodproofing of residential structures would not be a valid alternative because of the continued risk to life and safety.

Additional information on these measures can be found in the Engineering, Environmental, and Nonstructural Appendices.

3.12 Lines of Defense Concept

The list of damage reduction concepts and/or alignments to be retained for further analyses resulted in the development of a "Lines of defense" (LOD) concept depicted in Figure 3-4. The LOD concept incorporates a group of alternative measures which function together as a comprehensive approach to addressing the problems and opportunities. This grouping of alternative measures integrates structural, non-structural, and ecosystem restoration measures. This concept progresses geographically from the offshore barrier islands to what could be considered the inland surge extent of the worst possible theoretical storm. This storm, labeled the Maximum Possible Intensity (MPI) event, would be used to define a line that, based on ground surface elevation, the storm surge would not exceed. The lines of defense would be designed to provide increasing levels of damage reduction as storm events increased in size up to the MPI. Some lines would not provide much protection from large storms, and several areas of the coast could not be included in continuous line of defense. These areas would be addressed by a ring levee system or designated to a non-structural solution during the second round of evaluation. At this stage of the planning process, the conceptual LOD elements were primarily evaluated as stand alone measures, although the potential cumulative effects on damage reduction and construction costs were bracketed (i.e., likely high and low values). The cumulative effects of multiple LOD measures would be further evaluated, if multiple structural LOD elements were recommended.

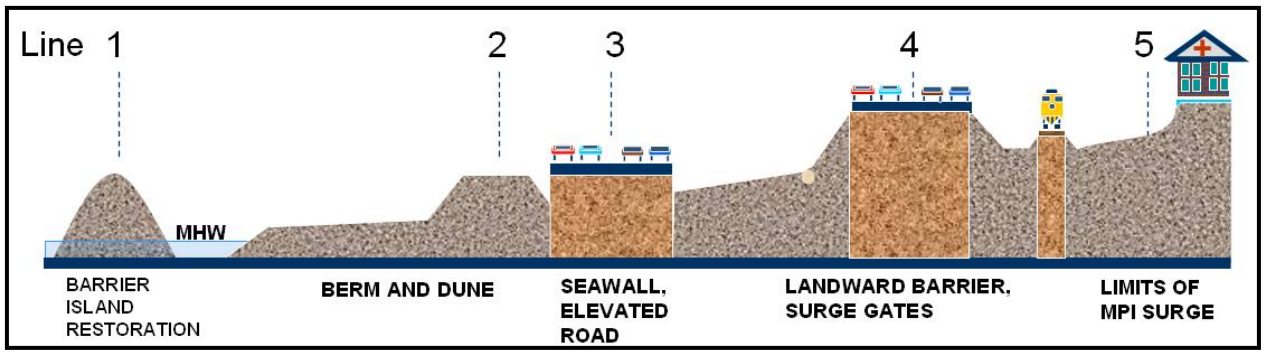


Figure 3-4
Lines of Defense Concept

3.12.1 First Line of Defense – Barrier Islands

The coastline of mainland Mississippi is bordered on the south by the Mississippi Sound, a shallow body of water that separates the coast from four barrier islands that lie several miles to the south. These barrier islands, managed by Gulf Islands National Seashore, are located along a littoral drift zone that moves sand westward creating three elongated islands and then to the westward most island where littoral currents are not as well defined. From east to west, the islands are Petit Bois, Horn, Ship, and Cat. Ship Island has been breached by prior hurricanes and now is actually two small islands, West Ship Island and East Ship Island, with a shallow sand bar between the two. Since Hurricane Camille in 1969, this breach has existed with varying amounts of natural rebuilding between later storms. The western ends of both Petit Bois and Ship Islands have migrated into maintained navigation channels and the continuing littoral drift of the sand into the channels is causing an artificial termination of the migration.

Soon after Hurricane Katrina, it was reported that many in Mississippi felt that if the islands had been in the condition that existed prior to Hurricane Camille, there would have been less damage along the coast from Hurricane Katrina. Restoration of barrier islands was also included in the Mississippi Governor's Restoration Plan, as described in Section 1.4 State Strategy, which called for restoring

the islands to their pre-Camille footprint. This measure (identified as LOD-1) was selected to be carried forward for further analysis.

3.12.2 Second Line of Defense – Dunes along Existing Beaches

Essentially all the beaches along coastal Mississippi are man-made. Harrison County has the most beach-front - 26-miles extending from Biloxi Bay to St. Louis Bay. Hancock County has several miles of beach and Jackson County only a short length. In total, the beaches extend along less than half of the Mississippi coastline. Most of the dunes that previously existed along these beaches were destroyed by Katrina and much of the beach was damaged. Reconstruction of the dunes, following implementation of the interim MsCIP beach projects, will likely provide reduction of damaging wave action from smaller storms, as has been shown in other areas along the gulf coast.

The beaches, situated immediately seaward of developed areas, provide a location where elevated dunes could be constructed to provide some protection from smaller hurricanes. This measure (identified as LOD-2) was selected to be carried forward for further analysis.

3.12.3 Third Line of Defense – Raised Roadway or Seawall and Ring Levees

All of the beaches described in LOD-2 have a roadway landward (North) of the beach. These roads vary from local or county roads to US Highway 90, a major, four-lane highway that extends across the entire Harrison County coast. The existing roadways vary in elevation from four to five feet above sea level (NAVD-88) in Jackson and Hancock County and up to about 15 feet above sea level in Harrison County. All of these roads are evacuation routes and all have been damaged in past hurricanes. In a damaged or destroyed condition, these roads make re-entry to the area difficult after a hurricane has passed. Raising and using these roadways and associated seawall as barriers defines the 3rd line of defense (LOD-3) and will be carried forward for further analysis.

The nonstructural components of LOD-3 include many elements: evacuation planning, building codes etc. and acquisition or flood proofing of all properties within the '100-yr' floodplain. These nonstructural components are also carried forward for further analysis.

3.12.4 Fourth Line of Defense – Inland Barrier

To preserve the shoreline environment as much as possible, a 4th line of defense (LOD-4) for very large storms is envisioned that would be a structure inland from the coast (and LOD-3). This line of defense could be designed to a high elevation that would reduce the risk from a very large storm surge, such as the "Maximum Possible Intensity" (MPI) hurricane, and will also be supplemented by nonstructural solutions such as elevating or buying out structures. This line of defense was selected to be carried forward for further analysis.

3.12.5 Fifth Line of Defense – Maximum Surge Limit

This line of defense will be a line on a map that indicates the extent of surge resulting from the "Maximum Possible Intensity" storm. Structures that are situated or built above (North of) this line should not be inundated from surge by large storm events. Measures associated with this line of defense would include relocation of existing emergency services such as hospitals, or police and fire stations to an area above the MPI surge. This fifth line of defense (LOD-5) was selected to be carried forward for further analysis.

A planning session conducted on the five conceptual lines of defense resulted in numerous refined variations of each of the lines. The further development of these concepts was made in a study team meeting that included engineers, environmentalists, planners, and geologists. Information from

along the coastline was utilized that included large scale aerial photography, topographic maps, navigation maps, and a large collection of pre and post-Katrina photographs.

Figures 3-5, 3-6, and 3-7 indicate the initial alignments of the lines of defense for each of the three Mississippi coastal counties, Hancock, Harrison, and Jackson.

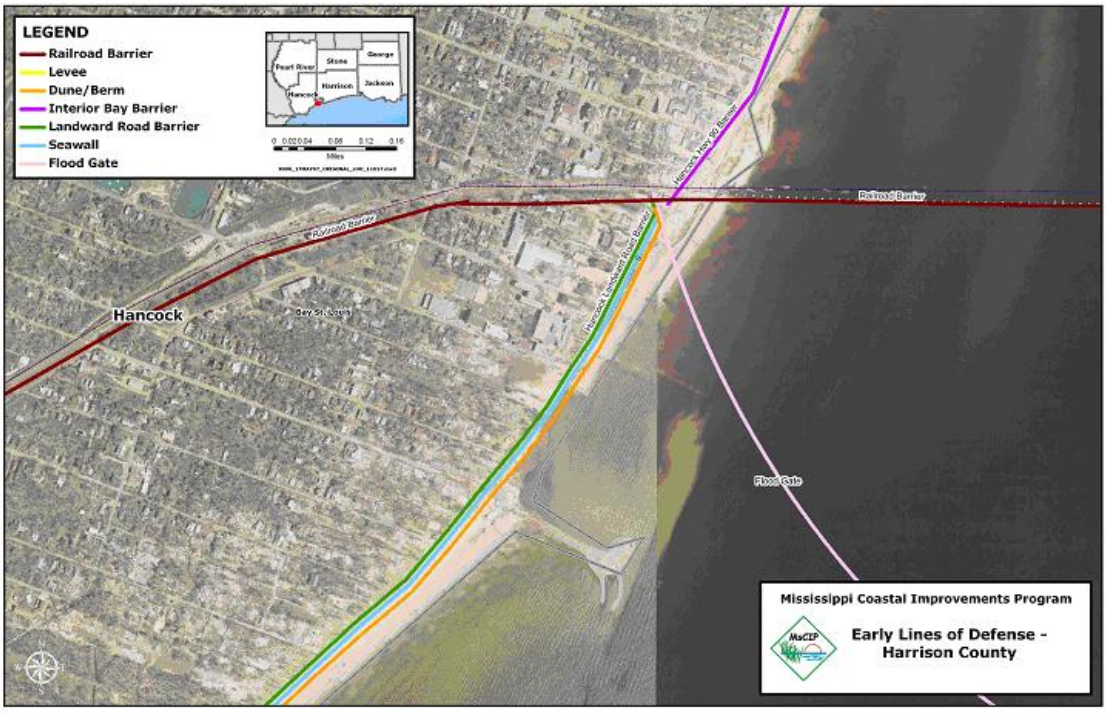


Figure 3-5
Initial Lines of Defense for Hancock County

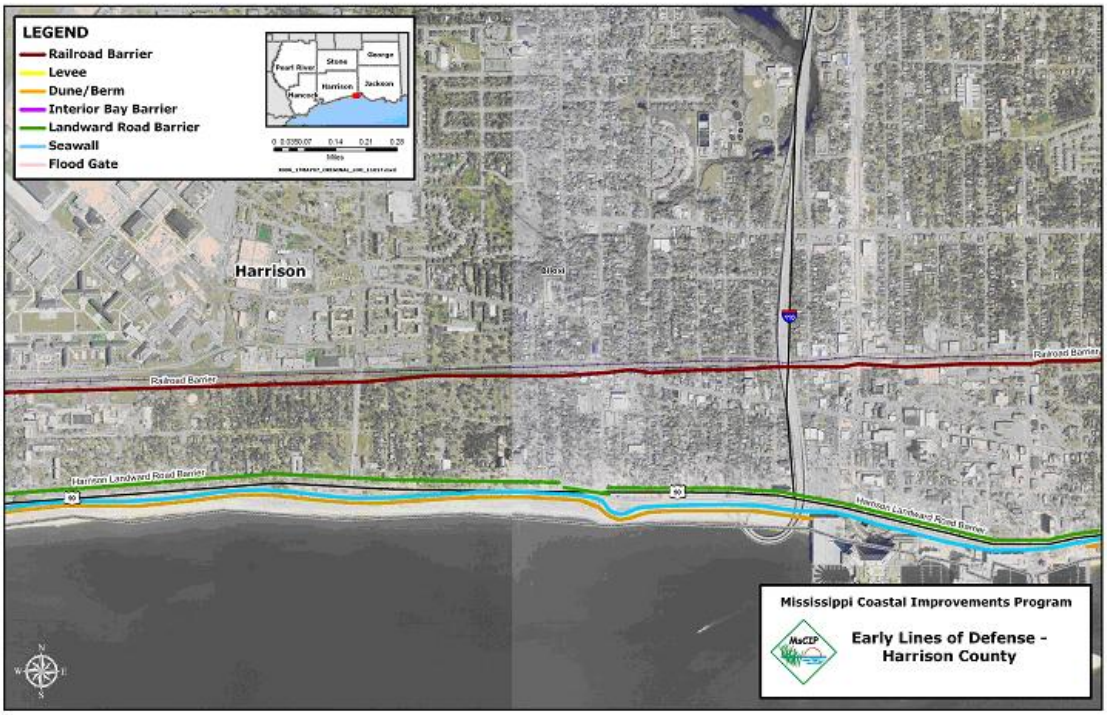


Figure 3-6 Initial Lines of Defense for Harrison County

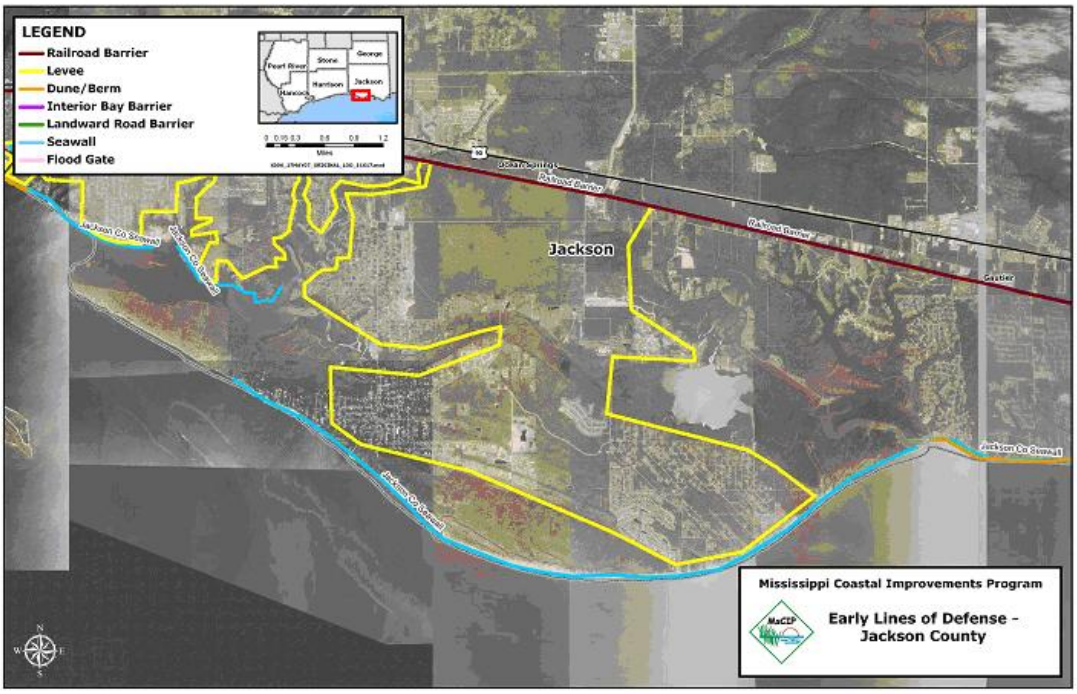


Figure 3-7
Initial Lines of Defense for Jackson County

3.13 Development of Preliminary Alternatives

The development of alternatives consisted of modifying measures to achieve higher desired comprehensive outputs (e.g., higher damage reduction benefits, greater ecosystem benefits), and to better serve the original intended purpose, based on feedback from stakeholder input, modeling efforts or better data availability. The combination of measures into alternatives was based on the following factors:

- development of more detail in design,
- cost estimation,
- environmental aspects and potential impacts,
- potential damages prevented,
- site considerations,
- more detailed technical requirements,
- more detailed source material and source area information,
- variations in materials that could be used to solve the problem in a similar way,
- species benefits or impacts considerations, and
- many other technical, environmental, or economic issues.

The list of preliminary alternatives, including structural and nonstructural alternatives, developed during this round is presented in Table 3-2.

Table 3-2
Preliminary Alternatives

Name (Alternatives screened out during this round are in ***bold italics***)	Description
Offshore Zone (LOD-1)	
Deer Island Restoration	Complete Restoration of Island back to its pre-Camille footprint
Increasing Islands Footprint (Option A)	Restore islands by sand dredged from off-shore
Placing River Sand in Littoral Zone (Option B)	Restore islands by placing dredged river sand in the littoral zone
Placing Off-shore Sand in Littoral Zone (Option C)	Restore islands by placing dredged sand in the littoral zone
Creating 2 FT Island Dunes with Beach Sand (Option D)	Restore islands by shaping existing beach sand into 2' high dunes
Creating 6 FT Island Dunes with Off-shore Sand (Opt E)	Restore islands by creating 6' high dunes with off-shore sand
Barrier Island No Action	
Barrier Island Restoration to Protect MS Sound Estuary	Study to recommend optimal solution to protect the MS Sound Estuary
Emergency Ship Island Restoration	Phased Advanced Engineering and Design to protect Ft. Mass. and Estuary
Sub Aquatic Vegetation Pilot Project	Tests various methods of planting SAVs in MS Sound
MS Sound Sub Aquatic Vegetation Restoration	Restore 4400 acres of lost SAVs in MS Sound using pilot results
Coastal Zone (LOD-2 and LOD-3)	
Hancock 40' Dune @ Elevated Roadway (Option A)	***Dune adjacent to the seawall with a 40' crest at elevation 10***
Hancock 50' Dune @ Elevated Roadway (Option B)	***Dune adjacent to the seawall with a 50' crest at elevation 8***
Hancock 20' Dune @ Elevated Roadway (Option C)	***Dune adjacent to the seawall with a 20' crest at elevation 10***

Hancock 30' Dune @ Elevated Roadway (Option D)	***Dune adjacent to the seawall with a 30' crest at elevation 8***
Hancock Dune Option A plus sea oats (Option E)	***Like option A + plantings on toe of dunes***
Hancock Dune Option B plus sea oats (Option F)	***Like option B + plantings on toe of dunes***
Hancock Dune Option C plus sea oats (Option G)	***Like option C + plantings on toe of dunes***
Hancock Dune Option D plus sea oats (Option H)	***Like option D + plantings on toe of dunes***
Hancock 55' Dune and beach berm (Option I)	***Dune w/ 55' crest at elev. 10 & beach berm on south side***
Hancock Dune Option I plus sea oats (Option J)	***Like Option I but with plantings on toe of berm***
Coastal Beach No Action	
Comprehensive 60' wide x 2' high Dune plus sea oats (Option K)	60' wide X 2' high berm with sea oats planted on 30" centers
Harrison 40' Dune @ Elevated Roadway (Option A)	***Dune adjacent to the seawall with a 40' crest at elevation 10***
Harrison 50' Dune @ Elevated Roadway (Option B)	***Dune adjacent to the seawall with a 50' crest at elevation 8***
Harrison 20' Dune @ Elevated Roadway (Option C)	***Dune adjacent to the seawall with a 20' crest at elevation 10***
Harrison 30' Dune @ Elevated Roadway (Option D)	***Dune adjacent to the seawall with a 30' crest at elevation 8***
Harrison Dune Option A plus sea oats (Option E)	***Like option A + plantings on toe of dunes***
Harrison Dune Option B plus sea oats (Option F)	***Like option B + plantings on toe of dunes***
Harrison Option C plus sea oats (Option G)	***Like option C + plantings on toe of dunes***
Harrison Dune Option D plus sea oats (Option H)	***Like option D + plantings on toe of dunes***
Harrison 55' Dune and beach berm (Option I)	***Dune w/ 55' crest at elev. 10 above datum and add beach berm***
Harrison Dune Option I plus sea oats (Option J)	***Like Option I but with plantings on toe of berm***
Hancock Seawall/Elevated Roadway at Elevation 11	***Seawall and Elevated Beach Road to Elevation 11***
Harrison Seawall/Elevated Roadway at Elevation 16	***Seawall and Elevated Beach Road to Elevation 16***
Jackson Seawall/Elevated Roadway at Elevation 11	***Seawall and Elevated Beach Road to Elevation 11***
Biloxi Bay Surge Gate at Elevation 20	***Required for LOD3 (same as LOD4 Biloxi Surge Barrier Option A)***
St Louis Bay Surge Gate at Elevation 20	***Required for LOD3 (same as LOD4 St Louis Bay Surge Option A)***
Pearlington No Action	
Pearlington Nonstructural at ABFE (Reach 6)	Buyouts and/or raising structures accounting for a 20' surge
Pearlington Ring Levee at Elev. 20 (Reach 6)	Ring levee around Pearlington 20' above datum (NAVD 88)
Pearlington Nonstructural for Elevation 20 (Reach 6)	Buyouts and/or raising structures accounting for a 20' surge
Pearlington Ring Levee at Elev. 30 (Reach 6)	Ring levee around Pearlington 30' above datum (NAVD 88)
Pearlington Nonstructural for Elevation 30 (Reach 6)	Buyouts and/or raising structures accounting for a 30' surge
ABFE Nonstructural for (Reach 5)	Includes everything in Reach 5
ABFE Nonstructural for (Reach 36)	Includes everything in Reach 36
Pearlington Ring Levee for up to a 'Moderate to Low Risk Event'	Ring levee around Pearlington designed for a 100-500 year event
Pearlington Nonstructural for up to a 'Moderate to Low Risk Event'	Nonstructural options for Pearlington to handle a 100-500 year event
Pearlington Ring Levee plus NS up to a 'Moderate to Low Risk Event'	Reach 5-6
Pearlington Ecosystem Restoration with NS Buyouts	Buyouts and Ecosystem Restoration of high risk properties
ABFE Nonstructural for Reaches 5,6,36)	Nonstructural buyouts / elevation of structures
Pearlington North Eco Restoration Plan - 1	76 Acres - residential infrastructure
Pearlington South Restoration Plan - 2	11 Acres - residential infrastructure
Port / West Ecosystem Restoration Plan - 3	49 Acres - residential infrastructure
Ansley Ecosystem Restoration Plan - 4	2024 Acres - residential infrastructure
Heron Bay Ecosystem Restoration Plan - 5	595 Acres - residential infrastructure
Bayou Caddy Ecosystem Restoration Plan - 8	362 Acres - residential / commercial infrastructure

Bay St. Louis / Waveland No Action	
ABFE Nonstructural for Reach 4	Nonstructural buyouts / elevation of structures
Clermont Harbor Ecosystem Restoration Plan - 9	210 Acres - residential infrastructure
ABFE Nonstructural for Reach 3	Nonstructural buyouts / elevation of structures
ABFE Nonstructural for Reaches 3,4	Nonstructural buyouts / elevation of structures
Henderson Point No Action	
Henderson Point Nonstructural for Reach 9	
Henderson Point B Accelerated Buyout	Nonstructural buyout of properties
Pass Christian Nonstructural for Reach 10	Nonstructural buyouts / elevation of structures
Pass Christian Beach Front Eco Restoration Plan - 20	21 Acres - Low forested drainage area / residential
Pass Christian Nonstructural for Reach 13	Nonstructural buyouts / elevation of structures
Pass Christian Nonstructural for Reach 15	Nonstructural buyouts / elevation of structures
Biloxi Front Beach Ecosystem Restoration Plan - 26	41 Acres South of Hwy 90 (commercial retail outlet)
Pass Christian Nonstructural for Reach 18	Nonstructural buyouts / elevation of structures
Nonstructural for Reaches 10,13,15,18	Nonstructural buyouts / elevation of structures
Ocean Springs No Action	
Ocean Springs Ring Levee at Elev. 20	Ring levee around Ocean Springs 20' above datum (NAVD 88)
Ocean Springs Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Ocean Springs Ring Levee at Elev. 30	Ring levee around Ocean Springs 30' above datum (NAVD 88)
Ocean Springs Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Ocean Springs Nonstructural for Reach 22	Nonstructural buyouts / elevation of structures
Ocean Springs Nonstructural for Reach 24	Nonstructural buyouts / elevation of structures
Nonstructural for Reaches 22,24	Nonstructural buyouts / elevation of structures
Gulf Park / Belle Fontaine No Action	
Pine Island Plan - 30	238 Acres - restore to emergent tidal marsh
Nonstructural for Reach 28	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 26	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 27	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 31	Nonstructural buyouts / elevation of structures
Gulf Park Estates Ring Levee at Elev. 20 (Option A)	Ring levee around Gulf Park Estates 20' above datum (NAVD 88)
Gulf Park Estates Alternate Ring Levee at Elev. 20 (Option C)	Ring levee around Gulf Park Estates 20' requires ABO plan
Gulf Park Estates Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Gulf Park Estates Ring Levee at Elev. 30 (Option B)	Ring levee around Gulf Park Estates 30' above datum (NAVD 88)
Gulf Park Estates Alternate Ring Levee at Elev. 30 (Option D)	Ring levee around Gulf Park Estates 30' require ABO plan
Gulf Park Estates Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Gulf Park Estates Nonstructural ABO Plan	Nonstructural Advanced Buyout Plan for areas not in Ring Levee
Belle Fontaine Ring Levee at Elev. 20 (Option A)	Ring levee around Belle Fontaine 20' above datum (NAVD 88)
Belle Fontaine Alternate Ring Levee at Elev. 20 (Option C)	Ring levee around Belle Fontaine 20' require ABO plan
Belle Fontaine Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Belle Fontaine Ring Levee at Elev. 30 (Option B)	Ring levee around Belle Fontaine 30' above datum (NAVD 88)
Belle Fontaine Alternate Ring Levee at Elev. 30 (Option D)	Ring levee around Belle Fontaine 30' require ABO plan

Belle Fontaine Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Belle Fontaine Nonstructural ABO Plan	Nonstructural Advanced Buyout Plan for areas not in Ring Levee
Belle Fontaine Ecosystem Restoration Plan - 31	1517 Acres (Contained in ABO area named Belle Fontaine)
Nonstructural for Reaches 26,27,28	Nonstructural buyouts / elevation of structures
Gautier No Action	
Nonstructural for Reach 29	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 30	Nonstructural buyouts / elevation of structures
Gautier Ring Levee at Elev. 20	Ring levee around Gautier 20' above datum (NAVD 88)
Gautier Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Gautier Ring Levee at Elev. 30	Ring levee around Gautier 30' above datum (NAVD 88)
Gautier Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Nonstructural for Reaches 29,30	Nonstructural buyouts / elevation of structures
Moss Point / Pascagoula No Action	
Pascagoula/Moss Point Ring Levee at Elev. 20 (Option A)	Ring levee around Pascagoula/Moss Point 20' above datum
Pascagoula / Washington St. Ring Levee at Elev. 20 (Option C)	Ring levee around Pascagoula/Washington Street @ 20'
Moss Point Alternate Ring Levee at Elev. 20 (Option E)	Ring levee around Moss Point 20' above datum (NAVD 88)
Washington St + Moss Point Alternate Ring Levee at Elev. 20 (Opt G)	Ring levee around Washington St + Moss Point Alt at Elev. 20
Pascagoula / Moss Point Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Pascagoula/Moss Point Ring Levee at Elev. 30 (Option B)	Ring levee around Pascagoula/Moss Point 30' above datum
Pascagoula / Moss Point Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Pascagoula / Washington St. Ring Levee at Elev. 30 (Option D)	Ring levee around Pascagoula/Washington Street @ 30'
Moss Point Alternate Ring Levee at Elev. 30 (Option F)	Ring levee around Moss Point 30' above datum (NAVD 88)
Washington St + Moss Point Alternate Ring Levee at Elev. 30 (Opt H)	Ring levee around Washington St + Moss Point Alt at Elev. 30
Nonstructural for Reach 54	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reach 53	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reach 52	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reach 51	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reaches 51,52,53, 54	Nonstructural buyouts / elevation of structures
Griffin Point Ecosystem Restoration Plan - 32	183 Acres - restore to emergent tidal marsh
Bayou Chico Ecosystem Restoration Plan - 33	259 Acres - restore to emergent tidal marsh
Grand Bay / Bayou Cumbest Ecosystem Restoration Plan - 34	1517 Acres (Contained in ABO area named Belle Fontaine)
Inland Zone (LOD-4)	
Inland Zone No Action	
Inland Barrier A Levee at Elev. 20	3 County Levees at Elev. 20' plus surge gates
Inland Barrier D Levee at Elev. 20 with Roadway	3 County Levees at Elev. 20' plus surge gates with roadway on top
Inland Barrier F Menge Ave. Levee at Elev. 20	3 County Levees at Elev. 20' with no Bay St. Louis Surge gate
Inland Barrier I Menge Ave. Levee at Elev. 20 w/ Roadway	3 County Levees at Elev. 20' with no Bay St. Louis Surge gate w/ roadway
Nonstructural at Inland Barrier Footprint for Elevation 20	Coast-wide Nonstructural comparison for inland barriers
Inland Barrier B Levee at Elev. 30	3 County Levees at Elev. 30' plus surge gates
Inland Barrier E Levee at Elev. 30 with Roadway	3 County Levees at Elev. 30' plus surge gates with roadway on top
Inland Barrier G Menge Ave. Levee at Elev. 30	3 County Levees at Elev. 30' with no Bay St. Louis Surge gate

Inland Barrier J Menge Ave. Levee at Elev. 30 w/ Roadway	3 County Levees at Elev. 30' with no Bay St. Louis Surge gate w/ roadway
Nonstructural at Inland Barrier Footprint for Elevation 30	Coast-wide Nonstructural comparison for inland barriers
Inland Barrier C Levee at Elev. 40	3 County Levees at Elev. 40' plus surge gates
Inland Barrier H Menge Ave. Levee at Elev. 40	3 County Levees at Elev. 40' with no Bay St. Louis Surge gate
Nonstructural at Inland Barrier Footprint for Elevation 40	Coast-wide Nonstructural comparison for inland barriers
Nonstructural for Reach 7	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 37	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 38	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 1	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 2	Nonstructural buyouts / elevation of structures
Lower Bay Rd Ecosystem Restoration Plan - 6	227 Acres - residential infrastructure
Lakeshore Ecosystem Restoration Plan - 7	275 Acres - residential / commercial infrastructure
Bay St. Louis No Action	
Bay St. Louis Ring Levee at Elevation 20	Ring levee around Bay St. Louis 20' above datum (NAVD 88)
Bay St. Louis Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Bay St. Louis Ring Levee at Elevation 30	Ring levee around Bay St. Louis 30' above datum (NAVD 88)
Bay St. Louis Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Shoreline Park ABO Plan	buyouts of structures in high risk zones
Shoreline Park Ecosystem Restoration Plan	Restore tidal marsh - Requires buyout
Bayou LaCroix Ecosystem Restoration Plan - 10	260 Acres - residential infrastructure
Admiral Island DSS Ecosystem Restoration Plan - 11	245 Acres - (ABO area in Shoreline Park B and 2/3 of site is demo project and state owned)
State's Admiral Island Ecosystem Restoration	Exotic control and Debris Removal
Chapman Road Ecosystem Restoration Plan - 13	146 Acres - (ABO area in Shoreline Park C)
Diamondhead Ecosystem Restoration Plan - 15	434 Acres
Henderson Point / Pass Christian No Action	
Henderson Point A Nonstructural ABO Plan	Nonstructural Advanced Buyout Plan for areas not in Ring Levee
Delisle Ecosystem Restoration Plan - 16	Harrison County 121 Acres - removal of residential infrastructure
Ellis Ecosystem Restoration Plan - 17	443 Acres
Pine Point Shores East Ecosystem Restoration Plan - 18	103 Acres - removal of residential structures
Pine Point Shores West Ecosystem Restoration Plan - 19	84 Acres - removal of residential structures
Bayou Portage Ecosystem Restoration Plan - 21	44 Acres - Restore to emergent tidal marsh
Nonstructural for Reach 8	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 39	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 40	Nonstructural buyouts / elevation of structures
Gulf Port No Action	
Nonstructural for Reach 12	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 40	Nonstructural buyouts / elevation of structures
Turkey Creek Ecosystem Restoration Plan - 22	948 Acres - Restore Wet Pine Savannah
Forrest Heights No Action	
Forrest Heights 17’ Levee Option	Levee around Forrest Heights 17' above datum (NAVD 88)
Forrest Heights 21’ Levee Option	Levee around Forrest Heights 21' above datum (NAVD 88)

Brickyard Bayou at Courthouse Rd Eco Plan - 23	15 Acres - Restore to emergent tidal marsh
Biloxi River - Shorecrest Eco Restoration Plan - 24	15 Acres - Restore to emergent tidal marsh
Biloxi River - Eagle Point Eco Restoration Plan - 25	17 Acres -
Biloxi No Action	
Nonstructural for Reach 14	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 17	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 19	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 16	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 20	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 48	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 50	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 47	Nonstructural buyouts / elevation of structures
Keegan Bayou Ecosystem Restoration Plan - 27	55 Acres - restore to emergent tidal marsh
Ocean Springs No Action	
Nonstructural for Reach 21	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 23	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 25	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 32	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 33	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 34	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 35	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 41	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 42	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 43	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 44	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 45	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 46	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 49	Nonstructural buyouts / elevation of structures
Nonstructural Elevations for Waveland	Elevation of Houses in the City of Waveland
Moss Point Municipal Structures Relocation	Relocating Municipal services to higher ground
Escatawpa Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
Pearl River Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
Bonnie Carrie Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
Violet Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
St. Martin Ecosystem Restoration Plan - 28	Jackson County 468 Acres - restore to emergent tidal marsh
Fort Point Ecosystem Restoration Plan - 29	84 Acres - restore to emergent tidal marsh

3.13.1 Refinement of Preliminary Alternatives

In order to conduct an evaluation of preliminary alternatives, additional development of the LOD concept was required. The LOD concept was modeled using both the ADCIRC model, to determine the degree of surge height reduction, and also the Beach-FX model, which was used to determine beach behavior (primarily the erosion resulting) during a hurricane event. In addition to numerous separate “lines” (barriers to surge), additional combinations of measures were also modeled to determine the most comprehensive package of measures.

The first Line of Defense, designated as LOD-1, was modeled to help predict what effects the islands have in storm reduction. LOD-1 alternatives included restoration to a pre-Camille condition, restoration to a pre-Katrina condition, restoration to a condition equivalent to the 1920's, and one in which additional height and length was created on each island. Model results are discussed in Section 2-10 of the Engineering Appendix.

Adding higher dunes and/or dune vegetation to shoreline beaches was designated as LOD-2. These dunes would not provide protection from large storms, but would be beneficial for smaller storms and would provide recreational and environmental benefits. Each of the three counties has beaches which are appropriate for adding dunes. For each county, 11 options were considered for adding some measure of dune creation. Most of the options have versions that included adding vegetation and sand fencing as well as dunes without these features. Eight of the options in each county have the dune placed against roadways that parallel the beaches with the assumption that these roadways would be elevated as a separate measure. Each of these options have a dune crest elevation less than the adjacent roadway (possibly raised in the future under LOD-3 options) to prevent sand from constantly being blown onto the road These options have some value as protection for the road, but more value as an ecological benefit. Two other options include a stand-alone dune out on the beach that could provide some level of surge defense along with ecological benefits. Each county also has an option with a wide sand berm fully planted with sea oats, the preferred vegetation to help stabilize dunes. This option will allow the sea oats to trap wind-blown sand and naturally build a dune with time. The dune options in all three counties total 33 different alternatives that could be considered.

The roadways that coincide with the beaches, while not continuous along the coast, were designated as LOD-3. It was envisioned that raising these roadways would have minimal environmental impact and provide the first hardened barrier to surge damage. The new road elevations would not be high enough to act as a seawall for very large storms, but like LOD-2, they would be beneficial for smaller, more frequent storms.

While different elevations were initially considered for the roadways, the technical difficulty of raising the roads over six feet was realized. This is due to the numerous intersecting roads, driveways, and parking areas that could not be constructed without extreme grades. The existing beachfront roads in Hancock and Jackson have a typical grade elevation of 5.0 and the general grade elevation for US 90 in Harrison County is 10.0 although it varies from elevation 7.0 to 16.0 depending on the exact location. With the existing road elevations, a top elevation of 11.0 was selected for study in Hancock and Jackson County and a top elevation of 16.0 was selected for study in Harrison County for a total of three options. It was also recognized that LOD-3 would require barriers placed at the mouths of the bays to be effective against back-flooding. The locations of the barriers are shown in Section 2-1 of the Engineering Appendix.

Some areas of the coast were not associated with beaches or existing roadways, which allow for a continuous defense line. When including environmental and/or technical concerns, these areas could only be viewed as stand-alone projects such as ring levees. These areas include five communities in Jackson County, one in Harrison County, and two in Hancock County. For discussion purposes, these ring levees were also included in LOD-3. Each of the conceptual ring levees have been evaluated for construction at two elevations, 20.0 and 30.0. Costs include interior drainage, pumping stations, gates for roadways and overtopping protection. Some sites also have one or more alternate alignments. The alternate alignments were selected to lessen the impacts on wetlands, lessen the intensity of wave action or to decrease the construction costs versus adding non-structural solution areas. With all ring levee elevations and alternate alignments, there were 24 different options for further consideration.

One of the areas being considered as a stand alone project is the Forrest (Forest) Heights community in Harrison County. Since its establishment by freed slaves and their descendants,

federally funded construction programs (including the Gulfport Regional Airport, U.S. Highway 49, and Interstate 10) have impacted this community. The Federal Government is prohibited from adversely impacting identifiable minority or low-income communities by proposed flood damage reduction measures, so this area was also considered as a stand alone project.

Further inland, an existing railroad grade provided a levee-like barrier to storm surge from Katrina in some areas. This railway extends all the way across the State, crossing both St. Louis Bay and Biloxi Bay. In Harrison County, the railway parallels the coastline just a few blocks inland. Using a parallel, high-ground alignment as the railway system, an inland barrier was envisioned that could be constructed to such an elevation as to protect from a large storm surge, even larger than Katrina. This system would require that the bays be closed off with barriers to form a continuous line of defense to be effective against surge. As LOD-4, this barrier was studied at elevations up to the maximum storm surge or maximum possible intensity (MPI) storm that could be predicted based on simulated hurricane events. These selected elevations are 20.0, 30.0 and 40.0.

Possible options for LOD-4 also included omitting the surge barrier across St. Louis Bay. This would require that LOD-4 be terminated along the east side of the bay. An alternate alignment to satisfy this option was selected at Menge Avenue in Pass Christian where the LOD-4 levee could be extended northward to higher ground. This option would also leave the town of Bay St. Louis without any type of surge protection. If this alternate alignment is used, Bay St. Louis hurricane defenses could be included as a ring levee with an option under LOD-3. Many alignments for project termination on the western and eastern sides of the state were considered before one that was selected, mostly due to technical and environmental reasons. This system would not cross the Pearl River on the western side of the state nor the Pascagoula River in Jackson County. Including all the different elevations and alignments for LOD-4, there are a total of 22 options including the six options for the surge gates. A general discussion of the LOD's is included in Section 2.1 of the Engineering Appendix. A more detailed discussion can be found in Part 3 of the Engineering Appendix.

While actually a non-structural measure, LOD-5 was designated as the limit of an MPI event surge. It would be an area north of any potential surge damage that would be recommended for location of critical infrastructure such as hospitals, long-term care facilities, and emergency facilities.

To proceed with initial cost estimates, various components of the structural options were conceptually designed to the selected elevations described in previous paragraphs. The initial elevations selected for each component of the lines of defense are assumed to bracket a wide range of potential storms with corresponding surge elevations. Using these preliminary designs, rough order of magnitude cost estimates were completed for each of the structural options. These cost estimates can be used to develop cost curves for rough estimates after final design elevations are selected. With these cost curves, future studies can also evaluate varied levels of protection based on risk assessments as well as taking into account future estimates of relative sea level rise.

3.14 Evaluation of Preliminary Alternatives

Evaluation of preliminary alternatives utilized modeling results and technical analyses conducted for each alternative and site or problem area. The study team then discussed their evaluations as a group to arrive at a consensus as to what was being discovered about the benefits or issues with each alternative, and its conceptual application to the site or problem area in question. This evaluation process also involved the application of numerous technical models, to determine, for instance, the behavior of waves, under both a without-project and with-project condition, or the benefit over time to a particular ecosystem created by a particular alternative.

The list of alternatives developed for each problem area was further refined, and additional data was presented for consideration, based on continued technical, environmental, and cost-effectiveness

analyses. More detailed input from the resource agencies, public and private entities, and technical staff was obtained. Consideration of potentially combining alternatives into multi-purpose alternatives, capable of dealing with more than one identified problem at a given site was also attempted. The screened list of alternatives was then combined into a well-balanced group that included both non-structural and if applicable, structural measures that could potentially address the entire suite of environmental problems plaguing an individual site or problem area. Formulation of these alternatives also incorporated the following criteria:

- Does a potential alternative provide for an improvement in function and/or habitat values of significant resources that might also provide for potential preservation of fish and wildlife and their habitats?
- Does a proposed action or project negatively impact low income or minority populations and/or children [i.e. Executive Orders (EOs) Environmental Justice and Protection of Children)?
- Does a proposed alternative provide a potential reduction in coastal erosion?
- Does a proposed alternative provide a potential reduction in the extent or level of saltwater intrusion (encroachment)?
- Does the proposed project fit in with, or complement, the objectives of the State of Mississippi and/or locals' plans and desires for the area?
- Does the proposal contribute to the short-term or long-term recovery of coastal Mississippi?

Using these questions as continued evaluative tools, the PDT employed these additional criteria specified in ER 1105-2-100:

- effectiveness
- completeness
- acceptability
- efficiency and cost-effectiveness.

Additional evaluative questions asked by the study team in its development of information on alternatives, but not considered screening criteria, also included:

- Does the alternative provide a reduction in risk at that specific site, or in other locations?
- Does the alternative provide a reduction in damage at that specific site, or in other locations?
- Can the alternative be combined as a component of a multi-purpose alternative?
- Can the measure be capable of dealing with more than one identified problem at a given site?
- Does a proposed alternative provide an increase in the level of education on hurricane risks?
- Does a proposed alternative provide a increase in time before one would be warned of an impending hurricane event (i.e., more time to prepare)?
- Does a proposed alternative provide an increased level of precision in information on the level of threat (i.e., better information on landfall location and magnitude of the event)?
- Does a proposed alternative provide an increase in the effectiveness of hurricane/storm warning to area residents and visitors?
- Does a proposed alternative provide better education as to evacuation options, required items a family or business might want to evacuate, and definitive information on routes to safety?
- Does this effort duplicate or compliment the work of others?
- Does the problem (or would lack of a solution to the alternative) enhance protection of life?

- Does the problem (or would lack of a solution to the alternative) enhance protection of property?
- Is a potential alternative sustainable after implementation?
- Does a potential alternative still provide a potential reduction in hurricane or storm damage (if applicable)?
- Does a potential alternative still provide a potential reduction in coastal erosion (if applicable)?
- Does a potential alternative still provide a potential reduction in the extent or level of saltwater intrusion (if applicable)?
- Does a potential alternative still provide for potential preservation of fish and wildlife and their habitats (if applicable)?
- Does a proposed action or project negatively impact low income or minority populations?
- Is the cost reasonable in the light of the risk and consequences of not implementing the project?
- Are there unresolved issues (with other groups or organizations) regarding this problem or proposed solution that may lead to longer implementation times?
- Would a proposed activity or project have potential regulatory and/or environmental issues that would preclude being implemented in the near-term?
- Does the proposed project fit in with, or complement the objectives of the State and/or locals plans and desires for this area?
- Would the implantation of the proposed project preclude other future options that may have a higher level of contribution or damage reduction?
- Does the proposed project contribute to the short or longer-term recovery of coastal Mississippi?

3.15 Comparison of Preliminary Alternatives

Comparison of preliminary alternatives consisted of analysis of “No-Action”, future “without-project”, and future “with-project” conditions for each site or problem area. Comprehensive plan development includes consideration of multiple mission, site and resource specific features. Inclusion of a feature into the comprehensive mean indicates that the feature meets the criteria and satisfies the goals and objectives of the MsCIP. Expediency is also a factor in ecosystem restoration site evaluation. Restoration sites which are currently state property or which are identified as potential restoration sites by existing state initiatives can more readily be restored and are more suitable for inclusion into a construction recommendation.

Data presented for comparison in Round Two included preliminary costs, benefits (monetary, or economic, environmental outputs, societal, etc.) to be derived from implementation, problems related to implementation, more detailed design considerations, environmental outputs and potential impacts, potential damages prevented, geotechnical/site considerations, more detailed technical requirements, source material and source area considerations, variations in materials that could be used to solve the problem in a similar way, species benefits or impacts considerations, and many other technical, environmental, or economic issues.

3.15.1 Storm Damage Reduction Alternatives

Comparison of damage reduction alternatives focuses on how effectively it reduced surge height and extent compared to other measures of similar output. This involved numerous iterations of potential height and geographic coverage, since literally thousands of potential alignments of levee or embankment might be created. The goal in damage reduction alternative formulation was to reduce

damages to the maximum extent possible for a given type of structural or non-structural measure. While many different measures such as levees, gates, seawalls, relocations, or structure elevations might produce a similar monetary damage reduction benefit, numerous iterations were necessary to develop the least costly and most productive alternative.

In general, non-structural plans including significant amounts of permanent acquisitions meet the objectives of storm damage reduction and reduced threats to life and public safety while providing substantial amounts of land for ecosystem restoration as wetlands and other sensitive habitat. Generally speaking these plans also are environmentally friendly having only minimal impacts (construction impacts at redevelopment sites) that can be mitigated and do not disproportionately affect low income or minority populations. Conversely, plans featuring substantial displacement of households may not be well accepted by the communities or local governments due to potential social and economic impacts (lost tax revenues).

The most notable differences in flood damage reduction alternatives were found when comparing 3rd line of defense (elevated seawall and beach roadways) with nonstructural alternatives along the same area (see Table 3-3). The structural alternatives are very costly for the amount of damages reduced compared to the nonstructural alternatives. This is due to the need for surge barriers across the bays, which must be construction in tandem with each structural alternative.

Table 3-3
Expected Annual Damage Reduction

Alternatives	Expected Annual Damage Reduction (Annual $)[1]	Residual Damage (Annual $)[1]	Implementation Cost ($)	Annual O&M (Annual $)	Average Annual Cost (Annual $)
(No Action)	$0	$0	$0	$0	$0
Seawall/Elevated Roadway[2]	$52,030,000	$374,010,000	$5,002,500,000	$60,148,000	$306,127,051
ABFE Nonstructural at Seawall/Elevated Roadway Footprint	$200,860,000	$225,180,000	$8,483,400,000	$110,000	$417,249,166

1/ Equivalent annual damages reduced are rounded to the nearest thousand dollars.
2/ The elimination of the seawall and elevated roadway option also eliminate the beach and dune placement options that are dependent on the raising of the seawall and roadway. Section 3.14 discusses this screening in more detail.

3.15.2 Ecosystem Restoration Alternatives

Preliminary alternatives for ecosystem restoration include site specific restoration efforts, potential freshwater diversion projects, restoration of barrier islands, submerged aquatic vegetation and multi-faceted restoration of Deer Island.

3.15.2.1 Preliminary Site Specific Restoration Alternatives

Comparison of ecosystem restoration alternatives involved the comparison of costs versus outputs, expressed in functional capacity units, FHIs, and other measures of benefit output, such as achievement of a critical level of restoration, or removal of an invasive plant that would prevent full restoration of that ecosystem.

Future with-project conditions were established by the study team, in analysis of the specific functions that would be modified, either positively or negatively, at each site. Those scores are presented in the Environmental Appendix, and summarized below.

1 **Table 3-4**
2 **Summary of Environmental Benefits**

Site	Restoration Acres	Alternative	AAFU/FHI* Benefits
Turkey Creek	879 wet pine savannah	Existing Condition (plans 1-2) North & South of Railroad	0
Turkey Creek	689 wet pine savannah	Existing Condition (plans 3-4) South of Railroad	0
Turkey Creek	190 wet pine savannah	Existing Condition (plans 5-6) North of Railroad	0
Turkey Creek	879 wet pine savannah	No-action Plan (plans 1-2) North & South of Railroad	0
Turkey Creek	689 wet pine savannah	No-action Plan (plans 3-4) South of Railroad	0
Turkey Creek	190 wet pine savannah	No-action Plan (plans 5-6) North of Railroad	0
Turkey Creek	879 wet pine savannah	Plan 1 – North & South of Railroad, Fill Ditches, Burn, Excavate Fill & Roadbeds	2,046
Turkey Creek	879 wet pine savannah	Plan 2 – North & South of Railroad, Fill Ditches, Mow, Excavate Fill & Roadbeds	1,352
Turkey Creek	689 wet pine savannah	Plan 3 – South of Railroad, Fill Ditches, Burn, Excavate Fill & Roadbeds	1,565
Turkey Creek	689 wet pine savannah	Plan 4 – South of Railroad, Fill Ditches, Mow, Excavate Fill & Roadbeds	815
Turkey Creek	190 wet pine savannah	Plan 5 – North of Railroad, Fill Ditches, Burn, Excavate Fill & Roadbeds	481
Turkey Creek	190 wet pine savannah	Plan 6 – North of Railroad, Fill Ditches, Mow, Excavate Fill & Roadbeds	327
Bayou Cumbest	110 emergent marsh 38 scrub shrub	No-action Plan	0
Bayou Cumbest	110 emergent marsh 38 scrub shrub	Plan 1 – Excavate, Remove Exotics, Fill Ditches, Plant 0.5 m spacing	191
Bayou Cumbest	110 emergent marsh 38 scrub shrub	Plan 2 – Excavate, Remove Exotics, Fill Ditches, Plant 1.0 m spacing	188
Bayou Cumbest	110 emergent marsh 38 scrub shrub	Plan 3 – Excavate, Remove Exotics, Fill Ditches, Plant 2.0 m spacing	184
Bayou Cumbest	110 emergent marsh 38 scrub shrub	Plan 4 – Excavate, Remove Exotics, Plant 0.5 m spacing	172
Bayou Cumbest	110 emergent marsh 38 scrub shrub	Plan 5 – Excavate, Remove Exotics, Plant 1.0 m spacing	169
Bayou Cumbest	110 emergent marsh 38 scrub shrub	Plan 6 – Excavate, Remove Exotics, Plant 2.0 m spacing	164

Site	Restoration Acres	Alternative	AAFU/FHI* Benefits
Dantzler	385 wet pine savannah	No-action Plan – North & South of Road	0
Dantzler	385 wet pine savannah	Plan 1 – North & South of Road Burn, Remove Exotics, Fill Ditches	1,244
Dantzler	385 wet pine savannah	Plan 2– North & South of Road Mow, Remove Exotics, Fill Ditches	943
Dantzler	151 wet pine savannah	Plan 3 – North of Road Burn, Remove Exotics, Fill Ditches	488
Dantzler	151 wet pine savannah	Plan 4 – North of Road Mow, Remove Exotics, Fill Ditches	370
Dantzler	234 wet pine savannah	Plan 5– South of Road Burn, Remove Exotics, Fill Ditches	756
Dantzler	234 wet pine savannah	Plan 6 – South of Road Mow, Remove Exotics, Fill Ditches	573
Admiral Island	62 emergent marsh 61 scrub shrub	No-action plan	0
Admiral Island	62 emergent marsh 61 scrub shrub	Plan 1 – Excavate Fill, Remove Exotic, Fill Ditches, Plant 0.5 M Spacing	61
Admiral Island	62 emergent marsh 61 scrub shrub	Plan 2 – Excavate Fill, Remove Exotic, Fill Ditches, Plant 1.0 M Spacing	60
Admiral Island	62 emergent marsh 61 scrub shrub	Plan 3 – Excavate Fill, Remove Exotic, Fill Ditches, Plant 2.0 M Spacing	59
Admiral Island	62 emergent marsh 61 scrub shrub	Plan 4 – Excavate Fill, Remove Exotic, Plant 0.5 M Spacing	51
Admiral Island	62 emergent marsh 61 scrub shrub	Plan 5 – Excavate Fill, Remove Exotic, Plant 1.0 M Spacing	50.5
Admiral Island	62 emergent marsh 61 scrub shrub	Plan 6 – Excavate Fill, Remove Exotic, Plant 2.0 M Spacing	49
Franklin Creek	149 wet pine savannah	No-action Plan (plans 1-2) North & South of Railroad	0
Franklin Creek	56 wet pine savannah	No-action Plan (plans 3-4) South of Railroad	0
Franklin Creek	149 wet pine savannah	Plan 1 – North & South of Railroad Fill Ditches, Burn, Excavate Roads & Fill, Add Culverts	516
Franklin Creek	149 wet pine savannah	Plan 2– North & South of Railroad Fill Ditches, Mow, Excavate Roads & Fill, Add Culverts	399
Franklin Creek	56 wet pine savannah	Plan 3 – South of Railroad Fill Ditches, Burn, Excavate Roads & Fill	194
Franklin Creek	56 wet pine savannah	Plan 4 – South of Railroad Fill Ditches, Burn, Excavate Roads & Fill	150
Deer Island	78 tidal marsh 30 dune habitat 78 maritime forest 86 beach habitat	Deer Island Seaward Shoreline Restoration Plan	2152.5*
Deer Island	20 tidal marsh	Deer Island Containment Restoration	243*

Site	Restoration Acres	Alternative	AAFU/FHI* Benefits
		Plan	
Deer Island	Maintains existing	Deer Island Breakwater Protection	122*
Deer Island	20 tidal marsh	Deer Island Eastern Marsh Plan	122*
Deer Island	128 tidal marsh 30 dune habitat 78 maritime forest 86 beach habitat	Deer Island Combination Restoration Plan	2639.5*

- AAFU's are based on a 50-year period of analysis.

See Economic Appendix for cost-effective analysis.

3.15.2.2 Preliminary Deer Island Restoration Alternatives

Storm events throughout history have resulted in severe erosion to Deer Island and it was actually divided into two parts after Hurricane Elena on Labor Day in 1985. Deer Island, located south of Biloxi, has maintained its coastal maritime forest, beach/dune complex, freshwater lake, and emergent tidal marsh habitat over time but has lost approximately 300 acres to erosion since the late 1800s. This uninhabited island is one of the last natural islands along the Gulf Coast and was designated as part of the Mississippi Coastal Preserve by MDMR. Deer Island provides the mainland with hurricane/storm protection by helping to dissipate wave energy prior to its reaching the shoreline of the coast The island also provides various species, such as blue herons, osprey, and feral pigs, with necessary habitat hard to find in this highly developed area. Within Mississippi Sound a number of island features have existed over time and today Deer Island is one of only four mainland islands left in existence in the Sound. Figure 3-8 displays a recent aerial photograph of Deer Island.



Figure 3-8
Deer Island Aerial Photograph

This unique mix of habitats on Deer Island is critical to the continued health of a number of fish and wildlife species. In addition to supporting many species of migratory waterfowl and shore/wading birds, Deer Island is located on the Mississippi flyway for many varieties of migratory neo-tropical species. The site is particularly important to grassland species, many of whom winter here, and migrate to northern states, Canada or the Arctic for the summer. Unless constrained by bad weather or insufficient fat reserves, birds are selective and they will search for a preferred habitat type in which to stop over. Most of these habitats have been impacted and/or destroyed nationally, regionally, and locally by development and/or natural events. Failure to address the loss of these types of habitats nationally, regionally, and locally (i.e. Deer Island) threatens the long-term health of the entire ecosystem. A delicate environmental web exists between these vital habitats. A shift in any of these habitats can cause detrimental effects, such as water quality issues or a reduction in fishery population due to emergent marsh loss. The beach/dune systems provide the first defense against wave action (i.e. tropical storms/hurricanes). Loss of these natural systems across the nation has resulted in many impacts, such as the loss of migratory bird nesting, higher property destruction, and reduction in sea turtle nesting. Emergent tidal marsh habitats serve as natural floodwater retention and over time, the loss of these marshes has contributed to increased flooding throughout the coast. Coastal maritime forests are typically found along the Gulf barrier islands. Unfortunately, following Hurricane Katrina approximately 80 to 90% of the habitat was significantly damaged and today only Cat Island in the west and Dauphin Island, Alabama to the east continue to have vibrant forest habitat. Deer Island's maritime forest was severely impacted by the tidal surge resulting in the loss of almost the entire pine forest. The community of the island is unique in that it is "trapped", and the climate and environment are relatively "harsh", resulting in a system that has very specifically adapted to the special conditions of the site.

In 2005, the Corps restored 45 acres of emergent marsh habitat via beneficial use of dredged material program within a containment site on the northeastern portion of the island. However, due

to Hurricane Katrina, the site has experienced severe erosion. As a result, it was determine that the breakwaters associated with this project are not sufficient to keep up with current erosion rates.

Another project, authorized under Section 528 of the Water Resources Development Act (WRDA) of 2000, consists of the filling of the western breach of the island. This effort is part of an overall restoration plan for the island, but due to funding limitations, the breach component will likely be the only portion completed. Thus, the additional items of that restoration plan, along with restoration of the 2005 project, have been considered in this comprehensive study. The MsCIP team determined that the following alternatives need to be evaluated further for consideration:

- Restoring the Southern Shoreline. This alternative would restore 30 acres of dune habitat, 78 acres of emergent tidal marsh habitat, 78 acres of coastal maritime forests, and 86 acres of beach habitat along the southern shoreline of the island.
- Restoring the containment area associated with the 2005 beneficial use of dredged material project. This alternative would restore the containment dikes, place new dredged material into the existing containment site, and plant 30 acres of emergent tidal marsh.
- Developing new breakwater protection for the Island. This alternative would extend both the southern and northeastern breakwaters to form a solid line of protection.
- Restoring eroded marsh from the northeastern end of the island. This alternative would restore 20 acres of emergent tidal marsh habitat adjacent to the existing 2005 containment site project.
- Combination restoration plan. This plan would extend both existing breakwaters, restore 128 acres of emergent tidal marsh habitat, 78 acres coastal maritime forest, 86 acres of beach habitat, and 30 acres of dune habitat.

In 2003, because of loss of wetland marsh areas, an aquatic restoration project was proposed near the eastern tip of Deer Island. The project was authorized under the continuing authority of Section 204 of the Water Resources Development Act of 1992, as amended. Dredged material from maintenance of Biloxi Harbor was used to create approximately 45 acres of tidal marsh on the north shore of the east end of the island. Wetland vegetation was planted by over 100 volunteers in April 2005. The created marsh area withstood Hurricane Katrina with minor scouring within the site but with a minor breach of the containment dike of the marsh area. Plants within the marsh area are thriving. Figure 3-9 displays the existing Section 204 project.



Figure 3-9
Existing Section 204 Project at Deer Island

Currently, the island has a large breach on its western end and a small breach has formed in the central area of the island in what is known as the Grand Bayou area. As the island degrades, the Federally authorized shallow draft Biloxi West Approach and Biloxi Lateral navigation channels that run between the City of Biloxi and Deer Island will experience increased shoaling and will require more frequent and costly maintenance dredging activities. Dredging in this area occurs twice as frequently as similar nearby channels. Deer Island also provides erosion protection to the mainland of the City of Biloxi. As the island continues to degrade, the impacts of increased wave action on the mainland shoreline will increase the amount of storm damages that can be suffered by commercial development congregated in this area.

In summary, there is a need to restore the shoreline of Deer Island, fill the breach areas, repair/improve existing marsh and maritime forest areas, and add additional marsh area. These efforts will provide protection to the mainland areas behind the island and improve critical coastal wetlands.

3.15.2.3 Preliminary Freshwater Diversion Alternatives

The Barrier Islands of the Mississippi Sound, the Grand Bay Savannahs and Marshes in the Escatawpa River basin of Jackson County, and the Hancock County Marshes on the western end of the Mississippi Sound, have degraded over the years. The levee systems built in eastern Louisiana and other man-made structures (i.e. railroads and highways) in the Escatawpa River basin have resulted in the loss of historic freshwater surface flows from the Mississippi, Pearl, and Escatawpa Rivers. This problem was greatly exacerbated by Hurricane Katrina and other storms in 2005. The lack of freshwater, and erosion of the Barrier Islands, have enabled more saline-tolerant predators to

enter the Mississippi Sound, causing a decline in fish and wildlife resources. Particularly hard hit were the oyster resources.

Freshwater diversions would enable the redistribution of freshwater and much needed sediments to several degraded ecosystems of coastal Mississippi. A sensitivity analysis was conducted by the MsCIP team in order to see if diversion of freshwater flows could indeed reduce salinity within the Mississippi Sound. Hydrodynamic circulation, salinity, and water quality model calibrations were made using a water quality model developed by ERDC in 1998 for a previous project near Gulfport, Mississippi. This analysis was conducted at three sites: (1) Increased diversion of freshwater flows from the Mississippi River at the existing Bonnet Carre' spillway, (2) a new diversion of freshwater flow from the Mississippi River at the Violet Marsh, and (3) a new diversion of all of the Escatawpa River flow into Grand Bay savannahs and marshes. Results showed that these diversions do have the potential to significantly influence coastal salinities.

Using this data, two new freshwater diversion alternatives were developed. One is located near the community of Violet, in the St. Bernard Parish of Southern Louisiana. This diversion structure would be located on the eastern bank of the Mississippi River, and would help restore the Hancock County Marshes. The second alternative is located within the eastern portion of the state along the Escatawpa River, and would help to restore the Grand Bay Savannahs and Marsh. While increasing flows at the existing diversion at Bonnet Carre' in Louisiana was considered, this alternative is believed to have significant negative environmental impacts to the Lake Pontchartrain ecosystem, as well as strong opposition from area residents.

It should be noted that freshwater diversions may also result in areas of excess nutrients. This can cause algal blooms, lower light attenuation, and other signs of eutrophication. Therefore, any diversion project needs to be carefully evaluated in order to insure the proper habitat and water quality conditions are met. Due to the time constraint of this MsCIP Comprehensive Report and Integrated Programmatic EIS, the MsCIP team was only able to qualitatively determine that freshwater input into the systems does change the overall environment. It is known that these systems have been altered and/or starved by lack of freshwater inflow. An integrated environmental web exists in these rivers and also in Mississippi Sound, which needs to be fully identified, in order to completely understand various effects that could possibly occur.

Therefore, the MsCIP team recommends additional water quality and quantity studies of the two freshwater diversion alternatives. These studies are necessary to assess the amount of freshwater flows required to positively impact each ecosystem.

Several key attributes that would be incorporated into the evaluation of the freshwater diversion options include:

- Salinities should average as closely as possible to the optimal range for oyster health and productivity;
- A diversion should not result in extended periods of low salinity resulting in oyster mortality or poor growth and reproduction;
- A diversion should not unduly influence habitat conditions for other critical resources, especially submerged aquatic vegetation;
- Other important environmental concerns include potential impacts on important fisheries species of those areas.

In a collaborative effort, the MsCIP team continues to work closely with the Louisiana Coastal Protection and Restoration team to coordinate our efforts. This close coordination allows both the States of Mississippi and Louisiana to accomplish its respective goal of increasing sedimentation and freshwater via diverting water from the Mississippi River. WRDA 2007 authorized a freshwater diversion project at Violet, Louisiana. The project is required to produce the same benefits for the

Biloxi Marshes and Mississippi Sound as an earlier project (1988) at the Bonnet Carre Spillway in Louisiana. As authorized, this project, through a collaborative effort between the Corps and the States of Mississippi and Louisiana, would be developed, analyzed for potential benefits and adverse environmental impacts, and designed to meet specific goals and objectives.

3.15.2.4 Preliminary Submerged Aquatic Vegetation Alternatives

The continued survival and growth of submerged aquatic vegetation (SAV) may be threatened by the cumulative effects of man's activities in addition to natural processes in the coastal marine environment. Natural causes of SAV decline, such as disease, storm events, salinity fluctuation, and hypoxic events, coupled with declining water quality caused by anthropogenic eutrophication currently threaten the health of many SAV systems (Montague and Ley 1993, Durako and Kuss 1994, Olesen and Sand-Jensen 1994, Zieman et al 1994). These habitats provide vital refuges, feeding, resting, staging, and spawning grounds for a variety of species found in Mississippi Sound and also in the Gulf of Mexico. Past studies throughout the years have attributed anywhere from 50% to 90% of all marine species utilize this vital habitat at some point in their life state.

In 1969, an estimated 20,000 acres of SAVs were documented in Mississippi and coastal bays. As of 1998, only 2000 acres were documented (Moncrieff 1998), see Table 3-5. Dramatic decreases have been noted on every Mississippi barrier island. Areas of SAV habitat loss coincide with areas where rapid coastal erosion and massive long-term movement of sand has been well-documented (Otvos 1981 and Oivanki 1994). Loss of vegetated areas corresponds with potential loss in water clarity over time due either to: (1) anthropogenic influences, (2) cyclic shifts in precipitation patterns, which would affect both salinity and turbidity, or (3) a combination of these factors (Moncrieff 1998). Primary reasons for the disappearance of SAVs are most likely an overall decline in water quality, extended periods of depressed salinities, and physical disturbances, such as tropical storms and hurricanes (Moncrieff 1998). Physical loss of habitat and decreased light availability coupled with declining water quality are the most visible features that directly affect SAVs (Moncrieff 1998). Moncrieff (1998) identified approximately 14,900 acres as being suitable SAV habitat [i.e. Potential Seagrass Habitat (PSGH)].

Table 3-5
SAV Historical, 1992 and Potential Habitat

Location	1969 (acres)	1992 (acres)	Potential SAV Habitat
Buccaneer State Park	206	55	316
Cat Island	598	169	5,128
Ship Island	1,536	253	1,603
Dog Keys Pass	2,079	0	1,149
Horn Island	5,567	530	4,350
Petit Bois Island	1,690	364	1,810
Point-aux-Chenes Bay	1,306	627	534
Totals	12,982	1,998	14,890

Reference: Moncrieff 1998

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physical disturbances, such as tropical storms and hurricanes (Moncrieff 1998). Physical loss of habitat and decreased light availability coupled with declining water quality are the most visible features that directly affect SAVs (Moncrieff 1998). Moncrieff (1998) identified approximately 14,900 acres as being suitable SAV habitat.

Therefore, the MsCIP team determined the need to include an alternative that would aid in restoring SAVs in Mississippi Sound and adjacent bays. Due to this large-scale effort and uncertainties of successful restoration of other efforts, the team decided that a smaller restoration effort may need to be conducted before lessons learned could be applied to any larger-scaled effort. Thus, one alternative measure evaluated consisted of restoring the SAV beds lost in Bayou Cumbest, adjacent to the Grand Bay NERR, as a result of the storms of 2005.

3.16 Screening of Preliminary Alternatives

Screening of preliminary alternatives included screening of structural, non-structural, and ecosystem restoration components of a comprehensive plan. The screening process involved comparison of the relative benefits, impacts, costs, societal impacts, or other outputs of a given plan, as compared to each other and the "No-Action" Plan.

A large number of site-specific alternatives were eliminated, such as some seawall or beach berm/dune alternatives, based on their failure to achieve significant damage reduction. Screening also eliminated a large number of embankment/levee options, as too environmentally damaging or technically infeasible. These included levees, embankments, and floodwalls across embayments and channels in western Hancock and eastern Jackson Counties, levees across Grand Bay Marsh, or the Pearl River delta systems, and across wetland areas along other parts of the coast, as shown in Table 3-6.

Table 3-6
Summary of Round Two Screening of Measures

Preliminary Alternatives Screened Out of the Analysis
Hancock 40' Dune @ Elevated Roadway (Option A)
Hancock 50' Dune @ Elevated Roadway (Option B)
Hancock 20' Dune @ Elevated Roadway (Option C)
Hancock 30' Dune @ Elevated Roadway (Option D)
Hancock Dune Option A plus sea oats (Option E)
Hancock Dune Option B plus sea oats (Option F)
Hancock Dune Option C plus sea oats (Option G)
Hancock Dune Option D plus sea oats (Option H)
Harrison 40' Dune @ Elevated Roadway (Option A)
Harrison 50' Dune @ Elevated Roadway (Option B)
Harrison 20' Dune @ Elevated Roadway (Option C)
Harrison 30' Dune @ Elevated Roadway (Option D)
Harrison Dune Option A plus sea oats (Option E)
Harrison Dune Option B plus sea oats (Option F)
Harrison Option C plus sea oats (Option G)
Harrison Dune Option D plus sea oats (Option H)

Preliminary Alternatives Screened Out of the Analysis
Jackson 40' Dune @ Elevated Roadway (Option A)
Jackson 50' Dune @ Elevated Roadway (Option B)
Jackson 20' Dune @ Elevated Roadway (Option C)
Jackson 30' Dune @ Elevated Roadway (Option D)
Jackson Dune Option A plus sea oats (Option E)
Jackson Dune Option B plus sea oats (Option F)
Jackson Option C plus sea oats (Option G)
Jackson Dune Option D plus sea oats (Option H)
Hancock Seawall/Elevated Roadway at Elevation 11
Harrison Seawall/Elevated Roadway at Elevation 16
Jackson Seawall/Elevated Roadway at Elevation 11
Biloxi Bay Surge Gate at Elevation 20
St Louis Bay Surge Gate at Elevation 20

The following discussion highlights those alternatives which were deemed "no longer feasible." More detailed information can be found in the accompanying appendices.

Lines of Defense (LOD) 2 and 3. The original concept behind these two lines of defense was to create barriers which would reduce flood damages from moderately sized storm surges. Larger storm surges (similar to Hurricane Katrina) would be addressed by the fourth line of defense. The "most workable" solution for the third line of defense included elevating the roadways along the beach. They would in turn be connected to "surge gates" across Bay Saint Louis and Biloxi Bay to keep water from entering around the sides of the roadway. Just raising the roadway up to an elevation of 6 feet, an elevation that could be overtopped by less than a "1 percent" chance storm, proved to be challenging. The side slopes of an elevated roadway, along with ramps to get local traffic onto the roadway, would require the buyout and removal of most of the houses they were designed to protect. Also, the surge gates proved to be exceedingly costly for the amount of damage reduction benefits received. Therefore, all of the LOD 3 options, parallel to the coastwere eliminated from further consideration. Ecosystem restoration benefits were also an objective of the second line of defense and several of the dune options were designed to work in tandem with the elevated road options. A cost effectiveness analysis eliminated several of these options (see the Economic Appendix for more information), and others were eliminated because they needed LOD3 in place. This left only the low dune options designated as i, j, and k to carry forward for further evaluation.

Ecosystem Restoration Alternatives. The Corps' SDSS tool was used to screen the 1,086 potential wetland restoration areas. These sites were identified as ones that would not likely provide the desired ecosystem benefits. These sites were "ground-truthed" by the MsCIP team, which included members from ERDC, MDMR, and the USFWS. The MsCIP team also coordinated with the Corps' Nonstructural Floodproofing Committee to help screen potential restoration sites in coastal Mississippi. Thirty-four of these restoration sites were selected for further analysis, and an additional eleven sites were selected as a result of cooperation with the State of Mississippi.

3.17 Development of Final Alternatives

All of the development of measures and alternatives, evaluation, and screening conducted to this point in the plan formulation process has resulted in a relatively small set of alternatives to be analyzed at the highest level of detail. The final refinement of alternatives consisted of incorporating comments from team members and stakeholders, as well as making adjustments based on the last set of evaluations. The final refinement was directed at identifying the most cost-effective options within the four key areas of study:

- Hurricane / storm damage reduction;
- Ecosystem restoration for preservation of fish, wildlife and habitat functions and values;
- Saltwater intrusion / encroachment reduction; and
- Coastline Erosion.

Saltwater intrusion/encroachment reduction and coastal erosion reduction purposes are encompassed under the discussions of hurricane / storm damage reduction and ecosystem restoration alternatives.

Each alternative was refined to achieve more damage reduction, more ecosystem benefits, greater freshwater inflow, or better salinity reduction, particularly during the period of greatest importance in the life cycles of select organisms.

The set of final storm damage reduction alternatives is listed and discussed below. Additional discussion is also provided for LOD 4 and LOD 5, which are not advanced as final alternatives. Each of the final alternatives was refined based on higher detail data collection and technical analyses where applicable. The System of Accounts Tables, located later in this section, display the evaluation and comparison of the final alternatives.

Final Hurricane / Storm Damage Reduction Alternatives

- LOD – 1 Barrier Island restoration
- LOD – 2 Beach/Dune restoration
- LOD – 3 Ring Levees
- High Hazard Risk Reduction Plans
- Elevation of Structures
- Relocation of Municipal Services

3.17.1 Barrier Islands

Modifications to the Mississippi barrier islands were identified as LOD-1. The islands were among the first storm reduction aspects that were discussed in Mississippi's Recovery Plan. Through many meetings, a set of options were formulated that could be combined into an alternative that would meet with approval of the state of Mississippi, plus be consistent with the 2006 NPS Management Policies. The options included:

Barrier Island Plan B – Replenishing sand in the littoral zone from inland river source;

Barrier Island Plan C – Replenishing sand in the littoral zone from offshore source;

Barrier Island Plan D – Reshaping the south beach to form 2-foot dune structure;

Barrier Island Plan E – Constructing a 6-foot dune structure using offshore source;

Barrier Island Plan F – SAV restoration;

Barrier Island Plan G – Restoration of the Ship Island breach; and

Barrier Island Plan H – Comprehensive Environmental Restoration of Barrier Islands Plan.

3.17.2 Beach and Dune System

Modifications to coastal Mississippi's beach and dune system were identified as LOD-2. Alternatives that would provide some degree of protection along the mainland beaches include constructing dunes in several configurations (Dune Options I, J, and K). Options I and J provide a 10-foot elevation stand alone dune, while Option K consists of a low elevation dune with dune vegetation onto the existing beaches (See Figure 3-10).

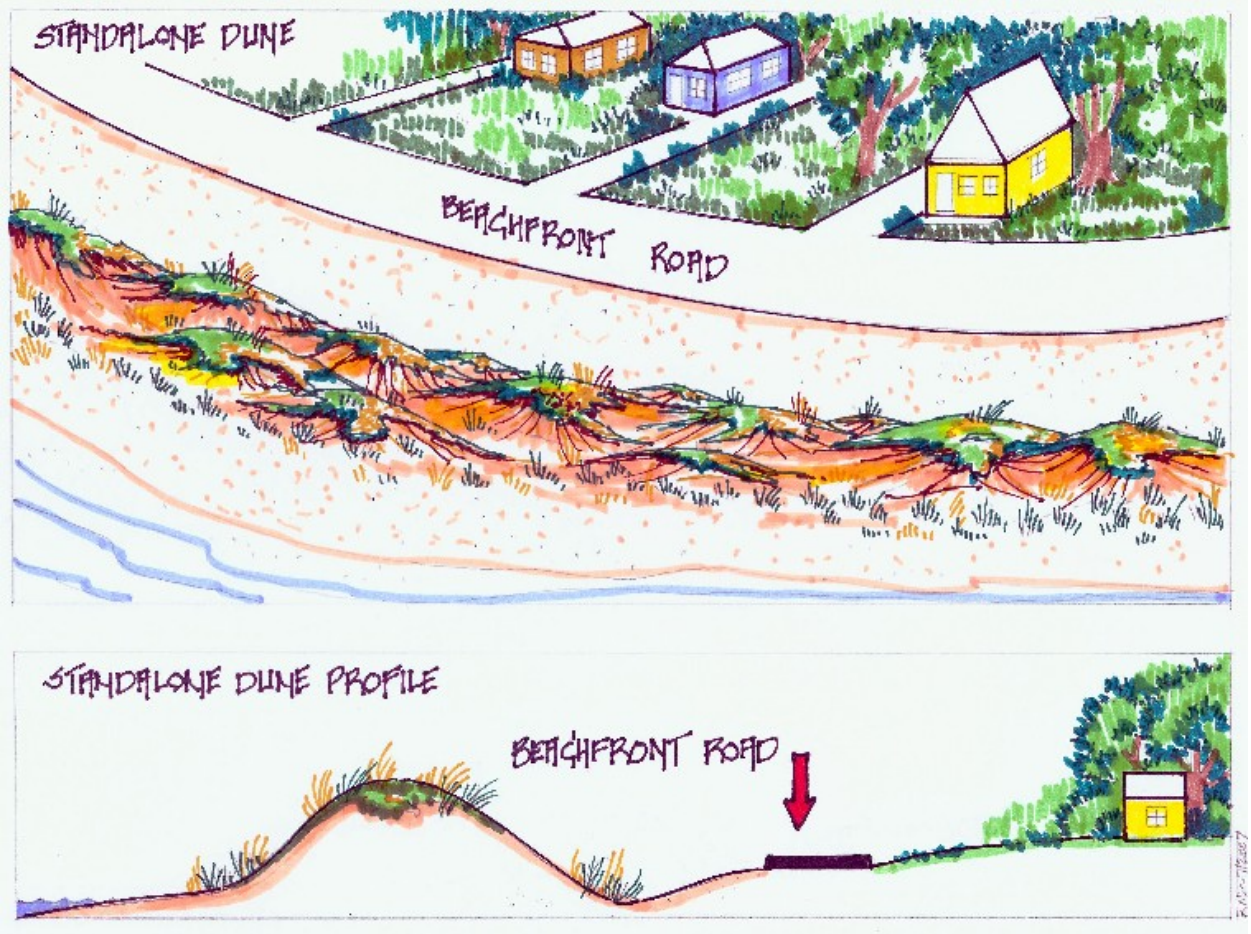


Figure 3-10
Rendering of Dune Options

3.17.3 Ring Levees

Ring Levees have been identified as a component of LOD-3. Many parts of the Mississippi coast do not have the topography or population density necessary to support a continuous barrier such as a levee parallel to the coast. To help provide some storm defense for these areas, such as the Forrest (Forest) Heights community, ring levees could be used. The alignment of these ring levees was initially selected to provide the maximum protection for the population centers. As initial alignments were evaluated, alternate alignments were selected in some cases to minimize impact on wetlands, provide attenuation from direct wave attack, or decrease the quantity of fill required for levee construction. Examples of alternate alignments include Gulf Park Estates, Belle Fontaine, and Pascagoula in Jackson County. The crest elevations for these ring levees could vary depending on the amount of risk that that community is willing to assume. The recommended crest elevation is typically designed for a surge and waves with a 0.2 percent annual chance of being exceeded.

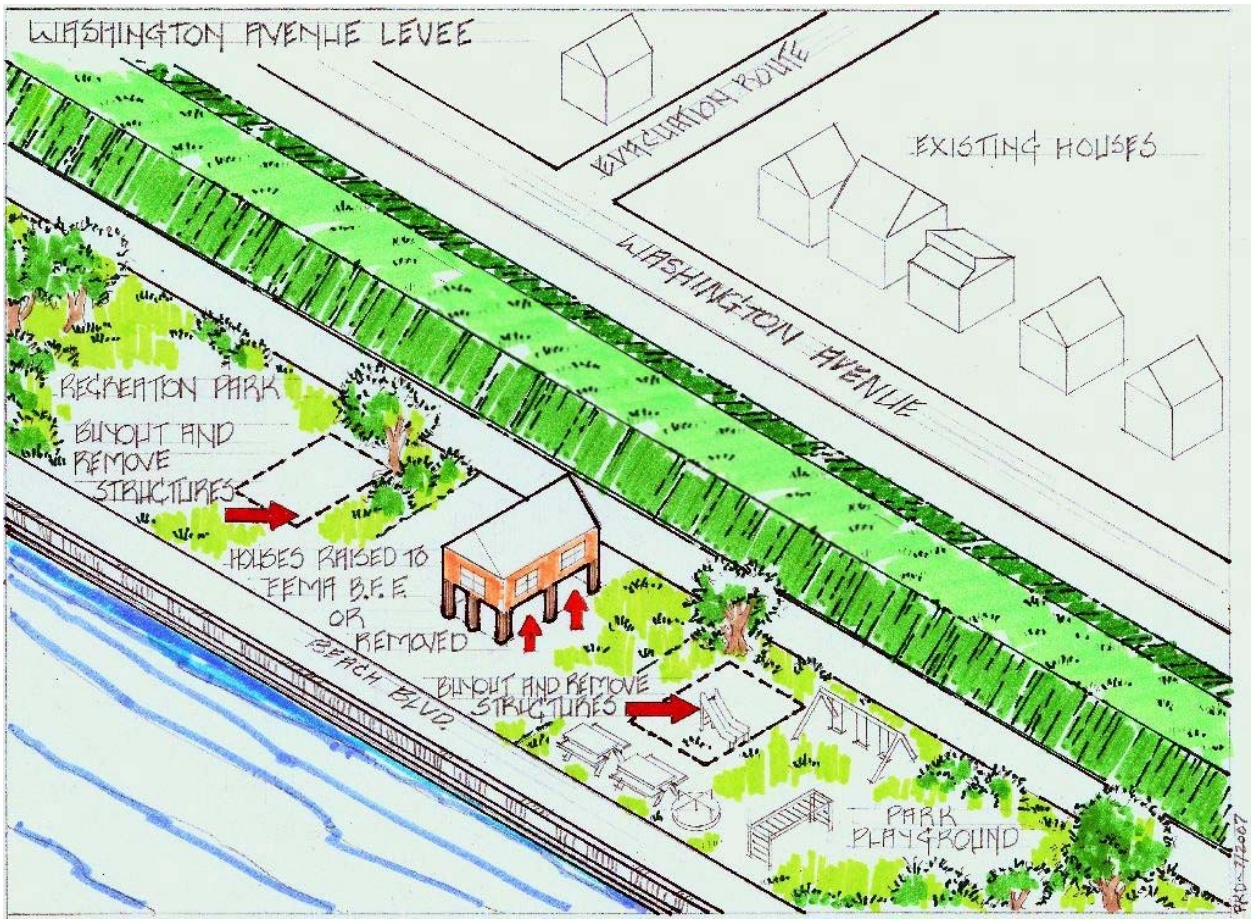


Figure 3-11
Rendering of a Ring Levee Alternative in Pascagoula.

3.17.4 Inland Barrier System

An inland barrier system (LOD-4) was not advanced as a final alternative, but the following information is provided for clarification. Alternatives within this line of defense, which could reduce the risk of inland flood damages from larger storms, are comprised of inland levees with surge barriers across the mouths of the two large bays in Mississippi. In combination, this barrier could

extend from the first watershed divide east of the Pearl River in Hancock County westward to the last watershed divide west of the Pascagoula River following parallel to an existing railway. While surge gates were not deemed cost effect in tandem with a LOD-3 barrier, this barrier could be designed to provide a defense from a very large storm, thus providing substantially more benefits. However, it would have some aspects that may not have public or political support. Depending on the selected crest elevation, the levee may be hardly noticeable in some areas with naturally high topography such as portions of Biloxi, but may be a very high feature in areas with low topography such as Pass Christian. Another feature is the surge gates that would be required to prevent back-flooding into the bays. Evaluation of the requirements to have the gates as a component revealed that the closure of St. Louis Bay could be omitted provided that the levee did not cross into Hancock County, but the closure of Biloxi Bay is required to provide any beneficial defense for Gulfport or Biloxi. The surge gate evaluation provided an alternate levee alignment in Harrison County that could omit this defense in western Harrison County and Hancock County. The alternate alignment would parallel the railway through Harrison County westward to the Menge Avenue crossing where the levee would turn north to high ground. Due to its east-west extent in Harrison County, this portion of the levee system could also be used to support the construction of a major roadway on top of the levee by widening the crest.

Due to the accelerated nature of this study, the study team was unable to develop feasibility level designs for any of the final structural alternatives. Further, based on input received at the various public and stakeholder meetings, the structural measures did not receive a majority of support. There is, however, sufficient information to make basic comparisons with nonstructural flood damage reduction alternatives, so these alternatives were carried forward for further consideration.

3.17.5 Non-Structural Risk Reduction

While the discussion of nonstructural measures at public meetings was emotionally charged, there was a general consensus that any relocations resulting from the 2005 storms not displace large portions of communities. This resulted in the development of multiple non-structural elements of the comprehensive plan, including evacuation planning, building codes etc. and acquisition or flood proofing of properties within the area identified as having a 1% annual chance of inundation from hurricane and storm surges (aka '100-yr' floodplain). A portion of this area is designated the high-hazard zone and in this area flood proofing by elevation is not considered appropriate due to the forces associated with the surge therefore permanent acquisition of properties and removal of structures is the only option for risk reduction.

Acquisition or flood proofing of all properties within the '100-yr' floodplain equates to approximately 35,000 parcels. Obviously it is not realistic to consider that this action could be undertaken within a short timeframe due to impacts on local tax base, ability to acquire, cost etc. It is more realistic to consider that this component could be phased in over a 25 – 40 year period. Therefore, phased implementation of separable elements was developed, including a flood proofing demonstration, a municipal acquisition and relocation project, a high hazard area risk reduction plan (HARP Phase I) and a long-term risk reduction plan (HARP Phase II). The flood proofing demonstration could lead to further study of specific areas of the coast and subsequent implementation by the Federal government or it could lead to increased involvement of local government or residents in providing for the risk reduction. Each of these elements is described in more detail below.

3.15.5.1 High Hazard Area Risk Reduction Plan (HARP) Phase I

The first phase of the non-structural High Hazard Area Risk Reduction Plan (HARP Phase I) involves the buyout of those properties that have been frequently flooded, or are at very high probability of future damage due to storm surge. The first phase of the HARP would include acquisition of approximately 2,000 properties which can be implemented over the next five years.

Further information on the High Hazard Area Risk Reduction Plan can be found in the Nonstructural and Real Estate Appendices.

3.15.5.2 High Hazard Area Risk Reduction Plan Phase II

During public involvement sessions a significant portion of the population believed that the rebuilding process might already be too far advanced to relocate a significant number of residents to another location at this time. Therefore, the second phase of the HARP is to develop a strategy where buyouts along the coast can occur quickly over a long period of time as properties and funding become available. This could also occur after the next significant storm event, and before another major reconstruction effort within the high-hazard surge-plain begins. The long-term risk reduction plan is envisioned as a coordinated effort between HUD, FEMA, and the Corps that would be applied as future storms impact the area.

3.15.5.3 Elevating Structures and Relocating Municipal Services

In addition to the HARP, the team developed alternatives for pilot projects involving new methods for elevating structures in the hardest hit areas of Waveland, Mississippi, and relocating municipal



services to higher ground in Moss Point, Mississippi, as shown in Figure 3-12a and 3-12b.

Figure 3-12a
Moss Point Public Facilities Relocation Pilot Project

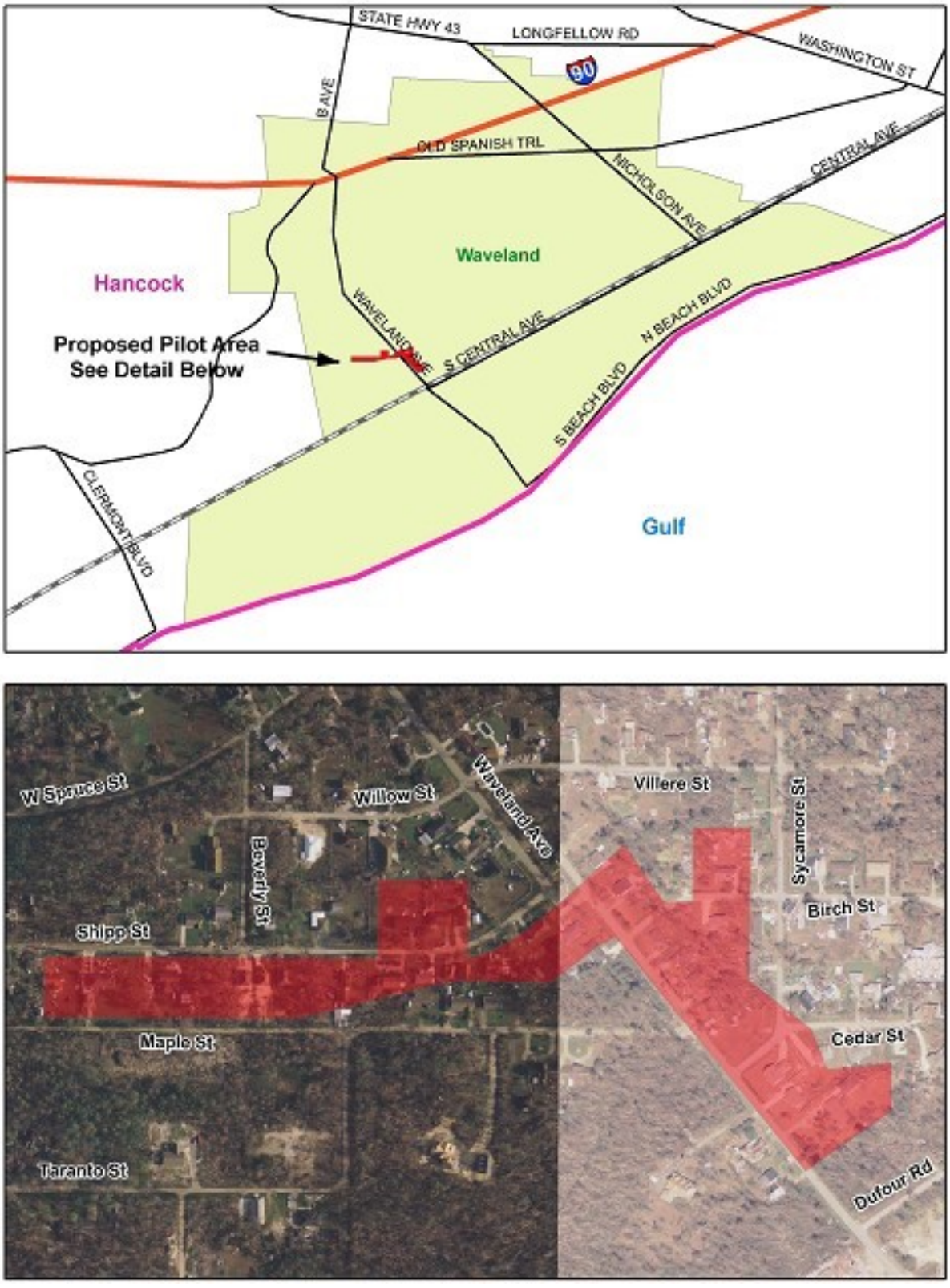


Figure 3-12b
Location of Proposed Waveland, MS Pilot Floodproofing Project

3.15.5.4 Maximum Possible Intensity Line (Line of Defense #5)

This is only a recommendation without a program requirement and has no direct implementation cost. The one option that will provide a very low probability of future damage from storm surge is moving all critical or emergency infrastructure construction northward / inland of the limits of the surge. This line would be based on the "Maximum Possible Intensity" (MPI) storm event modeling and could be accomplished by collaborative efforts at the local, county, and state levels.

3.17.6 Final Ecosystem Restoration Alternatives

The set of final ecosystem restoration alternatives includes actions which would directly address the salt water intrusion and fish and wildlife preservation aspects of the Congressional authorization. Some of the alternatives also provide secondary storm damage reduction and erosion reduction benefits. The following measures were carried forward into the final array of ecosystem restoration alternatives.

Final Ecosystem Restoration Alternatives

- Freshwater Diversions
- Restoration of Historical Wetlands at Multiple Sites
- Submerged Aquatic Vegetation (SAV) Restoration
- Deer Island Ecosystem Restoration

3.15.5.5 Freshwater Diversions

Diversion of Mississippi River freshwater and/or sediments in the vicinity of Violet, Louisiana has been strongly considered because of a number of positive factors. These include proximity of the river to target coastal wetland restoration areas' ability to influence Mississippi Sound salinities, strong public support, and high confidence in potential environmental benefits. The Violet Diversion Project is under consideration as a joint bi-state effort between Mississippi, Louisiana, and the Corps, Mobile and Corps, New Orleans Districts. This freshwater diversion project could have a positive impact to the Biloxi marshes of southeast Louisiana and wetlands in Hancock County (Mississippi Sound ecosystem). Preliminary results from modeling a simulated diversion of 7,500 cubic feet per second of Mississippi River water near Violet, Louisiana, suggest that after 180 days of initiation of the diversion, salinities would be lowered in Western Mississippi Sound sufficiently to warrant additional examination (Dortch et al 2007). A diversion at Violet was authorized in WRDA of 2007 but additional design and analysis is necessary to determine the specifics of the project and adequately examine the environmental impacts. Further refinement of the models should address current limitations and must be made to estimate potential beneficial or deleterious effects on oysters, seagrasses, marsh systems, and other coastal resources. Although this alternative appears viable at this point, additional information is needed to determine current problems within Hancock County Marshes and potential impacts to existing coastal resources as well as navigation impacts.

Historically, the estuarine marsh within the Grand Bay NERR represented the former deltaic environments of the Pascagoula and Escatawpa Rivers in eastern Jackson County. The outlets of these rivers have shifted westward over time, severely limiting the inflow of freshwater, nutrients, and sediments into the Bayou Cumbest area of the reserve. Currently, it is speculated that much of the freshwater entering the Grand Bay NERR estuary is from surface runoff through Bayou Heron and Bayou Cumbest, within the Bangs Lake Hydraulic Unit, measuring approximately 21,374 acres. Human disturbances to the area have also altered historic sheet flow and surface water flows into

the area, as well as the natural migration of the Pascagoula and Escatawpa Rivers. A freshwater diversion project along the Escatawpa River, if feasible, may serve to enhance the wildlife resources of the area. This need for freshwater diversion of the Escatawpa River flows to the Grand Bay savannahs and marshes would help restore the predominant wet pine savannah habitat. The study team's recommendation is to develop a refined hydrodynamic model for the area, inputting biological, water quality, and physical data into the model to evaluate a variety of freshwater diversion alternatives.

3.15.6.2 Environmental Restoration of Historical Wetland Sites

The MsCIP team evaluated the sites identified through the SDSS tool with cooperation of the State of Mississippi, ERDC, and other agencies. The identified sites contain wetland areas that were degraded by storm surge, as well as developed sites that were previously wetlands.

When residential and/or commercial structures and/or lands are purchased for the purpose of restoring floodplain areas (i.e. non-structural storm damage reduction measures), any structures present are demolished and the land is no longer available for residential and/or commercial development. Historically, vacated lands have been left with all or some of the infrastructure at the site, rather than being restored to their natural setting. The MsCIP environmental restoration plan proposes that land purchased as a non-structural storm damage reduction solution be restored to historic function as wetlands. Likewise, vacant or state owned land with degraded wetlands would also be restored to their historic function as viable ecosystems.

The SDSS was a unique collaborative effort which resulted in the following products:

1) A ModelBuilder based SDSS tool, which can be subsequently edited and applied to other areas along coastal Mississippi in the future as funding becomes available;

2) Maps, such as aerial photography, topographic, soil layers, etc., depicting areas in the study region that have a high probability of being successfully restored to functioning wetlands that would buffer and/or store stormwater as well as provide suitable habitat for fish and wildlife;

3) Photograph documentation and data sheets containing information on ground-truthed potential restoration sites.

Screening yielded numerous sites that were then reviewed by the Corps, Mobile District, MDMR, and USFWS personnel. The team ranked several variables, such as land ownership, proximity to State and other preserved lands, such as the Grand Bay NERR and wildlife management areas, acreage of site, proximity to water, site complexity, potential diversity of natural ecosystem at the site, existing and historical soils, etc., to screen the large list of SDSS sites. The team used these ranked variables for evaluation in order to identify those critical natural systems that would benefit the comprehensive system. These final environmental restoration sites include a combination of those identified based on the SDSS results, as well as some additional sites (i.e. State Initiatives). These were made using only the non-natural land-use and 100-year flood calculations as the original site selectors (i.e. no damage layers were used), and sites were greater than or equal to 5 acres.

The final list of alternative sites contained the following characteristics:

- Sites were greater than 5 acres in size
- Sites contained an SDSS Restorability class greater than Low or Medium Low
- Sites contained an SDSS Habitat class greater than Low or Medium Low
- Sites contained an SDSS Storm Surge/Flood Protection class greater than Low

The resulting 38 potential wetland restoration sites were selected as critical elements of the comprehensive plan. These sites are identified in Table 3-7 and shown in Figure 3-13.

1 **Table 3-7**
2 **Wetland Restoration Sites in Coastal Mississippi**

Site	Restoration Acres	Environmental Setting
(1) Pearlington, Hancock	76 acres (State owns 2,200 acres in the Pearlington area)	Emergent aquatic vegetation Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(2) Pearlington South, Hancock	11 acres	Emergent aquatic vegetation Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(3) Port /West, Hancock	49 acres	Emergent aquatic vegetation
(4) Ansley, Hancock	2,023 acres (State owns 6,000 acres west of Lakeshore Road)	Emergent aquatic vegetation Wet pine savannah
(5) Heron Bay	594 acres	Emergent aquatic vegetation
(6) Lower Bay	226 acres	Emergent aquatic vegetation
(7) Lakeshore, Hancock	275 acres	Emergent aquatic vegetation
(8) Bayou Caddy/Lakeshore, Hancock	362 acres	Emergent aquatic vegetation
(9) Clermont Harbor, Hancock	209 acres	Emergent aquatic vegetation
(10) Bayou La Croix, Hancock	259 acres	Emergent aquatic vegetation
(11) Shoreline Park, Hancock	889 acres	Emergent aquatic vegetation
(12) Chapman Road, Hancock	146 acres	Emergent aquatic vegetation
(13) Jourdan River – Interstate 10 Development, Hancock	638 acres	Emergent aquatic vegetation
(14) Diamondhead, Hancock	433 acres	Emergent aquatic vegetation
(15) Delisle, Harrison	120 acres (State owns 1,000 acres)	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs
(16) Ellis Property, Harrison	443 acres	Emergent aquatic vegetation Pine savannah - wet pine flatwoods.
(17) Pine Point East, Harrison	103 acres (State owns 40-50 tax forfeited lots)	Emergent aquatic vegetation Wet pine savannah habitat
(18) Pine Point West, Harrison	83 acres (State owns 40-50 tax forfeited lots)	Emergent aquatic vegetation Wet pine savannah habitat
(19) Pass Christian Beach Front, Harrison	21 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs
(20) Pass Christian Site – Bayou Portage, Harrison	43 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs

Site	Restoration Acres	Environmental Setting
(21) Brickyard Bayou, Harrison	14 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs
(22) Biloxi River – Shorecrest, Harrison	15 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs Riverine/levee forests
(23) Biloxi River – Eagle Point, Harrison	17 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs Riverine/levee forests
(24) Biloxi Front Beach - South of Highway 90, Harrison	40 acres	Dune System
(25) Keegan Bayou, Harrison	54 acres	Emergent aquatic vegetation Wet Pine Savannah habitat
(26) St. Martin, Jackson	467 acres	Emergent aquatic vegetation
(27) Fort Point, Jackson	83 acres	Emergent aquatic vegetation
(28) Pine Island, Jackson	237 acres	Emergent aquatic vegetation
(29) Belle Fontaine, Jackson	1,516 acres	Dune System
(30) Griffin Point, Jackson	182 acres	Emergent aquatic vegetation
(31) Bayou Chico, Jackson	258 acres	Emergent aquatic vegetation
(32) Grand Bay/Bayou Cumbest, Jackson	2,666 acres	Emergent aquatic vegetation
(33) Wachovia, Hancock	1,200 acres total – 800 marsh, 200 forested, 200 savannah	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(34) Ansley, Hancock	900 acres – 800 marsh, 100 forested	Emergent aquatic vegetation, Wet pine savannah
(35) LaFrancis Camp Trenaisse, Hancock	45 acres total – all open water	Open Water
(36) DuPont, Harrison	650 acres – 170 marsh, 480 forested	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(37) Dantzler, Jackson (Alternate)	900 acres – 500 marsh, 385 forested	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(38) Pascagoula River Marsh, Jackson	11,150 acres	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests

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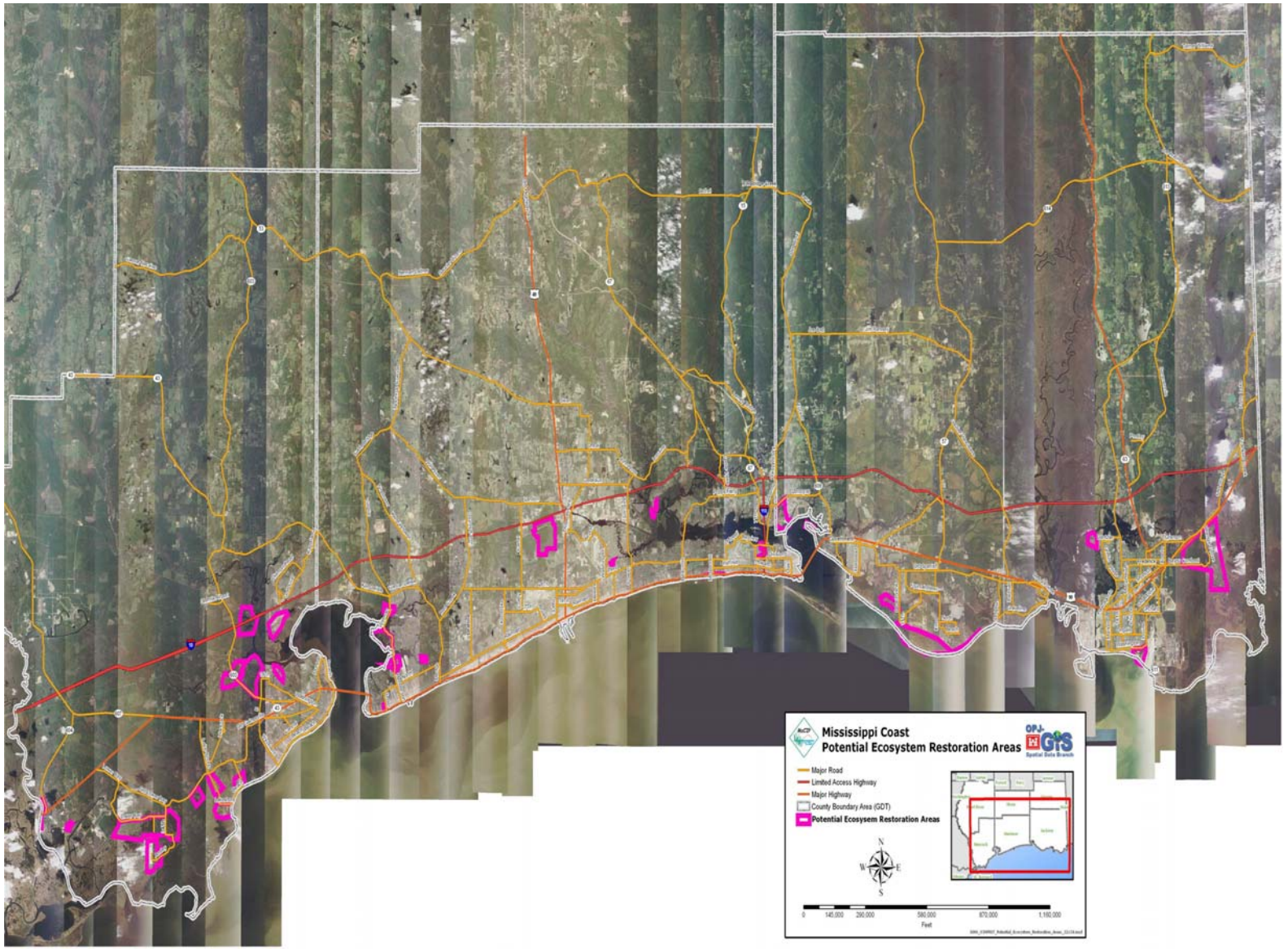


Figure 3-13
Potential Wetland Restoration Sites - Deer Island Ecosystem Restoration

Due to the time constraints of this study, an array of potential alternatives was developed for 5 sites – Turkey Creek, Bayou Cumbest, Franklin Creek, Admiral Island, and Dantzler. These sites were chosen by the team for various reasons. The five sites developed for ecosystem restoration implementation were selected because they were either:

- Already vacant lands with wetlands degraded by the storms of 2005;
- Previously functioning wetlands which would not require relocating residents; or
- Developed wetland areas where residents are willing to relocate.

The Turkey Creek site was selected due to having one land owner, critical resources that have ongoing developmental pressures, and an existing analysis conducted of the ecosystem functions (i.e. HGM wetland analysis conducted by ERDC during HGM development). FEMA's ongoing Hazard Grant Mitigation Program, including buy-outs, allowed the team to focus on Bayou Cumbest. In addition, this site has critical historic and existing degraded emergent tidal marsh habitat vital State of Mississippi's comprehensive ecosystem. Restoration of these critical marsh systems is essential to the State's and national seafood industry. The Franklin Creek project site has been funded for homeowner's assistance and relocation as part of the MsCIP Interim Report. Removal of these structures would allow for the team to restore the critical wet pine savannah habitat that has been historically developed by residential and commercial structures. Admiral Island and Dantzler restoration areas are state owned properties under MDMR Coastal Preserves Program. These protected sites were once functioning on their own prior to the storm season of 2005. However, the storms removed native vegetation resulting in vast open-spaces, which allowed exotic species to out compete historically productive native species (i.e. tidal marsh and wet pine savannah species); thus, reducing the sites' vital natural functions.

Without intervention, Deer Island would continue its degradation and ultimately increased wave action would occur along the mainland at the City of Biloxi. The southern shorelines would continue to erode; thus, adversely impacting those dependant species, such as birds and crabs. Wave action from daily occurrences and storm events would eventually erode the beach and then begin eroding the emergent tidal marsh and coastal maritime forests. Furthermore, the Section 204 emergent tidal marsh restoration site would continue to degrade. Ultimately, this unique habitat would continue to change from a productive beach/dune, emergent tidal marsh, and coastal maritime forest habitat to stressed and non-functioning habitats. Deer Island contains a diverse habitat of beach/dunes, emergent tidal marshes, and coastal maritime forests. Its proximity to the City of Biloxi provides a certain amount of protection to the city from waves generated by approaching hurricanes. Currently, the uninhabited island is part of the MDMR Coastal Preserves Program. Restoration efforts have been funded under the Section 528 of WRDA of 2000 for breaches at the west end and near Grand Bayou, and parts of the southern shoreline. Although a substantial restoration effort in its own right, there are significant opportunities to further restore the island and repair hurricane-caused damage to the islands' ecosystems.

For the SAV restoration effort, MsCIP team assessed the continued survival and growth of seagrasses (i.e. SAVs) and found them threatened by the cumulative effects of man's activities, in addition to, natural processes in the coastal marine environment. Natural causes of SAV decline, such as disease, storm events, salinity fluctuation, and hypoxic events, coupled with declining water quality caused by anthropogenic eutrophication currently threaten the health of many SAV systems (Montague and Ley 1993, Durako and Kuss 1994, Olesen and Sand-Jensen 1994, Zieman et al 1994). These marine and brackish habitats provide vital refuges, feeding, resting, staging, and spawning grounds for a variety of species found in Mississippi Sound and also in the Gulf of Mexico. Past studies throughout the years have attributed anywhere from 50% to 90% of all marine species to utilize this vital habitat at some point in their life state. In 1969, an estimated 20,000 acres of SAVs were documented and as of 1998, only 2,000 acres were documented (Moncrieff 1998).

SAV restoration efforts across the nation have proven to be rather challenging and many examples can be identified close to Mississippi, such as in Florida. Thus, Bayou Cumbest was chosen due to its small size to produce data, such as salinity, water quality, currents, substrates, composition of sediments, boating traffic (propellor scarring/turbidity), transplant success rates, and heterogenoity of species composition, in order to determine the success criteria for future recovery efforts of SAV within brackish systems in Coastal Mississippi. Future SAV restoration site could include area north of Buccaneer State Park, Cat Island, Ship Island, Dog Keys Pass, Horn Island, Petit Bois Island, and Point aux-Chenes.

After discussing the potential SAV pilot project with biologists at ERDC, it has been determined there currently are no assessment tools for quantifying benefits of SAV restoration projects. Although quantified outputs of ecosystem projects have traditionally been used as the basis for justification, little data is available for use in establishing baseline conditions of existing SAVs, organisms currently using established beds, and the specific causes for the overall decline of brackish SAVs. As part of the data collection described above, an index would be developed most likely using acreages and density quantifying environmental outputs generated through the success of the SAV restoration pilot project. This quantifiable environmental output would then be used to demonstrate cost effective criteria for future brackish SAV systems.

For the five environmental restoration sites – Turkey Creek, Bayou Cumbest, Franklin Creek, Admiral Island, and Dantzler - final alternatives were determined by a cost effective analysis using IWR Plan (see the Economic Appendix for more details on this analysis). The existing Deer Island FHI evaluation from the Section 204 and WRDA Section 528 were used to develop the cost effective alternatives. For the SAV effort, limited knowledge of the functional restoration prohibited the team in developing cost effective alternatives; thus, a pilot project was identified at Bayou Cumbest to obtain the much needed described data. Final alternatives consist of the following:

Table 3-8
Final Ecosystem Restoration Alternatives

Ecosystem Restoration Alternative	Description
Turkey Creek No Action	
Turkey Creek Plan 1	Restoration of 879 Acres Maintained by Burning
Turkey Creek Plan 2	Restoration of 879 Acres Maintained by Mowing
Turkey Creek Plan 3	Restoration of 689 Acres Maintained by Burning
Turkey Creek Plan 4	Restoration of 689 Acres Maintained By Mowing
Turkey Creek Plan 5	Restoration of 190 Acres Maintained by Burning
Turkey Creek Plan 6	Restoration of 190 Acres Maintained by Mowing
Bayou Cumbest No Action	
Bayou Cumbest Plan 1	Excavate Fill, Remove Exotics, Plant Natives at 0.5 meter density, and fill ditches
Bayou Cumbest Plan 2	Excavate Fill, Remove Exotics, Plant Natives at 1.0 meter density, and fill ditches
Bayou Cumbest Plan 3	Excavate Fill, Remove Exotics, Plant Natives at 2.0 meter density, and fill ditches
Bayou Cumbest Plan 4	Excavate Fill, Remove Exotics, Plant Natives at 0.5 meter density
Bayou Cumbest Plan 5	Excavate Fill, Remove Exotics, Plant Natives at 1.0 meter density
Bayou Cumbest Plan 6	Excavate Fill, Remove Exotics, Plant Natives at 2.0 meter density

Admiral Island No Action	
Admiral Island Plan 1	Excavate Fill, Remove Exotics, Plant Natives at 0.5 meter density, and fill ditches
Admiral Island Plan 2	Excavate Fill, Remove Exotics, Plant Natives at 1.0 meter density, and fill ditches
Admiral Island Plan 3	Excavate Fill, Remove Exotics, Plant Natives at 2.0 meter density, and fill ditches
Admiral Island Plan 4	Excavate Fill, Remove Exotics, Plant Natives at 0.5 meter density
Admiral Island Plan 5	Excavate Fill, Remove Exotics, Plant Natives at 1.0 meter density
Admiral Island Plan 6	Excavate Fill, Remove Exotics, Plant Natives at 2.0 meter density
Dantzler No Action	
Dantzler Plan 1	385 Acre Restoration Maintained by Burning
Dantzler Plan 2	385 Acre Restoration Maintained by Mowing
Dantzler Plan 3	151 Acre Restoration Maintained by Burning
Dantzler Plan 4	151 Acre Restoration Maintained by Mowing
Dantzler Plan 5	234 Acre Restoration Maintained by Burning
Dantzler Plan 6	234 Acre Restoration Maintained by Mowing
Franklin Creek No Action	
Franklin Creek Plan 1	Restoration of 149 Acres North and South of Railroad Maintain by Burning
Franklin Creek Plan 2	Restoration of 149 Acres North and South of Railroad Maintain by Mowing
Franklin Creek Plan 3	Restoration of 56 Acres and Maintain by Burning
Franklin Creek Plan 4	Restoration of 56 Acres and Maintain by Mowing
Deer Island No Action	
Deer Island Plan 1 Southern Shoreline Restoration	Restore 30 acres of dune, 78 acres of emergent tidal marsh, 78 acres of coastal maritime forests, and 86 acres of beach habitats along the southern shoreline.
Deer Island Plan 2 Containment Area Restoration	Placement of dredged material into the existing containment site and planting 30 acres of emergent tidal marsh.
Deer Island Plan 3 Breakwater Protection	Extend both the southern and northeastern breakwaters to form a solid line of protection.
Deer Island Plan 4 Eastern Marsh Restoration	Restore 20 acres of emergent tidal marsh via beneficial use of dredged material adjacent to the existing containment site project.
Deer Island Plan 5 Combination Restoration Plan	Extend both existing breakwaters, restore 128 acres of emergent tidal marsh habitat, 78 acres coastal maritime forest, 86 acres of beach habitat, and 30 acres of dune habitat.
SAV No Action	
SAV Pilot Project	Restoration of 5 Acres in Bayou Cumbest
SAV Buccaneer State Park	Restoration of Potential SAV Habitat of 316
SAV Cat Island	Restoration of Potential SAV Habitat of 5,128
SAV Ship Island	Restoration of Potential SAV Habitat of 1,603
SAV Dog Keys Pass	Restoration of Potential SAV Habitat of 1,149
SAV Horn Island	Restoration of Potential SAV Habitat of 4,350

SAV Petite Bois Island	Restoration of Potential SAV Habitat of 1,810
SAV Point-aux-Chenes Bay	Restoration of Potential SAV Habitat of 534
Freshwater Diversion	Western Portion of Mississippi Sound
Freshwater Diversion	Eastern Portion of Mississippi Sound

3.18 Evaluation of Final Alternatives

3.18.1 Evaluation of Hurricane and Storm Damage Reduction Alternatives

The final evaluation process for hurricane / storm damage reduction alternatives involved the following considerations:

- determination of final surge and wave heights for a given event frequency,
- surge behavior under these same events,
- costs required for structural and non-structural designs or lists of features applying to a certain design level,
- final determination of damage reduction benefits derived for a certain design,
- societal and other OSE benefits and outcomes for each plan,
- secondary benefits over time to a particular ecosystem created by a particular measure.

3.18.2 Evaluation of Ecosystem Restoration Alternatives

The final evaluation process for ecosystem restoration alternatives was a cost-effective analysis conducted at the site level for five of the 38 ecosystem restoration sites previously identified using the SDSS prcess. The Institute for Water Resources (IWR) Plan model was used to conduct the cost effectiveness analysis for each of the measures and alternatives for the Admiral Island, Dantzler, Turkey Creek, Bayou Cumbest, and Franklin Creek sites. The analyses followed the methodologies established in the US Army Corps of Engineers Institute for Water Resources publications, Evaluation of Environmental Investment Procedures Manual, Interim: Cost Effectiveness and Incremental Analyses, May 1995, IWR Report #95-R-1 and Cost Effectiveness Analysis for Environmental Measuring: Nine Easy Steps, October 1994, IWR Report 94-PS-2. The nine steps outline in the cited IWR report have become the standard practice for identifying what are known as “Best Buy” ecosystem restoration measures, or those measures that yield the greatest ‘bang for the buck’ at various levels of output.

The IWR Measure model was developed based on these nine steps and is the preferred Corps of Engineers model for the evaluation for ecosystem restoration measures. For the MsCIP Comprehensive Plan Report, Congressional Authority stated, "…but shall not perform an incremental benefit-cost analysis to identify the recommended project…." Following this authorization, only the first five steps of the nine easy steps, which are bolded below, were used in the IWR Plan evaluation, resulting in the identification of cost effective plans for restoration purposes. The nine steps are:

- Formulation of combinations:
  Step 1 - Display Outputs and Costs
  Step 2 – Identify Combinable Management Measures
  Step 3 – Calculate Outputs and Costs
- Cost Effective Analysis:
  Step 4 – Eliminate Economically Inefficient Solutions
  Step 5 – Eliminate Economically Ineffective Solutions

- Development of Incremental Cost Curve
  Step 6 – Calculate average costs
  Step 7 – Recalculate average costs for additional output
- Incremental Cost Analysis:
  Step 8 – Calculate incremental costs
  Step 9 – Compare successive outputs and incremental costs

Specific details of the site specific cost effective analyses can be found in the Economic Appendix. Table 3-9 summarizes the cost effective plans for the Beach and Dune, Turkey Creek, Bayou Cumbest, Admiral Island, Dantzler, and Franklin Creek Areas. The existing Deer Island FHI evaluation from the Section 204 and WRDA Section 528 were used to develop the cost effective alternatives. For the SAV effort, limited knowledge of the functional restoration prohibited the team in developing cost effective alternatives; thus, a pilot project was identified at Bayou Cumbest to obtain the much needed described data.

Table 3-9
Final Ecosystem Restoration Alternatives

Ecosystem Restoration Alternative	Description
LOD 2 No Action	
LOD 2 Option I	10-foot by 50-foot Dune without Plantings
LOD 2 Option J	10-foot by 50-foot Dune with Plantings
LOD 2 Option K	2-foot by 60-foot Dune with Plantings
Turkey Creek No Action	
Turkey Creek Plan 1	Restoration of 879 Acres Maintained by Burning
Turkey Creek Plan 3	Restoration of 689 Acres Maintained by Mowing
Turkey Creek Plan 5	Restoration of 190 Acres Maintained by Burning
Bayou Cumbest No Action	
Bayou Cumbest Plan 1	Excavate Fill, Remove Exotics, Plant Natives at 0.5 meter density, and fill ditches
Bayou Cumbest Plan 2	Excavate Fill, Remove Exotics, Plant Natives at 1.0 meter density, and fill ditches
Bayou Cumbest Plan 3	Excavate Fill, Remove Exotics, Plant Natives at 2.0 meter density, and fill ditches
Bayou Cumbest Plan 6	Excavate Fill, Remove Exotics, Plant Natives at 2.0 meter density
Admiral Island No Action	
Admiral Island Plan 1	Excavate Fill, Remove Exotics, Plant Natives at 0.5 meter density, and fill ditches
Admiral Island Plan 2	Excavate Fill, Remove Exotics, Plant Natives at 1.0 meter density, and fill ditches
Admiral Island Plan 3	Excavate Fill, Remove Exotics, Plant Natives at 2.0 meter density, and fill ditches
Admiral Island Plan 6	Excavate Fill, Remove Exotics, Plant Natives at 2.0 meter density
Dantzler No Action	
Dantzler Plan 1	385 Acre Restoration Maintained by Burning
Dantzler Plan 3	151 Acre Restoration Maintained by Burning
Dantzler Plan 5	234 Acre Restoration Maintained by Burning

Ecosystem Restoration Alternative	Description
Franklin Creek No Action	
Franklin Creek Plan 1	Restoration of 149 Acres North and South of Railroad Maintain by Burning
Franklin Creek Plan 3	Restoration of 56 Acres and Maintain by Burning
Barrier Island No Action	
Barrier Island Plan B	Replenishing sand in the littoral zone from inland river source
Barrier Island Plan C	Replenishing sand in the littoral zone from offshore source
Barrier Island Plan D	Reshaping the south beach to form 2-foot dune structure
Barrier Island Plan E	Constructing a 6-foot dune structure using offshore source
Barrier Island Plan F	SAV restoration
Barrier Island Plan G	Restoration of the Ship Island breach
Barrier Island Plan H	Comprehensive Environmental Restoration of Barrier Islands Plan
Deer Island No Action	
Deer Island Plan 1 Southern Shoreline Restoration	Restore 30 acres of dune, 78 acres of emergent tidal marsh, 78 acres of coastal maritime forests, and 86 acres of beach habitats along the southern shoreline.
Deer Island Plan 2 Containment Area Restoration	Placement of dredged material into the existing containment site and planting 30 acres of emergent tidal marsh.
Deer Island Plan 3 Breakwater Protection	Extend both the southern and northeastern breakwaters to form a solid line of protection.
Deer Island Plan 4 Eastern Marsh Restoration	Restore 20 acres of emergent tidal marsh via beneficial use of dredged material adjacent to the existing containment site project.
Deer Island Plan 5 Combination Restoration Plan	Extend both existing breakwaters, restore 128 acres of emergent tidal marsh habitat, 78 acres coastal maritime forest, 86 acres of beach habitat, and 30 acres of dune habitat.
SAV No Action	
SAV Pilot Project	Restoration of 5 Acres in Bayou Cumbest
SAV Buccaneer State Park	Restoration of Potential SAV Habitat of 316
SAV Cat Island	Restoration of Potential SAV Habitat of 5,128
SAV Ship Island	Restoration of Potential SAV Habitat of 1,603
SAV Dog Keys Pass	Restoration of Potential SAV Habitat of 1,149

Ecosystem Restoration Alternative	Description
SAV Horn Island	Restoration of Potential SAV Habitat of 4,350
SAV Petite Bois Island	Restoration of Potential SAV Habitat of 1,810
SAV Point-aux-Chenes Bay	Restoration of Potential SAV Habitat of 534

The results of the comparison of measures were presented to Stakeholders as part of the risk informed decision making process. Table 3-10 shows the results of the preliminary final evaluation of alternatives. Please note that the damages reduced/avoided and residual damage values are expressed in average annual dollars. These alternatives were carried forward into the System of Accounts analysis.

Table 3-10
Preliminary Display of Final Plans to Stakeholders

Measure	Tidal Habitat Restored (Acres)	Tidal Habitat Lost (Acres)	Non-Tidal Habitat Restored (Acres)	Non-Tidal Habitat Lost (Acres)	Damages Reduced / Avoided ($)	Residual Damages ($)	Cost to Implement Plan ($)	Local Cost Burdens (1-10)	Regional Economic Benefits (1-10)	Cultural and Historical Heritage (1-10)	Public Service Disruptions (1-10)	Personal Impacts (1-10)	Long-Term Sustainability (1-10)	Consequences of Plan Failing (1-10)	Residual Risk (1-10)
Barrier Island No Action	0	4058	0	2705	$-	$426,040,000	$ -	10	1	1	1	1	1	2	1
Barrier Island Option A	644	0	2036	0	$ -	$426,040,000	$ 942,200,000	4	5	5	3	3	6	5	5
Barrier Island Option B	1029	0	686	0	$ -	$426,040,000	$ 1,013,800,000	3	5	4	2	3	4	3	4
Barrier Island Option C1 & C2	326	0	217	0	$ -	$426,040,000	$ 232,900,000	7	2	6	2	3	5	4	5
Barrier Island Option D	0	0	820	0	$ -	$426,040,000	$ 14,200,000	9	1	5	2	3	1	2	3
Barrier Island Option E	0	0	907	0	$ -	$426,040,000	$ 39,200,000	8	1	6	2	3	1	3	3
Barrier Island Option F	4400	4058	0	2705	$ -	$426,040,000	$ 264,500,000	3	2	2	2	3	1	2	3
Barrier Island Option G	130	1227	477	2453	$ -	$426,040,000	$ 114,100,000	5	1	7	2	3	3	4	3
Barrier Island Comp Plan	456	0	694	0	$ -	$426,040,000	$ 347,902,000	5	2	8	3	3	6	6	6
LOD2 No Action	0	0	0	0	$ -	$426,040,000	$ -	10	1	3	1	1	2	2	2
LOD2 Option I	0	0	351	0	$ -	$426,040,000	$ 63,880,000	3	2	4	2	2	4	5	2
LOD2 Option J	0	0	351	0	$ -	$426,040,000	$ 65,480,000	4	2	5	3	3	5	4	2
LOD2 Option K	0	0	304	0	$ -	$426,040,000	$ 15,430,000	7	1	6	3	3	7	4	2
Turkey Creek No Action	0	0	0	0	$ -	$ 16,890,000	$ -	10	1	3	1	1	10	10	1
Turkey Creek Ecosystem Plan 1	0	0	879	0	$ -	$ 16,890,000	$ 7,200,000	4	1	6	1	1	5	7	5
Turkey Creek Ecosystem Plan 3	0	0	689	0	$ -	$ 16,890,000	$ 5,900,000	6	1	5	1	1	6	6	4
Turkey Creek Ecosystem Plan 5	0	0	190	0	$ -	$ 16,890,000	$ 2,300,000	8	1	4	1	1	7	5	3
Bayou Cumbest No Action	0	0	0	0	$ -	$ 6,674,000	$ -	10	1	3	1	1	10	10	1
Bayou Cumbest Acquisition	0	0	0	0	$ 459,000	$ 6,674,000	$ 15,500,000	7	1	1	2	2	7	10	5
Bayou Cumbest Ecosystem Plan 1	373	0	0	0	$ 459,000	$ 6,674,000	$ 74,610,000	4	1	1	2	2	6	7	6
Bayou Cumbest Ecosystem Plan 2	373	0	0	0	$ 459,000	$ 6,674,000	$ 58,720,000	5	1	1	2	2	5	7	6
Bayou Cumbest Ecosystem Plan 3	373	0	0	0	$ 459,000	$ 6,674,000	$ 50,830,000	6	1	1	2	2	4	7	6
Bayou Cumbest Ecosystem Plan 6	373	0	0	0	$ 459,000	$ 6,674,000	$ 50,780,000	6	1	1	2	2	4	7	6
Admiral Island No Action	0	0	0	0	$ -	$ 150,860,000	$ -	10	1	2	1	1	10	10	1
Admiral Island Ecosystem Plan 1	118	0	0	0	$ -	$ 150,860,000	$ 42,900,000	4	1	3	1	1	6	7	6
Admiral Island Ecosystem Plan 2	118	0	0	0	$ -	$ 150,860,000	$ 38,400,000	5	1	3	1	1	5	7	6
Admiral Island Ecosystem Plan 3	118	0	0	0	$ -	$ 150,860,000	$ 36,100,000	6	1	3	1	1	4	7	6
Admiral Island Ecosystem Plan 6	118	0	0	0	$ -	$ 150,860,000	$ 36,000,000	6	1	3	1	1	4	7	6
Dantzler No Action	0	0	0	0	$ -	$ 7,130,000	$ -	10	1	3	1	1	10	10	1
Dantzler Ecosystem Plan 1	0	0	385	0	$ -	$ 7,130,000	$ 1,880,000	6	1	6	1	1	5	7	5
Dantzler Ecosystem Plan 3	0	0	151	0	$ -	$ 7,130,000	$ 870,000	7	1	5	1	1	6	6	4
Dantzler Ecosystem Plan 5	0	0	234	0	$ -	$ 7,130,000	$ 1,040,000	8	1	4	1	1	7	5	3
Franklin Creek No Action	0	0	0	0	$ -	$ 7,130,000	$ -	10	1	3	1	1	10	10	1
Franklin Creek Ecosystem Plan 1	0	0	149	0	$ -	$ 7,130,000	$ 1,630,000	6	1	6	1	1	5	7	5
Franklin Creek Ecosystem Plan 3	0	0	56	0	$ -	$ 7,130,000	$ 550,000	7	1	5	1	1	6	6	4
Forrest Heights No Action	0	0	0	0	$ -	$ 816,791	$ -	10	1	3	2	2	10	10	1
Forrest Heights Plan 1	0	0	0	9	$ 331,036	$ 485,755	$ 6,000,000	5	1	8	5	5	6	8	5
Forrest Heights Plan 2	0	0	0	20	$ 331,508	$ 485,283	$ 9,000,000	5	1	9	6	6	5	9	6
Nonstructural No Action	0	0	0	0	$ -	$426,040,000	$ -	10	1	3	2	2	10	10	1
Long-term Homeowners Assistance and Relocations Plan	0	0	0	0	$ 209,665,350	$ 216,374,650	$ 7,999,019,430	2	6	3	6	8	5	9	9
Very High Risk Homeowners Assistance and Relocations Plan	0	0	0	0	$ 22,380,000	$ 403,660,000	$ 482,000,000	6	3	5	5	5	8	9	7

Note: Refinement of values were made after stakeholder meetings and are captured in system of accounts.

3.19 Comparison of Final Alternatives

Comparisons identify which of the final alternatives (plans) is the best and identify which of the final alternatives should be included as a recommended action of the comprehensive plan. The comprehensive plan is comprised of a number of mission, site, and resource specific features. Therefore, comparisons are made among alternatives directed at specific features. Comparisons are not made across features. For example, ecosystem restoration alternatives at a specific location are compared to each other, but ecosystem restoration alternatives are not compared to storm damage protection alternatives. Because no one plan is likely to be best in all categories of importance, we have to compare the effects of the various plans and make tradeoffs among the differences observed. In the previous section, the effects of each plan were examined individually. In this comparison step, we look at the important effects across all plans.

The best plan cannot be selected from among a set of good plans unless there is some way to compare them. It is only by comparison that a plan is no longer good enough, or that a good plan becomes the best plan. The purpose of plan comparison is to identify the most important effects, and to compare the plans against one another across those effects.

The comparison of final MsCIP alternatives started with presenting the future without-project conditions and future "with-project" conditions for each site or problem area, in both a descriptive presentation, and also in a "System of Accounts" comparison format. Data presented for comparison of final alternatives included:

- revised costs,
- benefits (monetary, or economic, environmental outputs, societal, etc.),
- potential impacts related to implementation,
- detailed design considerations,
- environmental outputs,
- damages prevented,
- geotechnical/site considerations,
- more detailed technical requirements,
- source material and source area considerations, and
- other technical, environmental, or economic issues.

The "System of Accounts" analysis presents information in four separate "accounts" or categories for comparison that include:

- "National Economic Development" (NED), which in this case only compares and contrasts the cost-effectiveness of each group of alternatives,
- "Regional Economic Development "(RED), which discusses the potential regional impacts of each group of alternatives,
- Environmental Quality (EQ), which discusses potential positive and negative environmental impacts of each group of alternatives and their environmental quality implications, and
- Other Social Effects (OSE) evaluations, which discusses and contrasts the potential social, and other effects of each group of alternatives.

The alternatives were also compared and contrasted according to their achievement of the additional criteria of a) effectiveness; b) completeness; c) acceptability, and d) efficiency (cost-effectiveness) according to applicable Corps guidelines.

In addition to these four traditional accounts, information on potential risks, uncertainties, and consequences, is also presented in System of Accounts format, for comparison at the same level of scrutiny of the information presented in other accounts.

The System of Accounts tables also include a "stakeholder risk score" which identifies stakeholder preferences for each of the final alternatives presented in the Systems of Accounts tables. The "stakeholder preference score" rates each alternative as a percentage of a theoretical "perfect plan" (in the eyes of the stakeholder groups). The higher the percentage, the more acceptable the alternative is to the stakeholder. Development of the "stakeholder preference score", which entailed more than a year of developing and integrating public and agency input, is discussed in section 3.19 Risk Assessment and Education in Plan Formulation, which follows the System of Accounts tables. The System of Accounts tables are presented in their entirety in section 3.18.

3.20 System of Accounts Tables

The following System of Accounts Tables presents the detailed evaluation of Final Alternatives. Selected alternatives are highlighted. The System of Accounts Tables present evaluation results for each of the four accounts (NED, RED, OSE, and NER) and proves evaluation information elicited from the public involvement process described in section 3.19 below. Public and stakeholder input was solicited through the presentation of measures and preliminary alternatives, to all stakeholder groups, at a series of public workshops. Workshops were conducted to elicit "stakeholder preferences" on potential solutions to each identified problem area. Stakeholders were also asked to "score" measures and preliminary alternatives, in comparison to one another. The results of this process are presented in the System of Accounts tables, as both "Stakeholder Preference" scores, and a summary of stakeholder preferences (the final row in each problem area's account summary). Stakeholder input into the plan evaluation process is discussed in sections 3.19 and 3.20, and in greater detail in Attachment 1 to the Risk Appendix

1 **Table 3-11**
2 **System of Accounts table for Barrier Island Alternatives**

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: The benefits of Plan H are greater than the sum of the benefits of its component parts (Plans C & G).

Item	No Action	Plan A	Plan C	Plan G	Plan H
A. PLAN DESCRIPTION	No Federal Action	Restore Barrier Island Chain Footprint	Replenish Sand in Littoral Zone of Ship & Petit Bois Islands	Restoration of Ship Island Breach	Combination of C + G
B. IMPACT ASSESSMENT					
1. National Economic Development					
a. Beneficial Impacts					
(1) Damages Prevented	$0	$18,866,000	$10,468,000	$7,616,000	$18,866,000
(2) Emergency Costs Avoided	$0				
(3) Recreation	$0	$466,000	$117,000	$466,000	$466,000
(4) Total Beneficial Impacts	None.	$19,332,000	$10,585,000	$8,082,000	$19,332,000
b. Adverse Impacts					
(1) Project Cost	$0	$942,200,000	$147,400,000	$181,400,000	$328,800,000
(2) Interest During Construction	$0	$119,317,000	$18,667,000	$22,972,000	$41,639,000
(3) Average Annual First Cost	N/A	$58,376,000	$9,133,000	$11,239,000	$20,372,000
(4) Annual O&M	$0	$0	$0	$0	$0
(5) Total Avg. Annual Costs	$0	**$58,376,000**	**$9,133,000**	**$11,239,000**	**$20,372,000**
2. Environmental Quality (EQ)					
(1) Ecosystem Restoration	No benefit	Restoration of 644 acres of tidal habitat and 2036 acres of nontidal habitat.	Restoration of 326 acres of tidal habitat and 217acres of nontidal habitat.	Restoration of 130 acres of tidal habitat and 477 acres of nontidal habitat.	Restoration of 456 acres of tidal habitat and 694 acres of nontidal habitat.

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: The benefits of Plan H are greater than the sum of the benefits of its component parts (Plans C & G).

(2) Protection of Fisheries	**Loss of $43,618,143** in average annual fishery landings	Avoidance of **$43,618,143** in lost fishery landings.	Avoidance of **$6,542,721** in lost fishery landings.	Avoidance of **$21,809,072** in lost fishery landings.	Avoidance of **$43,618,143** in lost fishery landings.
(3) Water Circulation	Area would become more open Gulf in nature as islands erode	Preservation of MS sound circulation	Minor Preservation of MS sound circulation	Significant preservation of MS sound circulation	Preservation of MS sound circulation
(4) Noise Level Changes	No change in noise levels	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction
(5) Public Facilities	Loss of the barrier islands would result in loss of National Park resources	National Park resources would be preserved.	National Park resources would be enhanced by supplemental sand supply.	National Park resources would be enhanced by supplemental sand supply.	National Park resources would be preserved.
(6) Aesthetic Values	Continued degradation of natural aesthetic values	Significant aesthetic improvement	Moderate aesthetic improvement	Moderate aesthetic improvement	Significant aesthetic improvement
(7) Natural Resources	Continued degradation of islands and loss of function of MS Sound.	Significant reduction in loss of island and function of MS Sound.	Minor reduction in loss of island and function of MS Sound.	Moderate reduction in loss of island and function of MS Sound.	Significant reduction in loss of island and function of MS Sound.
(8) Biological Resources	Continued degradation and loss of biological resources.	Significant improvement in biological resources.	Moderate improvement in biological resources.	Moderate improvement in biological resources.	Significant improvement in biological resources.
(9) Air Quality	No anticipated effect on air quality	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: The benefits of Plan H are greater than the sum of the benefits of its component parts (Plans C & G).

(10) Water Quality	Water quality is anticipated to deteriorate with future loss of the island system (salinity increase will decrease size of estuarine zone).	Temporary negative impacts to water quality due to construction but overall long-term improvements to water quality are anticipated.	Temporary negative impacts to water quality due to construction but overall long-term improvements to water quality are anticipated.	Temporary negative impacts to water quality due to construction but overall long-term improvements to water quality are anticipated.	Temporary negative impacts to water quality due to construction but overall long-term improvements to water quality are anticipated.
(11) Public Services	Possible increase in interruption of services as islands continue to erode	Increased stability of barrier islands would reduce likelihood of interruption of public services.	Increased stability of barrier islands would reduce likelihood of interruption of public services.	Increased stability of barrier islands would reduce likelihood of interruption of public services.	Increased stability of barrier islands would reduce likelihood of interruption of public services.
(12) Cultural and Historical Preservation	Alternative would result in future loss of important cultural resources at Ship Island.	Alternative would preserve cultural and historical artifacts, including Fort Massachusetts and the French Warehouse.	Alternative would provide some reduction in impact to cultural and historical artifacts, including Fort Massachusetts and the French Warehouse.	Alternative would preserve cultural and historical artifacts, including Fort Massachusetts and the French Warehouse.	Alternative would preserve cultural and historical artifacts, including Fort Massachusetts and the French Warehouse.
(13) Total Quality of the Environment	Significant negative impact on the total quality of this environment if the islands erode away	Significant positive impacts on the total quality of environment (i.e. future production of Mississippi Sound)	Positive impact on the total quality of environment (i.e. future production of Mississippi Sound)	Moderate positive impact on the total quality of environment (i.e. future production of Mississippi Sound)	Significant positive impacts on the total quality of environment (i.e. future production of Mississippi Sound)
3. Regional Economic Development (RED)					
(1) Impact on Sales Volume	No impact to the local economy.	Increase of **$2,289,546,000** in additional sales volume.	Increase of **$358,182,000** in additional sales volume.	Increase of **$440,802,000** in additional sales volume.	Increase of **$798,984,000** in additional sales volume.

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: The benefits of Plan H are greater than the sum of the benefits of its component parts (Plans C & G).

(2) Impact on Income	Negative impact to individuals involved in fishing industry as islands erode and MS Sound environment changes.	Increase of **$480,984,800** in additional local income.	Increase of **$75,246,410** in additional local income.	Increase of **$92,603,120** in additional local income.	Increase of **$167,849,530** in additional local income.
(3) Impact on Employment	Negative impact to individuals involved in fishing industry as islands erode and MS Sound environment changes.	Increase of **14,100** new jobs.	Increase of **2,206** new jobs.	Increase of **2,714** new jobs.	Increase of **4,920** new jobs.
(4) Tax Changes	Possible negative impacts as islands erode and chance of storm damage increases	None	None	None	None
4. Other Social Effects (OSE)					
a. Beneficial Impacts					
(1) Security of Life, Health, and Safety	Continued risks to life, health and safety	Significant decrease in risks to life, health and safety.	Moderate decrease in risks to life, health and safety.	Moderate decrease in risks to life, health and safety.	Significant decrease in risks to life, health and safety.
(2) Community Cohesion	Negative impacts as islands continue to erode and damages from waves and storms increase above the existing level.	Significant positive impact as community observes coastal resources being restored and stability of barrier islands and MS Sound increased.	Positive impact as community observes coastal resources being restored and stability of barrier islands and MS Sound increased.	Positive impact as community observes coastal resources being restored and stability of barrier islands and MS Sound increased.	Significant positive impact as community observes coastal resources being restored and stability of barrier islands and MS Sound increased.

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: The benefits of Plan H are greater than the sum of the benefits of its component parts (Plans C & G).

(3) Tax Values	Negative impacts as islands erode and chance of storm damage increases	Moderate increase in tax values due to decreased risk to properties.	Small increase in tax values due to decreased risk to properties.	Small increase in tax values due to decreased risk to properties.	Moderate increase in tax values due to decreased risk to properties.
(4) Community Growth	Could have negative impact on community structure as islands continue to erode	Moderate stabilization to community structure	Minor stabilization to community structure	Moderate stabilization to community structure	Moderate stabilization to community structure
(5) Property Values	Negative impacts as islands erode and chance of storm damage increases	Moderate increase in property values due to decreased risk to properties.	Small increase in property values due to decreased risk to properties.	Small increase in property values due to decreased risk to properties.	Moderate increase in property values due to decreased risk to properties.
(6) Displacement of Businesses	Potential impacts to businesses from increased risk of surge damage.	Reduced risk of displacement of businesses.	Reduced risk of displacement of businesses.	Reduced risk of displacement of businesses.	Reduced risk of displacement of businesses.
(7) Public Facilities	Negative impacts to public facilities from increased risk of surge damage.	Reduced risk to public facilities.	Reduced risk to public facilities.	Reduced risk to public facilities.	Reduced risk to public facilities.
(8) Injurious Displacement of Farms	N/A	N/A	N/A	N/A	N/A
b. Preservation of life	Could contribute to loss of life as risk to mainland shoreline becomes greater.	Could reduce loss of life with decreased risk to mainland shoreline.	Could reduce loss of life with decreased risk to mainland shoreline.	Could reduce loss of life with decreased risk to mainland shoreline.	Could reduce loss of life with decreased risk to mainland shoreline.

C. PLAN EVALUATION

1. Contributions to Planning Objectives

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: The benefits of Plan H are greater than the sum of the benefits of its component parts (Plans C & G).

a. Flood, Hurricane and/or Storm Damage Reduction	Increased risk in damage reduction from further degradation of islands.	Significant avoidance of increased risk.	Minor avoidance of increased risk.	Moderate avoidance of increased risk.	Significant avoidance of increased risk.
b. Recovery of lost environmental resources	Alternative will result in continued loss of environmental resources.	Barrier Island restoration will accrue significant benefits.	Littoral zone disposal will accrue minor benefits.	Ship Island restoration will accrue moderate benefits.	Barrier Island restoration will accrue significant benefits.
2. Response to Planning Constraints					
a. Avoid environmental impacts and minimize induced damages	Continued loss of significant environmental resources.	Beneficial effect on environmental resources.	Beneficial effect on environmental resources.	Beneficial effect on environmental resources.	Beneficial effect on environmental resources.
b. Institutional Acceptability	Is not supported by state or local government	Is supported by local and state governments	Is somewhat supported by local and state governments	Is supported by local and state governments	Is supported by local and state governments
3. Response to Evaluation Criteria					
a. Acceptability	NO	No, does not meet all Federal policies and regulations (i.e. Wilderness Act)	YES	YES	YES
b. Completeness	NO	YES	NO, it does not avoid all of the future degradation.	NO, it does not avoid all of the future degradation.	YES
c. Effectiveness	NO	YES	NO, not a completely effective solution.	NO, not a completely effective solution.	YES
d. Efficiency (Cost-Effectiveness; i.e., most efficient use of Federal and Non-Federal Funds)	NO	No, over 2 1/2 times as expensive as plan H	No, less efficient than plan A and H.	No, less efficient than plan A and H.	YES, most efficient / cost effective plan.

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: The benefits of Plan H are greater than the sum of the benefits of its component parts (Plans C & G).

e. Integration	N/A	Seamless addition to system.	Seamless addition to system.	Seamless addition to system.	Seamless addition to system.
f. Reversibility	This issue does not apply	Alternative could be reversible, given means to remove sand.	Alternative could not be reversible, given placement in open-water.	Alternative could be reversible, given means to remove sand.	A portion of this alternative could not be reversible, given placement in open-water.
4. Stakeholder Preference Score (From MCDA weightings analysis)					
a. Summary Score	**15.53%**	**71.69%**	**62.28%**	**41.70%**	**72.03%**
Cluster Group A	27.16%	67.62%	63.08%	47.53%	73.93%
Cluster Group B	18.82%	70.58%	63.58%	45.57%	73.93%
Cluster Group C	11.83%	74.03%	63.92%	41.81%	73.58%
Cluster Group D	4.30%	74.51%	58.55%	31.90%	66.66%
b. Stakeholder Preference	All groups ranked this plan lowest	Plan ranked very high, but less than H.	Plan ranked lower than A and H.	Plan ranked lowest of all action plans.	Plan ranked highest overall
D. Implementation Responsibility	Does not have any implementation responsibilities	Elements would be joint Federal/Non-Federal implementation responsibility.	Elements would be joint Federal/Non-Federal implementation responsibility.	Elements would be joint Federal/Non-Federal implementation responsibility.	Elements would be joint Federal/Non-Federal implementation responsibility.
E. State and other Non-Federal Coordination	Would require no State or other Non-Federal coordination activities	Would require significant State or other Non-Federal coordination activities	Would require significant State or other Non-Federal coordination activities	Would require significant State or other Non-Federal coordination activities	Would require significant State or other Non-Federal coordination activities
F. Risk Evaluation					
1. Risk and Vulnerabilities					
a. Risk of Failure	N/A	Low	Moderate	Moderate	Low

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi					
Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events. **Note: The benefits of Plan H are greater than the sum of the benefits of its component parts (Plans C & G).**					
b. Residual Risk	Significant risk to MS sound ecosystem. All barrier islands will overtop during large surge events, and will not provide significant reduction of surge and waves.	Minor reduction residual risk to MS sound ecosystem. All barrier islands will overtop during large surge events, and will not provide significant reduction of surge. Plan A would provide a significant reduction to waves.	Moderate reduction residual risk to MS sound ecosystem. All barrier islands will overtop during large surge events, and will not provide significant reduction of surge and waves.	Moderate reduction residual risk to MS sound ecosystem. All barrier islands will overtop during large surge events, and will not provide significant reduction of surge and waves.	All barrier islands will overtop during large surge events, and will not provide significant reduction of surge. Plan A would provide a moderate reduction to waves.
c. Reliability	N/A	Plan A would provide a moderate level of reliability, would be resistant to damage from storm events, and would not require significant maintenance.	This plan would provide a low level of reliability, would receive damage from storm events, and would require significant maintenance.	This plan would provide a low level of reliability, would receive damage from storm events, and would not require significant maintenance.	Plan A would provide a moderate level of reliability, would be resistant to damage from storm events, and would not require significant maintenance
d. Relative Sea Level Rise	Problems will be substantially exacerbated by an increasing relative rise of sea level	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be moderately impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be moderately impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: The benefits of Plan H are greater than the sum of the benefits of its component parts (Plans C & G).

e. Risk of Ecosystem Damage	Ecosystem damage will continue to accrue at a rate at least that of recent history with substantial negative outcomes.	Risk of ecosystem damage will be minimal throughout the period of analysis.	Risk of ecosystem damage will be moderate throughout the period of analysis.	Risk of ecosystem damage will be moderate throughout the period of analysis.	Risk of ecosystem damage will be minimal throughout the period of analysis.
f. Risk to Life and Safety	Significant threats to Life and Safety from storm surge will continue to rise due to continued deterioration of the Barrier Islands.	Threats to Life and Safety from storm surge will still exist, but this plan will provide the least risk to life and safety.	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide less risk to life and safety than the No Action Plan.	Threats to Life and Safety from storm surge will still exist, but this plan will provide less risk to life and safety than the No Action Plan and Plan C.	Threats to Life and Safety from storm surge will still exist, but this plan will provide the least risk to life and safety, except for Plan A.
g. Risk to Mental and Physical Health	Significant threats to Mental and Physical Health from storm surge will continue to rise due to continued deterioration of the Barrier Islands.	Threats to Mental and Physical Health from storm surge will still exist, but this plan will provide the least risk to Mental and Physical Health.	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide less risk to Mental and Physical Health than the No Action Plan.	Threats to Mental and Physical Health from storm surge will still exist, but this plan will provide less risk to Mental and Physical Health than the No Action Plan and Plan C.	Threats to Mental and Physical Health from storm surge will still exist, but this plan will provide the least risk to Mental and Physical Health, except for Plan A.
2. Recommendations and Preferences					

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi					
Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events. **Note: The benefits of Plan H are greater than the sum of the benefits of its component parts (Plans C & G).**					
a. Federal Recommendation					This Plan has the highest NED benefits, substantial RED benefits, substantial EQ benefits, the greatest achievement of OSE outcomes, does not violate any local, state, or Federal statues, laws, and regulations, and is the most cost effective and efficient recommendation of the Barrier Island component of the Comprehensive Plan
b. Stakeholder Preference					This Plan has the highest stakeholder preference score, and creates a low risk environment.

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Table 3-12
System of Accounts table for Beach and Dune Alternatives

Problem Area: Beach and Dune Placement, Hancock, Harrison, and Jackson Counties, Mississippi				
Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.				
Item	**No Action**	**Measure I**	**Measure J**	**Measure K**
A. PLAN DESCRIPTION	No Federal Action	Dune 5 feet high and 50 feet wide and extend berm to match and include the sand fence	Dune 5 feet high and 50 feet wide and extend berm to match and include the sand fence and with plantings	Dune 2 feet high and 60 feet wide with berm expansion, sand fencing and plantings
B. IMPACT ASSESSMENT				
1. National Economic Development				
a. Beneficial Impacts				
(1) Damages Prevented	$0	Minimal level of damages prevented.	Minimal level of damages prevented.	Minimal level of damages prevented.
(2) Emergency Costs Avoided	$0	$0	$0	$0
(3) Recreation	No significant change in recreation benefits	Expanding berm area could provide minimal benefits	Expanding berm area could provide minimal benefits	Expanding berm area could provide minimal benefits
(4) Total Beneficial Impacts	None.			
b. Adverse Impacts				
(1) Project Cost	$0	$63,880,000	$65,480,000	$15,430,000
(2) Interest During Construction	$0	$1,911,000	$1,960,500	$460,800
(3) Average Annual First Cost	N/A	$3,534,443	$3,623,058	$853,690
(4) Annual O&M	$0	$17,158,897	$17,588,675	$0
(5) Total Avg. Annual Costs	$0	**$20,693,340**	**$21,211,733**	**$853,690**
2. Environmental Quality (EQ)				

Problem Area: Beach and Dune Placement, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Measure I	Measure J	Measure K
(1) Ecosystem Restoration	Alternative would provide no ecosystem restoration benefits.	Alternative would provide a Functional Habitat Index (FHI) increase of **412**.	Alternative would provide a Functional Habitat Index (FHI) increase of **652**.	Alternative would provide a Functional Habitat Index (FHI) increase of **736**.
(2) Water Circulation	N/A	No Impact	No Impact	No Impact
(3) Noise Level Changes	no change in noise levels	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction
(4) Public Facilities	No change in public facilities.	Minor protection of public facilities public facilities.	Minor protection of public facilities public facilities.	Minor protection of public facilities public facilities.
(5) Aesthetic Values	No significant change in aesthetic values	Moderate aesthetic improvement	Significant aesthetic improvement	Significant aesthetic improvement
(6) Natural Resources	Existing resources would continue to be impacted during future storm events	Moderate restoration of beach and dune resources.	Significant restoration of beach and dune resources.	Significant restoration of beach and dune resources.
(7) Biological Resources	Existing resources would continue to be impacted during future storm events	Moderate increase in biological resources utilizing beach habitat including T&E species	Significant increase in biological resources utilizing beach and dune habitat including T&E species	Significant increase in biological resources utilizing beach and dune habitat including T&E species
(8) Air Quality	No anticipated effect on air quality	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*
(9) Water Quality	No anticipated effect on water quality	Minor transitory impacts during construction	Minor transitory impacts during construction	Minor transitory impacts during construction
(10) Public Services	Damages to public services would continue	Overall negative effect due to wind blown sand on roadway	Overall negative effect due to wind blown sand on roadway	Small but positive effect on public services from reduced inundation risk.

Problem Area: Beach and Dune Placement, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Measure I	Measure J	Measure K
(11) Cultural and Historical Preservation	Damage to cultural and historical resources north of the beach would continue	Would provide some reduction of risk to cultural and historical artifacts located north of the beach	Would provide some reduction of risk to cultural and historical artifacts located north of the beach	Would provide some reduction of risk to cultural and historical artifacts located north of the beach
(12) Total Quality of the Environment	Some degradation of the environment would continue during storm events	Environmental quality of the area would be moderately improved	Environmental quality of the area would be significantly improved	Environmental quality of the area would be significantly improved
3. Regional Economic Development (RED)				
(1) Impact on Sales Volume	No impact to the local economy.	increase of **$830,227,800** in additional sales volume.	Increase of **$851,240,400** in additional sales volume.	Increase of **$33,413,200** in additional sales volume.
(2) Impact on Income	No impact to the local economy.	Increase of **$181,540,007** in additional local income.	Increase of **$186,094,644** in additional local income.	Increase of **$7,306,957** in additional local income.
(3) Impact on Employment	No impact to the local economy.	Increase of **5,164** new jobs.	Increase of **5,296** new jobs.	Increase of **208** new jobs.
(4) Tax Changes	N/A	N/A	N/A	N/A
4. Other Social Effects (OSE)				
a. Beneficial Impacts				
(1) Security of Life, Health, and Safety	No Impact	Small reduction in risk during storm events	Small reduction in risk during storm events	Small reduction in risk during storm events
(2) Community Cohesion	No negative impacts on community cohesion	No negative impacts on community cohesion	No negative impacts on community cohesion	No negative impacts on community cohesion
(3) Tax Values	Tax values could decline due to damage	Tax values could decline due to damage from future storm	Tax values could decline due to damage from future storm	N/A

Problem Area: Beach and Dune Placement, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Measure I	Measure J	Measure K
	from future storm events	events	events	
(4) Community Growth	No effect on community growth	No effect on community growth	No effect on community growth	No effect on community growth
(5) Property Values	Property values could decline due to damage from future storm events	Minor impact in preservation of property values	Minor impact in preservation of property values	Minor impact in preservation of property values
(6) Displacement of Businesses	No Impact	Small reduction of risk of displacement of businesses immediately adjacent to shoreline	Small reduction of risk of displacement of businesses immediately adjacent to shoreline	Small reduction of risk of displacement of businesses immediately adjacent to shoreline
(7) Public Facilities	No Impact	Some reduction of risk of damage to public facilities immediately adjacent to the shoreline	Some reduction of risk of damage to public facilities immediately adjacent to the shoreline	Some reduction of risk of damage to public facilities immediately adjacent to the shoreline
(8) Injurious Displacement of Farms	N/A	N/A	N/A	N/A
b. Preservation of life	Taking no action could contribute to future loss of life	Minor reduction in the chance of loss of life during future events	Minor reduction in the chance of loss of life during future events	Minor reduction in the chance of loss of life during future events
C. PLAN EVALUATION				
1. Contributions to Planning Objectives				
a. Flood, Hurricane and/or Storm Damage Reduction	No improvement	Alternative will result in minor improvement in damage reduction.	Alternative will result in minor improvement in damage reduction.	Alternative will result in minor improvement in damage reduction.

Problem Area: Beach and Dune Placement, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Measure I	Measure J	Measure K
b. Recovery of lost environmental resources	No improvement	Will provide habitat to various biological resources with those numbers increasing with time.	Will provide habitat to various biological resources with those numbers increasing with time.	Will provide significant habitat to various biological resources with those numbers increasing with time.
2. Response to Planning Constraints				
a. Avoid environmental impacts and minimize induced damages	Continued loss of environmental resources.	Alternative is anticipated to have a beneficial effect on environmental resources.	Alternative is anticipated to have a beneficial effect on environmental resources.	Alternative is anticipated to have a beneficial effect on environmental resources.
b. Institutional Acceptability	Not supported by state or local government	Is supported by local and state governments	Is supported by local and state governments	Is supported by local and state governments
3. Response to Evaluation Criteria				
a. Acceptability	NO	YES	YES	YES
b. Completeness	NO	YES	YES	YES
c. Effectiveness	NO	YES	YES	YES
d. Efficiency (Cost-Effectiveness; i.e., most efficient use of Federal and Non-Federal Funds)	NO	YES	YES	YES, the most cost effective
e. Integration	N/A	Seamless part of overall system.	Seamless part of overall system.	Seamless part of overall system.
f. Reversibility	N/A	Could be reversible	Could be reversible	Could be reversible
4. Stakeholder Preference Score (From MCDA weightings analysis)				
a. Summary Score	**23.30%**	**54.19%**	**65.54%**	**77.86%**
Cluster Group A	30.99%	44.52%	58.00%	74.04%
Cluster Group B	28.07%	49.57%	61.64%	75.23%
Cluster Group C	22.00%	53.83%	64.90%	80.50%

Problem Area: Beach and Dune Placement, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Measure I	Measure J	Measure K
Cluster Group D	12.12%	68.83%	77.63%	81.66%
b. Stakeholder Preference	All groups ranked this plan lowest.	Plan ranked low, but higher than no action.	Plan ranked high, but lower than measure k.	Plan ranked highest of all action plans.
D. Implementation Responsibility	No implementation responsibilities	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.
E. State and other Non-Federal Coordination	No State or other Non-Federal coordination activities	Would require limited, State or other Non-Federal coordination activities	Would require limited, State or other Non-Federal coordination activities	Would require limited, State or other Non-Federal coordination activities
F. Risk Evaluation				
1. Risk and Vulnerabilities				
a. Risk of Failure	N/A	Low	Low	Low
b. Residual Risk	All dunes will overtop during most surge events, and will not provide significant reduction of surge and waves. Residual risk of ecological failure of dune ecosystems would remain very high	Large residual risk from surge and waves would remain in the event of project implementation, from moderate to large events. Residual risk of ecological failure of dune ecosystems would still exist, but at less risk than No-Action Plan	Large residual risk from surge and waves would remain in the event of project implementation, from moderate to large events. . Residual risk of ecological failure of dune ecosystems would still exist, but at less risk than No-Action Plan	Large residual risk from surge and waves would remain in the event of project implementation, from moderate to large events. . Residual risk of ecological failure of dune ecosystems would still exist, but at less risk than No-Action Plan

Problem Area: Beach and Dune Placement, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Measure I	Measure J	Measure K
c. Reliability	N/A	Plan would provide for reliable reduction of surge and wave damage from events less than 10 ft. in depth, but would require periodic repair and rehabilitation after damaging surge and wave events.	Plan would provide for reliable reduction of surge and wave damage from events less than 10 ft. in depth, but would require periodic repair and rehabilitation after damaging surge and wave events.	Plan would provide for reliable reduction of surge and wave damage from events less than 2 ft. in depth, but would require periodic repair and rehabilitation after damaging surge and wave events.
d. Relative Sea Level Rise	Problems will be substantially exacerbated by an increasing relative rise of sea level	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be moderately impacted by an increasing relative rise of sea level over the period of analysis due to low height of berm dune. May require eventual addition of height to compensate.
e. Risk of Ecosystem Damage	Ecosystem damage will continue to accrue at a rate at least that of recent history with substantial negative outcomes.	Risk of dune ecosystem damage will be moderate throughout the period of analysis.	Risk of dune ecosystem damage will be moderate throughout the period of analysis.	Risk of dune ecosystem damage will be moderate throughout the period of analysis.

Problem Area: Beach and Dune Placement, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Measure I	Measure J	Measure K
f. Risk to Life and Safety	Significant threats to Life and Safety from storm surge will continue to rise due to continued deterioration of the dune system.	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide less risk to life and safety than the No Action Plan or plan K	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide less risk to life and safety than the No Action Plan or plan K	Significant threats to Life and Safety from storm surge will still exist but this plan will provide less risk to life and safety than the No Action Plan
g. Risk to Mental and Physical Health	Significant threats to Mental and Physical Health from storm surge will continue to rise due to continued deterioration of the dune system.	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide less risk to Mental and Physical Health than no action or plan K.	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide less risk to Mental and Physical Health than the No Action Plan or plan K.	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide less risk to Mental and Physical Health than the No Action Plan.
2. Recommendations and Preferences				
a. Federal Recommendation				Plan K provides best balance of ecosystem and damage reduction benefits, at considerably lower cost than Plans I & J, and at similar risk. Provides considerable benefits compared to No-Action Plan.

Problem Area: Beach and Dune Placement, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Measure I	Measure J	Measure K
b. Stakeholder Preference				Stakeholder preference indicated by summary scores of Plan K. Lower scores achieved by Plan J, but even lower for Plan I. Lowest scores achieved for No-Action Plan.

1 **Table 3-13**
2 **System of Accounts table for Turkey Creek Alternatives**

Problem Area: Turkey Creek Ecosystem Restoration, Harrison County, Mississippi

Problems ID: Environmental damages suffered by flooding due to hurricanes; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
A. PLAN DESCRIPTION	No Federal Action	Restoration of 879 Acres North and South of Railroad Maintain by Burning	Restoration of 689 Acres South of Railroad Maintain by Burning	Restoration of 190 Acres North of Railroad Maintain by Burning
B. IMPACT ASSESSMENT				
1. National Economic Development				
a. Beneficial Impacts				
(1) Damages Prevented	$0	Moderate level of damage reduction from improved storm water storage	Moderate level of damage reduction from improved storm water storage	Moderate level of damage reduction from improved storm water storage
(2) Emergency Costs Avoided	$0	$0	$0	$0
(3) Recreation	No significant change in recreation benefits	Significant opportunity for ecotourism	Significant opportunity for ecotourism	Moderate opportunity for ecotourism
(4) Total Beneficial Impacts	None.			
b. Adverse Impacts				
(1) Project Cost	$0	$7,636,000	$5,887,000	$1,871,000
(2) Interest During Construction	$0	$169,000	$130,000	$41,000
(3) Average Annual First Cost	N/A	$419,000	$323,000	$101,000
(4) Annual O&M	$0	$60,000	$47,000	$13,000

Problem Area: Turkey Creek Ecosystem Restoration, Harrison County, Mississippi

Problems ID: Environmental damages suffered by flooding due to hurricanes; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
(5) Total Avg. Annual Costs	$0	$479,000	$370,000	$114,000
2. Environmental Quality (EQ)				
(1) Ecosystem Restoration	No ecosystem restoration benefits.	Average Annual Functional Units (AAFU) increase of **2,046**.	Average Annual Functional Units (AAFU) increase of **1,565**.	Average Annual Functional Units (AAFU) increase of **481**.
(2) Water Circulation	No effect on water circulation.	No effect on water circulation.	No effect on water circulation.	No effect on water circulation.
(3) Noise Level Changes	Alternative would result in no change in noise levels	Alternative would result in temporary increase in noise levels during construction	Alternative would result in temporary increase in noise levels during construction	Alternative would result in temporary increase in noise levels during construction
(4) Public Facilities	Development likely to be commercial/residential	Opportunity for passive recreation	Opportunity for passive recreation	Opportunity for passive recreation
(5) Aesthetic Values	Future development would change aesthetics	Significant aesthetic improvement	Significant aesthetic improvement	Significant aesthetic improvement
(6) Natural Resources	Continued degradation of existing natural resources.	Restoration of 879 acres of regionally significant coastal wet pine savannah habitat.	Restoration of 689 acres of regionally significant coastal wet pine savannah habitat.	Restoration of 190 acres of regionally significant coastal wet pine savannah habitat.

Problem Area: Turkey Creek Ecosystem Restoration, Harrison County, Mississippi

Problems ID: Environmental damages suffered by flooding due to hurricanes; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
(7) Biological Resources	Biological resources would degrade due to altered hydrology and lost as future development proceeds	Significant improvement of habitat and associated biological resources	Significant improvement of habitat and associated biological resources	Moderate improvement of habitat and associated biological resources
(8) Air Quality	No effect on air quality	Air emission would be *de minimus* & intermittent with maintenance burning	Air emission would be *de minimus*& intermittent with maintenance burning	Air emission would be *de minimus* & intermittent with maintenance burning
(9) Water Quality	No anticipated effect on water quality	Significant long-term improvements are anticipated.	Significant long-term improvements are anticipated.	Some long-term improvements are anticipated.
(10) Public Services	Development would result in a significant need of additional public services	N/A	N/A	N/A
(11) Cultural and Historical Preservation	N/A	N/A	N/A	N/A
(12) Total Quality of the Environment	Continued degradation without development could become significant with development.	Total quality of environment would be significantly improved.	Total quality of environment would be significantly improved.	Total quality of environment would be moderately improved.

3. Regional Economic Development (RED)

Problem Area: Turkey Creek Ecosystem Restoration, Harrison County, Mississippi

Problems ID: Environmental damages suffered by flooding due to hurricanes; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
(1) Impact on Sales Volume	No impact to the local economy.	Increase of **$19,602,000** in additional sales volume.	Increase of **$15,237,000** in additional sales volume.	Increase of **$4,815,000** in additional sales volume.
(2) Impact on Income	No impact to the local economy.	Increase of **$4,149,260** in additional local income.	Increase of **$3,225,297** in additional local income.	Increase of **$1,019,217** in additional local income.
(3) Impact on Employment	No impact to the local economy.	Increase of **124** new jobs.	Increase of **97 new jobs**.	Increase of **31** new jobs.
(4) Tax Changes	Taxes could increase as land use changes	Alternative would result in no change in taxes	Alternative would result in no change in taxes	Alternative would result in no change in taxes
4. Other Social Effects (OSE)				
a. Beneficial Impacts				
(1) Security of Life, Health, and Safety	N/A	N/A	N/A	N/A
(2) Community Cohesion	No Impact.	Forrest Heights, a culturally significant minority community in the Turkey Creek watershed, would benefit significantly	Forrest Heights, a culturally significant minority community in the Turkey Creek watershed, would benefit significantly	Forrest Heights, a culturally significant minority community in the Turkey Creek watershed, would receive moderate benefit from this alternative
(3) Tax Values	No Impact.	Land would be taxed differently because it would be owned by State.	Land would be taxed differently because it would be owned by State.	Land would be taxed differently because it would be owned by State.

Problem Area: Turkey Creek Ecosystem Restoration, Harrison County, Mississippi

Problems ID: Environmental damages suffered by flooding due to hurricanes; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
(4) Community Growth	No Impact.	Would restrict development in this area of Gulfport.	Would restrict development in this area of Gulfport.	Would restrict development in this area of Gulfport.
(5) Property Values	No Impact.	Adjacent property values could increase due to greenspace and less frequent flooding	Adjacent property values could increase due to greenspace and less frequent flooding	Adjacent property values could increase due to greenspace and less frequent flooding
(6) Displacement of Businesses	No Impact.	No Impact.	No Impact.	No Impact.
(7) Public Facilities	No Impact.	No Impact.	No Impact.	No Impact.
(8) Injurious Displacement of Farms	N/A	N/A	N/A	N/A
b. Preservation of loss of life	No Impact.	Moderate reduction of risk within Turkey Creek watershed	Moderate reduction of risk within Turkey Creek watershed	Moderate reduction of risk within Turkey Creek watershed
C. PLAN EVALUATION				
1. Contributions to Planning Objectives				
a. Flood, Hurricane and/or Storm Damage Reduction	N/A	YES	YES	YES
b. Recovery of lost environmental resources	N/A	YES	YES	YES
2. Response to Planning Constraints				
a. Avoid environmental impacts and minimize induced damages	No Action could significant increase impacts	YES	YES	YES

Problem Area: Turkey Creek Ecosystem Restoration, Harrison County, Mississippi

Problems ID: Environmental damages suffered by flooding due to hurricanes; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
b. Institutional Acceptability	N/A	YES	YES	YES
3. Response to Evaluation Criteria				
a. Acceptability	N/A	YES	YES	YES
b. Completeness	N/A	YES, most complete	YES, moderately complete	YES, least complete
c. Effectiveness	N/A	Most effective	Highly effective	Moderately effective
d. Efficiency (Cost-Effectiveness; i.e., most efficient use of Federal and Non-Federal Funds)	N/A	YES, moderately efficient balance of habitat benefit/cost/risk.	YES, moderately efficient balance of habitat benefit/cost/risk.	YES, moderately efficient balance of habitat benefit/cost/risk.
e. Integration	N/A	Seamless part of overall system.	Seamless part of overall system.	Seamless part of overall system.
f. Reversibility	This issue does not apply	No-land could not be resold for development	No-land could not be resold for development	No-land could not be resold for development
4. Stakeholder Preference Score (From MCDA weightings analysis)				
a. Summary Score	**62.23%**	**43.20%**	**42.27%**	**39.07%**
Cluster Group A	79.63%	26.30%	33.16%	44.64%
Cluster Group B	67.39%	38.70%	39.23%	42.19%
Cluster Group C	61.90%	43.81%	42.00%	37.21%
Cluster Group D	40.00%	64.00%	54.67%	32.24%

Problem Area: Turkey Creek Ecosystem Restoration, Harrison County, Mississippi

Problems ID: Environmental damages suffered by flooding due to hurricanes; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
b. Stakeholder Preference	Plan ranked highest by stakeholders.	All action plans ranked lower than no action by stakeholders.	All action plans ranked lower than no action by stakeholders.	All action plans ranked lower than no action by stakeholders.
D. Implementation Responsibility	N/A	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.
E. State and other Non-Federal Coordination	Would require no State or other Non-Federal coordination activities	Would require limitedState or other Non-Federal coordination activities	Would require limitedState or other Non-Federal coordination activities	Would require limited State or other Non-Federal coordination activities
F. Risk Evaluation				
1. Risk and Vulnerabilities				
a. Risk of Failure	N/A	Low	Low	Low
b. Residual Risk	Residual risk to loss of environmental resources is extremely high. Residual risk to adjacent communities remains high from storm-induced flooding.	Residual risk of ecosystem damage is significantly lower level than No-Action Plan. Residual risk to adjacent communities would be moderately reduced	Residual risk of ecosystem damage is at significantly lower level than No-Action Plan. Residual risk to adjacent communities would be moderately reduced	Residual risk of ecosystem damage is at moderately lower level than No-Action Plan. Residual risk to adjacent communities would be moderately reduced

Problem Area: Turkey Creek Ecosystem Restoration, Harrison County, Mississippi

Problems ID: Environmental damages suffered by flooding due to hurricanes; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
c. Reliability	N/A	Would provide a moderate level of reliability, would be resistant to damage from storm events, and would not require significant maintenance.	Would provide a moderate level of reliability, would be resistant to damage from storm events, and would not require significant maintenance.	Would provide a minor level of reliability, would be resistant to damage from storm events, and would not require significant maintenance.
d. Relative Sea Level Rise	Problems could be exacerbated by an increasing relative rise of sea level	This Plan would not be impacted by an increasing relative rise of sea level over the period of analysis	This Plan would not be impacted by an increasing relative rise of sea level over the period of analysis	This Plan would not be impacted by an increasing relative rise of sea level over the period of analysis
e. Risk of Ecosystem Damage	Risk of ecosystem damage is significant as increased development proceeds	Risk of ecosystem damage will be minimal	Risk of ecosystem damage will be minimal	Risk of ecosystem damage will be moderate
f. Risk to Life and Safety	This plan will not reduce threats to life and safety.	This plan would provide a small but positive contribution to reducing threats to life and safety by provision of	This plan would provide a small but positive contribution to reducing threats to life and safety by provision of additional	This plan would provide a small but positive contribution to reducing threats to life and safety by

Problem Area: Turkey Creek Ecosystem Restoration, Harrison County, Mississippi

Problems ID: Environmental damages suffered by flooding due to hurricanes; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
		additional stormwater storage.	stormwater storage.	provision of additional stormwater storage.
g. Risk to Mental and Physical Health	Significant threats to Mental and Physical Health from flooding would still exist.	Moderatethreats to Mental and Physical Health from flooding would still exist.	Moderate threats to Mental and Physical Health from flooding would still exist.	Significant threats to Mental and Physical Health from flooding would still exist.
2. Recommendations and Preferences				
a. Federal Recommendation			Federal recommendation is for Plan 3, which achieves best balance of plan outcomes, at lower costs than Plan 1, achieves objectives for problem solving at this site, with much higher benefit than Plan 5 or No-Action Plan.	

Problem Area: Turkey Creek Ecosystem Restoration, Harrison County, Mississippi

Problems ID: Environmental damages suffered by flooding due to hurricanes; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
b. Stakeholder Preference	Initial Stakeholder preference scores indicated the No-Action Plan		Even though the initial stakeholder preference scores pointed towards the No-Action Plan, additional consultation with local and state entities show strong support for Plan 3	

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1 **Table 3-14**
2 **System of Accounts table for Bayou Cumbest Alternatives**

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
A. PLAN DESCRIPTION	No Federal Action	Excavate Fill, Remove Exotic Species, Plant native species at 0.5 meter density, and fill ditches, plus acquisition	Excavate Fill, Remove Exotic Species, Plant native species at 1.0 meter density, and fill ditches, plus acquisition	Excavate Fill, Remove Exotic Species, Plant native species at 2.0 meter density, and fill ditches, plus acquisition	Excavate Fill, Remove Exotic Species, and Plant native species at 2 meter density, plus acquisition
B. IMPACT ASSESSMENT					
1. National Economic Development					
a. Beneficial Impacts					
(1) Damages Prevented	$0	$0	$0	$0	$0
(2) Emergency Costs Avoided	$0	$0	$0	$0	$0
(3) Recreation	$0	Possible increase in ecotourism	Possible increase in ecotourism	Possible increase in ecotourism	Possible increase in ecotourism
(4) Total Beneficial Impacts	None.	$0	$0	$0	$0
b. Adverse Impacts					
(1) Project Cost	$0	$28,000,000	$22,350,000	$21,030,000	$21,020,000
(2) Interest During Construction	$0	$620,000	$520,000	$470,000	$470,000

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
(3) Average Annual First Cost	N/A	$1,538,000	$1,282,000	$1,155,000	$1,154,000
(4) Annual O&M	$0	$2,000	$114,000	$112,000	$1,266,000
(5) Total Avg. Annual Costs	$0	$1,540,000	$1,396,000	$1,267,000	$2,420,000
2. Environmental Quality (EQ)					
(1) Ecosystem Restoration	No ecosystem restoration benefits.	Restoration of approximately 110 acres with an average annual functional unit (AAFU) values of **191.**	Restoration of approximately 110 acres with an average annual functional unit (AAFU) values of **188**	Restoration of approximately 110 acres with an average annual functional unit (AAFU) values of 184**.**	Restoration of approximately 110 acres with an average annual functional unit (AAFU) values of **164**.
(2) Water Circulation	No anticipated effect on water circulation.	No anticipated effect on water circulation.	No anticipated effect on water circulation.	No anticipated effect on water circulation.	No anticipated effect on water circulation.
(3) Noise Level Changes	No change in noise levels	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction
(4) Public Facilities	N/A	N/A	N/A	N/A	N/A
(5) Aesthetic Values	No significant change in aesthetic values	Significant improvement to natural aesthetic values	Significant improvement to natural aesthetic values	Significant improvement to natural aesthetic values	Significant improvement to natural aesthetic values

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
(6) Natural Resources	Continued degradation with possible increase of invasive species	Alternative would result in restoration of coastal marsh resources.	Alternative would result in restoration of coastal marsh resources.	Alternative would result in restoration of coastal marsh resources.	Alternative would result in restoration of coastal marsh resources.
(7) Biological Resources	Continued degradation with possible increase of invasive species	Biological resources would be significantly improved versus the no-action alternative.	Biological resources would be significantly improved versus the no-action alternative.	Biological resources would be moderately improved versus the no-action alternative.	Biological resources would be somewhat improved versus the no-action alternative.
(8) Air Quality	Alternative would have no anticipated effect on air quality	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*
(9) Water Quality	No impact.	Temporary negative impacts to water quality due to construction , significant long-term improvements.	Temporary negative impacts to water quality due to construction , significant long-term improvements.	Temporary negative impacts to water quality due to construction , significant long-term improvements.	Temporary negative impacts to water quality due to construction , significant long-term improvements.
(10) Public Services	Public services to community would continue to be interrupted during storm events	No impact. Reduced need for public services in the area	No impact. Reduced need for public services in the area	No impact. Reduced need for public services in the area	No impact. Reduced need for public services in the area

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
(11) Cultural and Historical Preservation	No impact.	No impact.	No impact.	No impact.	No impact.
(12) Total Quality of the Environment	Environmental quality will degrade thru time	Environmental quality would be improved.	Environmental quality would be improved.	Environmental quality would be improved.	Environmental quality would be improved.
3. Regional Economic Development (RED)					
(1) Impact on Sales Volume	No impact.	Increase of **$59,451,160** in additional sales volume.	Increase of **$54,072,720** in additional sales volume.	Increase of **$48,910,520** in additional sales volume.	Increase of **$48,910,520** in additional sales volume.
(2) Impact on Income	No impact.	Increase of **$11,594,495** in additional local income.	Increase of **$10,545,562** in additional local income.	Increase of **$9,538,801** in additional local income.	Increase of **$9,538,801** in additional local income.
(3) Impact on Employment	No impact.	Increase of **337** new jobs.	Increase of **306** new jobs.	Increase of **277** new jobs.	Increase of **277** new jobs.
(4) Tax Changes	No impact.	Would result in loss of some local tax revenue due to acquisition of properties.	Would result in loss of some local tax revenue due to acquisition of properties.	Would result in loss of some local tax revenue due to acquisition of properties.	Would result in loss of some local tax revenue due to acquisition of properties.
4. Other Social Effects (OSE)					
a. Beneficial Impacts					

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
(1) Security of Life, Health, and Safety	HMGP purchase of properties currently reducing	Minor additional reduction in potential loss of life from evacuation of persons and property.	Minor additional reduction in potential loss of life from evacuation of persons and property.	Minor additional reduction in potential loss of life from evacuation of persons and property.	Minor additional reduction in potential loss of life from evacuation of persons and property.
(2) Community Cohesion	Community currently being dispersed with HMGP action	Community would continue to be dispersed	Community would continue to be dispersed	Community would continue to be dispersed	Community would continue to be dispersed
(3) Tax Values	Currently being impacted via HMGP acquisition	Ownership and landuse changes would impact tax value	Ownership and landuse changes would impact tax value	Ownership and landuse changes would impact tax value	Ownership and landuse changes would impact tax value
(4) Community Growth	Growth being shifted as residents relocate	Growth would continue to be shifted to other areas of coastal Mississippi	Growth would be shifted to other areas of coastal Mississippi	Growth would be shifted to other areas of coastal Mississippi	Growth would be shifted to other areas of coastal Mississippi
(5) Property Values	Currently being impacted via HMGP acquisition	Minor temporary negative impact to additional adjacent properties during acquisition phase.	Minor temporary negative impact to additional adjacent properties during acquisition phase.	Minor temporary negative impact to additional adjacent properties during acquisition phase.	Minor temporary negative impact to additional adjacent properties during acquisition phase.
(6) Displacement of Businesses	N/A	N/A	N/A	N/A	N/A

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
(7) Public Facilities	N/A	Enhances opportunities for passive recreation	Enhances opportunities for passive recreation	Enhances opportunities for passive recreation	Enhances opportunities for passive recreation
(8) Injurious Displacement of Farms	N/A	N/A	N/A	N/A	N/A
b. Preservation of loss of life	Currently being reduced via HMGP acquisition	Some additional reduction in potential loss of life.	Some additional reduction in potential loss of life.	Some additional reduction in potential loss of life.	Some additional reduction in potential loss of life.
C. PLAN EVALUATION					
1. Contributions to Planning Objectives					
a. Flood, Hurricane and/or Storm Damage Reduction	Some reduction being gained via HMGP acquisition	Additional reduction in damages at project site and minor improvement to storm water conveyance through restoration.	Additional reduction in damages at project site and minor improvement to storm water conveyance through restoration.	Additional reduction in damages at project site and minor improvement to storm water conveyance through restoration.	Additional reduction in damages at project site and minor improvement to storm water conveyance through restoration.

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
b. Recovery of lost environmental resources	Continued loss of environmental resources.	Significant opportunity to recover environmental resources negatively impacted in past	Significant opportunity to recover environmental resources negatively impacted in past	Significant opportunity to recover environmental resources negatively impacted in past	Significant opportunity to recover environmental resources negatively impacted in past
2. Response to Planning Constraints					
a. Avoid environmental impacts and minimize induced damages	Continued loss ofenvironmental resources.	Positive effect on environmental resources.	Positive effect on environmental resources.	Positive effect on environmental resources.	Positive effect on environmental resources.
b. Institutional Acceptability	HMGP acquisitional has local support	Is supported by local and state governments	Is supported by local and state governments	Is supported by local and state governments	Is supported by local and state governments
3. Response to Evaluation Criteria					
a. Acceptability	NO	YES	YES	YES	YES
b. Completeness	NO	YES	YES	YES	YES
c. Effectiveness	NO	YES	YES	YES	YES
d. Efficiency (Cost-Effectiveness; i.e., most efficient use of Federal and Non-Federal Funds)	NO	YES	YES, but moderate risk of exotic species return over period of analysis.	YES, but high risk of exotic species return over period of analysis.	YES, but high risk of exotic species return over period of analysis.

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
e. Integration	N/A	Seamless part of overall system.	Seamless part of overall system.	Seamless part of overall system.	Seamless part of overall system.
f. Reversibility	N/A	NO - land could not be resold for development	NO - land could not be resold for development	NO - land could not be resold for development	NO - land could not be resold for development
4. Stakeholder Preference Score (From MCDA weightings analysis)					
a. Summary Score	**48.52%**	**55.99%**	**57.45%**	**57.83%**	**57.84%**
Cluster Group A	59.26%	46.09%	48.51%	49.61%	49.62%
Cluster Group B	50.00%	53.81%	56.31%	57.43%	57.44%
Cluster Group C	54.39%	50.88%	51.95%	51.89%	51.90%
Cluster Group D	30.43%	73.19%	73.03%	72.40%	72.40%
b. Stakeholder Preference	No clear stakeholder preference indicated, but all action plans preferred to no action plan.	No clear stakeholder preference indicated, but all action plans preferred to no action plan.	No clear stakeholder preference indicated, but all action plans preferred to no action plan.	No clear stakeholder preference indicated, but all action plans preferred to no action plan.	No clear stakeholder preference indicated, but all action plans preferred to no action plan.
D. Implementation Responsibility	No additional implementation responsibilities	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
E. State and other Non-Federal Coordination	No State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities
F. Risk Evaluation					
1. Risk and Vulnerabilities					
a. Risk of Failure	N/A	Very low risk of failure	Very low risk of failure.	Very low risk of failure.	Very low risk of failure.
b. Residual Risk	Residual risk to properties not acquired in HMGP remain substantial due to storm surge.	Residual risk to additional properties reduced. Residual risk of ecosystem damage would be substantially lower than No-Action Plan.	Residual risk to additional properties reduced. Residual risk of ecosystem damage would be substantially lower than No-Action Plan,and Plans 3 & 6	Residual risk to additional properties reduced. Residual risk of ecosystem damage would be substantially lower than No-Action Plan but higher than plans 1 & 2.	Residual risk to additional properties reduced. Residual risk of ecosystem damage would be substantially lower than No-Action Plan but higher than plans 1 & 2.

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
c. Reliability	N/A	This plan would provide a significantly greater degree of reliability than all other plans, but at much higher cost, would be most resistant to damage from storm events, and would require some maintenance.	This plan would provide a significantly greater degree of reliability than Plans 3 and 6, and at lesser cost than Plan 1; would be resistant to damage from storm events, and would require moderate maintenance.	This plan would provide a significantly lesser degree of reliability than Plans 1 and 3, would be somewhat resistant to damage from storm events, and would require high maintenance.	Plan would provide a significantly lesser degree of reliability than all other action plans; would be least resistant to damage from storm events of all action plans, and would require significant maintenance
d. Relative Sea Level Rise	Problems will be substantially exacerbated by an increasing relative rise of sea level	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
e. Risk of Ecosystem Damage	Ecosystem damage will continue to accrue at a rate at least that of recent history with substantial negative outcomes.	Risk of ecosystem damage will be least throughout the period of analysis.	Risk of ecosystem damage will be minimal throughout the period of analysis.	Risk of ecosystem damage will be most throughout the period of analysis.	Risk of ecosystem damage will be most throughout the period of analysis.
f. Risk to Life and Safety	Threats being reduced via HMGP acquisition	Additional reduction in threats via HMGP acquisition	Additional reduction in threats via HMGP acquisition	Additional reduction in threats via HMGP acquisition	Additional reduction in threats via HMGP acquisition
g. Risk to Mental and Physical Health	Risks being reduced via HMGP acquisition	Additional reduction via HMGP acquisition	N/A	N/A	N/A

2. Recommendations and Preferences

Problem Area: Bayou Cumbest Restoration, Jackson County, Mississippi

Problems ID: Ecosystem and Structural damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.
Note: Acquisition only is not a stand alone alternative

Item	No Action	Plan 1	Plan 2	Plan 3	Plan 6
a. Federal Recommendation			Plan 2 achieves best balance of outcomes, at similar cost to Plans 1,3, and 6, but with substantially greater functional improvement and greater reliability of outcomes when compared to all other plans.		
b. Stakeholder Preference	No clear stakeholder preference indicated, but all action plans preferred to no action plan.		Even though the initial stakeholder preference scores were slightly higher for plans 3 & 6 the differences are not significant. Additional consultation with local and state entities shows strong support for Plan 2		

Table 3-15
System of Accounts table for Admiral Island Alternatives

Problem Area: Admiral Island Ecosystem Restoration, Hancock County, Mississippi					
Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack have threatened environmental sustainability of the area.					
Item	**No Action Plan**	**Plan 1**	**Plan 2**	**Plan 3**	**Plan 6**
A. PLAN DESCRIPTION	No Federal Action	Excavate Fill, Remove Exotic Species, Plant native species at 0.5 meter density, and fill ditches	Excavate Fill, Remove Exotic Species, Plant native species at 1.0 meter density, and fill ditches	Excavate Fill, Remove Exotic Species, Plant native species at 2.0 meter density, and fill ditches	Excavate Fill, Remove Exotic Species, and Plant native species at 2.0 meter density
B. IMPACT ASSESSMENT					
1. National Economic Development					
a. Beneficial Impacts					
(1) Damages Prevented	$0	Moderate level of damages prevented from increased flood storage capacity.	Moderate level of damages prevented from increased flood storage capacity.	Moderate level of damages prevented from increased flood storage capacity.	Moderate level of damages prevented from increased storm storage capacity.
(2) Emergency Costs Avoided	$0	$0	$0	$0	$0
(3) Recreation	N/A	Possible ecotourism benefits	Possible ecotourism benefits	Possible ecotourism benefits	Possible ecotourism benefits
(4) Total Beneficial Impacts	None.				
b. Adverse Impacts					
(1) Project Cost	$0	$26,340,000	$23,790,000	$22,490,000	$22,440,000
(2) Interest During Construction	$0	$580,000	$530,000	$500,000	$500,000
(2) Average Annual First Cost	N/A	$1,447,000	$1,306,000	$1,235,000	$1,232,000
(3) Annual O&M	$0	$2,000	$58,000	$58,000	$58,000
(4) Total Avg. Annual Costs	$0	$1,449,000	$1,364,000	$1,293,000	$1,290,000
2. Environmental Quality (EQ)					

Problem Area: Admiral Island Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack have threatened environmental sustainability of the area.

Item	No Action Plan	Plan 1	Plan 2	Plan 3	Plan 6
(1) Ecosystem Restoration	No ecosystem restoration benefits. Potential for further loss of habitat function.	Average Annual Functional Units (AAFU) increase of **61**.	Average Annual Functional Units (AAFU) increase of **60**.	Average Annual Functional Units (AAFU) increase of **59**.	Average Annual Functional Units (AAFU) increase of **49**.
(2) Water Circulation	No anticipated effect on water circulation.	No anticipated effect on water circulation.	No anticipated effect on water circulation.	No anticipated effect on water circulation.	No anticipated effect on water circulation.
(3) Noise Level Changes	No change in noise levels	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction
(4) Public Facilities	N/A	N/A	N/A	N/A	N/A
(5) Aesthetic Values	The aesthetic value of the resource would continue to degrade as invasive species outcompete native species	Alternative would result in improvement of the aesthetic experience through restoration of natural vegetative habitat	Alternative would result in improvement of the aesthetic experience through restoration of natural vegetative habitat	Alternative would result in improvement of the aesthetic experience through restoration of natural vegetative habitat	Alternative would result in improvement of the aesthetic experience through restoration of natural vegetative habitat
(6) Natural Resources	Existing natural resources would continue to be degraded	Alternative would result in restoration of natural vegetative habitat with improved natural resource value.	Alternative would result in restoration of natural vegetative habitat.	Alternative would result in restoration of natural vegetative habitat.	Alternative would result in restoration of natural vegetative habitat.

Problem Area: Admiral Island Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack have threatened environmental sustainability of the area.

Item	No Action Plan	Plan 1	Plan 2	Plan 3	Plan 6
(7) Biological Resources	Biological resources would continue to be degraded.	Biological resources would be significantly improved versus the no-action alternative.	Biological resources would be significantly improved versus the no-action alternative.	Biological resources would be moderately improved versus the no-action alternative.	Biological resources would be somewhat improved versus the no-action alternative.
(8) Air Quality	No Impact	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*
(9) Water Quality	No anticipated effect on water quality	Temporary negative impacts to water quality due to construction but overall water quality would be greatly improved by marsh restoration.	Temporary negative impacts to water quality due to construction but overall water quality would be greatly improved by marsh restoration.	Temporary negative impacts to water quality due to construction but overall water quality would be moderately improved by marsh restoration.	Temporary negative impacts to water quality due to construction but overall water quality would be moderately improved by marsh restoration.
(10) Public Services	N/A	N/A	N/A	N/A	N/A
(11) Cultural and Historical Preservation	N/A	N/A	N/A	N/A	N/A
(12) Total Quality of the Environment	Quality of environment would continue to degrade	Environmental quality would be improved significantly.	Environmental quality would be improved significantly.	Environmental quality would be improved significantly.	Environmental quality would be improved.
3. Regional Economic Development (RED)					

Problem Area: Admiral Island Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack have threatened environmental sustainability of the area.

Item	No Action Plan	Plan 1	Plan 2	Plan 3	Plan 6
(1) Impact on Sales Volume	No impact to the local economy.	Increase of **$52,686,000** in additional sales volume to the local economy.	Increase of **$49,750,000** in additional sales volume to the local economy.	Increase of **$47,150,000** in additional sales volume to the local economy.	Increase of $**46,950,000** in additional sales volume to the local economy.
(2) Impact on Income	No impact to the local economy.	Increase of **$12,704,442** in additional local income to the local economy.	Increase of **$11,996,469** in additional local income to the local economy.	Increase of **$11,369,518** in additional local income to the local economy.	Increase of **$11,321,291** in additional local income to the local economy.
(3) Impact on Employment	No impact to the local economy.	Increase of **319** new jobs to the local economy.	Increase of **301** new jobs to the local economy.	Increase of **285** new jobs to the local economy.	Increase of **284** new jobs to the local economy.
(4) Tax Changes	N/A	N/A	N/A	N/A	N/A
4. Other Social Effects (OSE)					
a. Beneficial Impacts					
(1) Security of Life, Health, and Safety	Continued risks to life, health and safety	Some reduction in risk due to improved storm water storage.	Some reduction in risk due to improved storm water storage.	Some reduction in risk due to improved storm water storage.	Some reduction in risk due to improved storm water storage.
(2) Community Cohesion	N/A	N/A	N/A	N/A	N/A
(3) Tax Values	N/A	N/A	N/A	N/A	N/A
(4) Community Growth	N/A	N/A	N/A	N/A	N/A

Problem Area: Admiral Island Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack have threatened environmental sustainability of the area.

Item	No Action Plan	Plan 1	Plan 2	Plan 3	Plan 6
(5) Property Values	Property values in adjacent areas could decrease with of areas	Property values in adjacent areas could improve through restoration of the natural habitat and open greenspace.	Property values in adjacent areas could improve through restoration of the natural habitat and open greenspace.	Property values in adjacent areas could improve through restoration of the natural habitat and open greenspace.	Property values in adjacent areas could improve through restoration of the natural habitat and open greenspace.
(6) Displacement of Businesses	N/A	N/A	N/A	N/A	N/A
(7) Public Facilities	N/A	N/A	N/A	N/A	N/A
(8) Injurious Displacement of Farms	N/A	N/A	N/A	N/A	N/A
b. Preservation of loss of life	N/A	N/A	N/A	N/A	N/A
C. PLAN EVALUATION					
1. Contributions to Planning Objectives					
a. Flood, Hurricane and/or Storm Damage Reduction	N/A	YES	YES	YES	YES
b. Recovery of lost environmental resources	NO	YES	YES	YES	YES
2. Response to Planning Constraints					
a. Avoid environmental impacts and minimize induced damages	NO	YES	YES	YES	YES
b. Institutional Acceptability	NO	YES	YES	YES	YES
3. Response to Evaluation Criteria					
a. Acceptability	NO	YES	YES	YES	YES

Problem Area: Admiral Island Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack have threatened environmental sustainability of the area.

Item	No Action Plan	Plan 1	Plan 2	Plan 3	Plan 6
b. Completeness	N/A	YES	YES, but minor risk of exotic species return over period of analysis.	YES, but moderate risk of exotic species return over period of analysis.	YES, but high risk of exotic species return over period of analysis.
c. Effectiveness	N/A	YES	YES	YES	YES
d. Efficiency (Cost-Effectiveness; i.e., most efficient use of Federal and Non-Federal Funds)	N/A	Moderate efficient balance of habitat benefit/cost/risk.	Most efficient balance of habitat benefit/cost/risk.	Moderate efficient balance of habitat benefit/cost/risk.	Least efficient balance of habitat benefit/cost/risk.
e. Integration	N/A	Seamless part of overall system.	Seamless part of overall system.	Seamless part of overall system.	Seamless part of overall system.
f. Reversibility	N/A	N/A	N/A	N/A	N/A
4. Stakeholder Preference Score (From MCDA weightings analysis)					
a. Summary Score	**58.39%**	**47.77%**	**48.37%**	**48.25%**	**48.29%**
Cluster Group A	79.63%	28.40%	30.03%	30.71%	30.76%
Cluster Group B	64.58%	40.97%	42.59%	43.25%	43.29%
Cluster Group C	57.78%	48.89%	48.81%	48.04%	48.07%
Cluster Group D	31.58%	72.81%	72.04%	71.01%	71.02%

Problem Area: Admiral Island Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack have threatened environmental sustainability of the area.

Item	No Action Plan	Plan 1	Plan 2	Plan 3	Plan 6
b. Stakeholder Preference	No clear stakeholder preference indicated, although no action plan ranked higher than action plans.(58.39%) but there is no clear preference	All action plans ranked lower than no action by stakeholders.(47.77%) but there is no clear preference	All action plans ranked lower than no action by stakeholders. (48.37%) but there is no clear preference	All action plans ranked lower than no action by stakeholders. (48.25%) but there is no clear preference	All action plans ranked lower than no action by stakeholders. (48.29%) but there is no clear preference
D. Implementation Responsibility	Does not have any implementation responsibilities	Elements would be joint Federal/Non-Federal implementation responsibility.	Elements would be joint Federal/Non-Federal implementation responsibility.	Elements would be joint Federal/Non-Federal implementation responsibility.	Elements would be joint Federal/Non-Federal implementation responsibility.
E. State and other Non-Federal Coordination	Would require no State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities	Would require - State or other Non-Federal coordination activities
F. Risk Evaluation					
1. Risk and Vulnerabilities					
a. Risk of Failure	N/A	Very low risk of failure	Low risk of failure.	Moderate risk of failure.	Moderate risk of failure.

Problem Area: Admiral Island Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack have threatened environmental sustainability of the area.

Item	No Action Plan	Plan 1	Plan 2	Plan 3	Plan 6
b. Residual Risk	Residual risk of all actions will remain substantial due to lack of restoration	. Residual risk to ecosystem would be much reduced from that of any other plan.	Residual risk of ecosystem damage would be much reduced from all other plans other than Plan 1	Residual risk of ecosystem damage would be much higher than Plans 1 and 2	Residual risk of ecosystem damage would be much higher than all other action plans
c. Reliability	N/A	This plan would provide a significantly greater degree of reliability than Plans 2, 3 and 6, but at higher cost than all other plans and would require maintenance.	This plan would provide a significantly greater degree of reliability than Plans 3 and 6, but at lower cost than Plan 1and would require some maintenance.	This plan would provide a significantly lesser degree of reliability than Plans 1 and 2; and would require moderate maintenance.	Plan would provide a significantly lesser degree of reliability than all other action plans; and would require moderate maintenance
d. Relative Sea Level Rise	Problems will be substantially exacerbated by an increasing relative rise of sea level	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis

Problem Area: Admiral Island Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack have threatened environmental sustainability of the area.

Item	No Action Plan	Plan 1	Plan 2	Plan 3	Plan 6
e. Risk of Ecosystem Damage	Ecosystem damage will continue to accrue at a rate at least that of recent history with substantial negative outcomes.	Risk of ecosystem damage will be minimal throughout the period of analysis.	Risk of ecosystem damage will be minimal throughout the period of analysis.	Risk of ecosystem damage will be minimal throughout the period of analysis.	Risk of ecosystem damage will be minimal throughout the period of analysis.
f. Risk to Life and Safety	N/A	N/A	N/A	N/A	N/A
g. Risk to Mental and Physical Health	N/A	N/A	N/A	N/A	N/A
2. Recommendations and Preferences					

Problem Area: Admiral Island Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack have threatened environmental sustainability of the area.

Item	No Action Plan	Plan 1	Plan 2	Plan 3	Plan 6
a. Federal Recommendation			Plan 2 achieves best balance of outcomes, at similar cost to Plans 1,3, and 6, but with substantially greater functional improvement and greater reliability of outcomes when compared to all other plans.		
b. Stakeholder Preference	No clear stakeholder preference indicated, but slight overall preference for no action plan.		Even though the stakeholder preference scores pointed marginally towards the No-Action Plan, there is no clear preference, additional coordination with state indicates strong support for plan 2.		

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Table 3-16
System of Accounts table for Dantzler Alternatives

Problem Area: Dantzler Ecosystem Restoration, Hancock County, Mississippi				
Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.				
Item	**No Action**	**Plan 1**	**Plan 3**	**Plan 5**
A. PLAN DESCRIPTION	No Federal Action	385 Acre Restoration Maintain by Burning	151 Acre Restoration Maintain by Burning	234 Acre Restoration Maintain by Burning
B. IMPACT ASSESSMENT				
1. National Economic Development				
a. Beneficial Impacts				
(1) Damages Prevented	$0	Would provide a moderate level of damages prevented from increased flood storage capacity.	Would provide a moderate level of damages prevented from increased flood storage capacity.	Would provide a moderate level of damages prevented from increased flood storage capacity.
(2) Emergency Costs Avoided	$0	$0	$0	$0
(3) Recreation	No significant change in recreation benefits	Opportunity for ecotourism to increase	Opportunity for ecotourism to increase	Opportunity for ecotourism to increase
(4) Total Beneficial Impacts	None.			
b. Adverse Impacts				
(1) Project Cost	$0	$1,880,000	$870,000	$1,040,000
(2) Interest During Construction	$0	$41,000	$19,000	$23,000
(3) Average Annual First Cost	N/A	$103,000	$48,000	$57,000
(4) Annual O&M	$0	$26,000	$10,000	$16,000
(5) Total Avg. Annual Costs	$0	$129,000	$58,000	$73,000
2. Environmental Quality (EQ)				

Problem Area: Dantzler Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
(1) Ecosystem Restoration	No ecosystem restoration benefits.	Average Annual Functional Units (AAFU) increase of **1,244**.	Average Annual Functional Units (AAFU) increase of **488**.	Average Annual Functional Units (AAFU) increase of **756**.
(2) Water Circulation	No effect on water circulation.	No effect on water circulation.	No effect on water circulation.	No effect on water circulation.
3) Noise Level Changes	No change in noise levels	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction
(4) Public Facilities	N/A	N/A	N/A	N/A
(5) Aesthetic Values	Aesthetic values would continue to decrease	Significant improvement in aesthetic values	Improvement in aesthetic values	Significant improvement in aesthetic values
(6) Natural Resources	Continued degradation of natural resources.	Existing natural resources would be restored to historic wet pine savannah habitat conditions.	Existing natural resources would be partially restored to historic wet pine savannah habitat conditions.	Existing natural resources would be partially restored to historic wet pine savannah habitat conditions.
(7) Biological Resources	Continued degradation of biological resources.	Biological resources would be significantly improved versus the no-action	Biological resources would be somewhat improved versus no-action	Biological resources would be moderately improved versus no-action

Problem Area: Dantzler Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
(8) Air Quality	No effect on air quality	Air emission would be *de minimus* and intermittent during burning	Air emission would be *de minimus* and intermittent during burning	Air emission would be *de minimus* and intermittent during burning
(9) Water Quality	Continued negative impacts on water quality	Temporary negative impacts to water quality due to construction but would have a long-term significant improvement to water quality.	Temporary negative impacts to water quality due to construction but would have a long-term moderate improvement to water quality.	Temporary negative impacts to water quality due to construction but would have a long-term moderate improvement to water quality.
(10) Public Services	N/A	N/A	N/A	N/A
(11) Cultural and Historical Preservation	No effect on cultural and historical preservation	No effect on cultural and historical preservation	No effect on cultural and historical preservation	No effect on cultural and historical preservation
(12) Total Quality of the Environment	Significant continued degradation of the environment	Environmental quality would be significantly improved versus the no-action and other alternative restoration plans.	Environmental quality would be somewhat improved versus the no-action.	Environmental quality would be moderately improved versus the no-action and Plan 3.
3. Regional Economic Development (RED)				

Problem Area: Dantzler Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
(1) Impact on Sales Volume	No impact to the local economy.	**Increase of $3,985,600** in additional sales volume.	Increase of **$1,844,400** in additional sales volume.	Increase of **$2,204,800** in additional sales volume.
(2) Impact on Income	No impact to the local economy.	Increase of **$777,294** in additional local income.	Increase of **$359,705** in additional local income.	Increase of **$429,992** in additional local income.
(3) Impact on Employment	No impact to the local economy.	Increase of **22** new jobs.	Increase of **10** new jobs.	Increase of **12** new jobs.
(4) Tax Changes	N/A	N/A	N/A	N/A
4. Other Social Effects (OSE)				
a. Beneficial Impacts				
(1) Security of Life, Health, and Safety	Continued risks to life, health and safety	Decrease in risks to life, health and safety, due to re-establishment of stormwater conveyance.	Decrease in risks to life, health and safety, due to re-establishment of stormwater conveyance.	Decrease in risks to life, health and safety, due to re-establishment of stormwater conveyance.
(2) Community Cohesion	N/A	N/A	N/A	N/A
(3) Tax Values	N/A	N/A	N/A	N/A
(4) Community Growth	No effect on community growth	No effect on community growth	No effect on community growth	No effect on community growth
(5) Property Values	N/A	N/A	N/A	N/A
(6) Displacement of Businesses	N/A	N/A	N/A	N/A
(7) Public Facilities	N/A	N/A	N/A	N/A
(8) Injurious Displacement of Farms	N/A	N/A	N/A	N/A

Problem Area: Dantzler Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
b. Preservation of loss of life	N/A	Will result in improvement in safety to lives provided by restoration of stormwater conveyance.	Will result in improvement in safety to lives provided by restoration of stormwater conveyance.	Will result in improvement in safety to lives provided by restoration of stormwater conveyance.
C. PLAN EVALUATION				
1. Contributions to Planning Objectives				
a. Flood, Hurricane and/or Storm Damage Reduction	NO	YES	YES	YES
b. Recovery of lost environmental resources	NO	YES	YES	YES
2. Response to Planning Constraints				
a. Avoid environmental impacts and minimize induced damages	N/A	YES	YES	YES
b. Institutional Acceptability	N/A	YES	YES	YES
3. Response to Evaluation Criteria				
a. Acceptability	N/A	YES	YES	YES
b. Completeness	N/A	YES	Partially	Moderately
c. Effectiveness	N/A	YES	Partially	Moderately
d. Efficiency (Cost-Effectiveness; i.e., most efficient use of Federal and Non-Federal Funds)	N/A	Most efficient of all the plans	Moderately	Moderately
e. Integration	N/A	Seamless part of overall system.	Seamless part of overall system.	Seamless part of overall system.
f. Reversibility	N/A	N/A	N/A	N/A
2. Federal and non-Federal Comparison				

Problem Area: Dantzler Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
a. Federal				
b. Public				
4. Stakeholder Preference Score (From MCDA weightings analysis)				
a. Summary Score	**62.23%**	**43.20%**	**38.59%**	**41.05%**
Cluster Group A	79.63%	26.30%	36.46%	38.06%
Cluster Group B	67.39%	38.70%	40.68%	39.33%
Cluster Group C	61.90%	43.81%	37.71%	40.28%
Cluster Group D	40.00%	64.00%	39.52%	46.54%
b. Stakeholder Preference	No clear stakeholder preference indicated, although no action plan ranked higher than action plans.	All action plans ranked lower than no action by stakeholders.	All action plans ranked lower than no action by stakeholders.	All action plans ranked lower than no action by stakeholders.
D. Implementation Responsibility	No implementation responsibilities	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.
E. State and other Non-Federal Coordination	No State or other Non-Federal coordination activities	Additional State or other non-Federal coordination required	Additional State or other non-Federal coordination required	Additional State or other non-Federal coordination required
F. Risk Evaluation				
1. Risk and Vulnerabilities				
a. Risk of Failure	N/A	Very low risk of failure	Very low risk of failure.	Very low risk of failure

Problem Area: Dantzler Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
b. Residual Risk	Residual risk (economic) does not apply, but residual risks (potential damages to ecosystem left unattenuated) would remain very high	Residual risk (economic) does not apply, but residual risks (potential damages to ecosystem left unattenuated) would be reduced more by this plan than any other plan	Residual risk (economic) does not apply, but residual risks (potential damages to ecosystem left unattenuated) would be reduced more than No-Action Plan, but less than any other action plan	Residual risk (economic) does not apply, but residual risks (potential damages to ecosystem left unattenuated) would be reduced more by this plan over plan 3 but less than Plan 1
c. Reliability	No Action would have least reliable outcomes over period of analysis	Plan 1 would be most reliable of all plans including No-Action	Plan 3 would provide least reliability than all action plans, but more than No-Action Plan	Plan 5 would provide less reliability than Plan 1, but more than No-Action Plan or Plan 3
d. Relative Sea Level Rise	Sea level rise would cause continued loss of ecosystem functions and values	Plan would be minimally impacted by an increasing relative rise of sea level over the period of	Plan would be minimally impacted by an increasing relative rise of sea level over the period of	Plan would be minimally impacted by an increasing relative rise of sea level over the period of

Problem Area: Dantzler Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
		analysis	analysis	analysis
e. Risk of Ecosystem Damage	There would remain considerable risk of damage to ecosystem from hurricane-induced surge and/or waves and increase in invasive species.	There would be a reduced risk of damage to the ecosystem compared to No-Action Plan and all other action plans. Minimal level of risk as compared to No-action	There would be a reduced risk of damage to the ecosystem compared to No-Action Plan Moderate level of risk as compared to No-Action Plan or Plan 1 or 5.	There would be a reduced risk of damage to the ecosystem compared to No-Action Plan and Plan 3Moderate level of risk as compared to No-Action and Plan 3
f. Risk to Life and Safety	N/A	Increased stormwater storage will reduce risk to adjacent areas.	Increased stormwater storage will reduce risk to adjacent areas.	Increased stormwater storage will reduce risk to adjacent areas.
g. Risk to Mental and Physical Health	N/A	Increased stormwater storage will reduce risk to adjacent areas.	Increased stormwater storage will reduce risk to adjacent areas.	Increased stormwater storage will reduce risk to adjacent areas.

Problem Area: Dantzler Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
2. Recommendations and Preferences				
a. Federal Recommendation		Plan 1 achieves greater functional improvement and greater reliability of outcomes when compared to all other plans, and is a cost-effective means of achieving goals and objectives.		
b. Stakeholder Preference	Initial stakeholder preference indicated for No-Action Plan	Even though the initial stakeholder preference scores pointed towards the No-Action Plan, additional coordination among local & state		

Problem Area: Dantzler Ecosystem Restoration, Hancock County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3	Plan 5
		support entities expressed strong support for Plan 1.		

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2

1 **Table 3-17**
2 **System of Accounts table for Franklin Creek Alternatives**

Problem Area: Franklin Creek Ecosystem Restoration, Jackson County, Mississippi			
Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.			
Item	**No Action**	**Plan 1**	**Plan 3**
A. PLAN DESCRIPTION	No Federal Action	Restoration of 149 Acres North and South of Railroad Maintain by Burning and Mowing	Restoration of 56 Acres South of Railroad and Maintain by Burning and Mowing
B. IMPACT ASSESSMENT			
1. National Economic Development			
a. Beneficial Impacts			
(1) Damages Prevented	$0	Would provide a modest level of damage reduction due to increase in flood storage compared to existing condition.	Would provide a modest level of damage reduction due to increase in flood storage compared to existing condition.
(2) Emergency Costs Avoided	$0	$0	$0
(3) Recreation	No significant change in recreation benefits	Possible increase in ecotourism	Possible increase in ecotourism
(4) Total Beneficial Impacts	None.	None.	None.
b. Adverse Impacts			
(1) Project Cost	$0	$1,630,000	$550,000
(2) Interest During Construction	$0	$36,000	$12,000
(3) Average Annual First Cost	N/A	$90,000	$30,000
(4) Annual O&M	$0	$11,000	$4,000
(5) Total Avg. Annual Costs	$0	$101,000	$34,000
2. Environmental Quality (EQ)			
(1) Ecosystem Restoration	No ecosystem restoration benefits.	Average Annual Functional Units (AAFU) increase of **516**.	Average Annual Functional Units (AAFU) increase of **194**.

Problem Area: Franklin Creek Ecosystem Restoration, Jackson County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3
(2) Water Circulation	No effect on water circulation.	No effect on water circulation.	No effect on water circulation.
(3) Noise Level Changes	No change in noise levels	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction
(4) Public Facilities	N/A	N/A	N/A
(5) Aesthetic Values	No significant change in aesthetic values	Would result in aesthetic improvement to the overall environmental setting	Would result in aesthetic improvement to the overall environmental setting
(6) Natural Resources	Existing natural resources would remain in degraded state	Restoration of wet pine savannah resources.	Restoration of wet pine savannah resources.
(7) Biological Resources	Continued degradation of biological resources.	Biological resources would be improved versus the no-action alternative.	Biological resources would be improved versus the no-action alternative.
(8) Air Quality	No anticipated effect on air quality	Temporary negative impacts during construction and intermittently during burning.	Temporary negative impacts during construction and intermittently during burning.
(9) Water Quality	No anticipated effect on water quality	Temporary negative impacts to water quality due to construction but is anticipated to improve future water quality.	Temporary negative impacts to water quality due to construction but is anticipated to improve future water quality.
(10) Public Services	N/A	N/A	N/A
(11) Cultural and Historical Preservation	N/A	N/A	N/A

Problem Area: Franklin Creek Ecosystem Restoration, Jackson County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3
(12) Total Quality of the Environment	Continued degraded state	Environmental quality would be improved versus the no-action alternative; thus, restoring the historical environmental setting.	Environmental quality would be improved versus the no-action alternative; thus, restoring the historical environmental setting.
3. Regional Economic Development (RED)			
(1) Impact on Sales Volume	No impact to the local economy.	**Increase of $3,879,600** in additional sales volume.	Increase of **$1,378,000** in additional sales volume.
(2) Impact on Income	No impact to the local economy.	Increase of **$756,621** in additional local income.	Increase of **$268,745** in additional local income.
(3) Impact on Employment	No impact to the local economy.	Increase of **22** new jobs.	Increase of **8** new jobs.
(4) Tax Changes	N/A	N/A	N/A
4. Other Social Effects (OSE)			
a. Beneficial Impacts			
(1) Security of Life, Health, and Safety	Residents relocated as part of interim.	Decrease in risks to life, health and safety in adjacent areas, due to re-establishment of stormwater conveyance.	Decrease in risks to life, health and safety in adjacent areas, due to re-establishment of stormwater conveyance.
(2) Community Cohesion	N/A	N/A	N/A

Problem Area: Franklin Creek Ecosystem Restoration, Jackson County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3
(3) Tax Values	N/A	N/A	N/A
(4) Community Growth	N/A	N/A	N/A
(5) Property Values	N/A	N/A	N/A
(6) Displacement of Businesses	N/A	N/A	N/A
(7) Public Facilities	N/A	N/A	N/A
(8) Injurious Displacement of Farms	N/A	N/A	N/A
b. Preservation of loss of life	N/A	Alternative will result in minor increase in safety to lives provided by restoration of stormwater conveyance.	Alternative will result in minor increase in safety to lives provided by restoration of stormwater conveyance.
C. PLAN EVALUATION			
1. Contributions to Planning Objectives			
a. Flood, Hurricane and/or Storm Damage Reduction	N/A	YES	YES
b. Recovery of lost environmental resources	N/A	YES	YES
2. Response to Planning Constraints			
a. Avoid environmental impacts and minimize induced damages	N/A	YES	YES
b. Institutional Acceptability	N/A	YES	YES
3. Response to Evaluation Criteria			
a. Acceptability	N/A	YES	YES
b. Completeness	N/A	YES	YES
c. Effectiveness	N/A	YES	YES
d. Efficiency (Cost-Effectiveness; i.e., most efficient use of Federal and Non-Federal Funds)	N/A	YES, most effective	YES

Problem Area: Franklin Creek Ecosystem Restoration, Jackson County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3
e. Integration	N/A	Seamless part of overall system.	Seamless part of overall system.
f. Reversibility	N/A	N/A	N/A
4. Stakeholder Preference Score (From MCDA weightings analysis)			
a. Summary Score	**62.23%**	**41.16%**	**37.40%**
Cluster Group A	79.63%	24.07%	35.76%
Cluster Group B	67.39%	36.41%	39.91%
Cluster Group C	61.90%	41.67%	36.29%
Cluster Group D	40.00%	62.50%	37.65%
b. Stakeholder Preference	Stakeholder preference weighted to no action plan	All action plans ranked lower than no action by stakeholders.	All action plans ranked lower than no action by stakeholders.
D. Implementation Responsibility	No implementation responsibilities	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.
E. State and other Non-Federal Coordination	No State or other Non-Federal coordination activities	State or other non-Federal coordination required	State or other non-Federal coordination required
F. Risk Evaluation			
1. Risk and Vulnerabilities			
a. Risk of Failure	N/A	Very low risk of failure	Very low risk of failure.

Problem Area: Franklin Creek Ecosystem Restoration, Jackson County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3
b. Residual Risk	Residual risk (economic) does not apply, but residual risks to ecosystem would remain very high	Residual risk (economic) does not apply, but residual risks to ecosystem would be less than all other plans	Residual risk (economic) does not apply, but residual risks to ecosystem would be less than No-Action but higher than Plan 1
c. Reliability	N/A	This plan would provide a significant degree of reliability,	This plan would provide a moderate degree of reliability,
d. Relative Sea Level Rise	Habitat degradation will be substantially exacerbated by an increasing relative rise of sea level	This Plan would be less impacted by increasing relative rise of sea level over the period of analysis than all other plans	This Plan would be less impacted by increasing relative rise of sea level over the period of analysis than No-Action, but more so than Plan 1
e. Risk of Ecosystem Damage	Lack of restoration would encourage risk of invasion by exotics.	Risk of ecosystem damage would be less than all other plans.	Risk of ecosystem damage would be less than No-Action Plan, but more than Plan 1.
f. Risk to Life and Safety	N/A	N/A	N/A
g. Risk to Mental and Physical Health	N/A	N/A	N/A
2. Recommendations and Preferences			

Problem Area: Franklin Creek Ecosystem Restoration, Jackson County, Mississippi

Problems ID: Environmental damages suffered by hurricane-induced surge and wave attack; Potential future environmental damages from storm and hurricane events.

Item	No Action	Plan 1	Plan 3
a. Federal Recommendation		Plan 1 achieves greater functional improvement and greater reliability of outcomes when compared to all other plans, and is cost-effective means of achieving goals and objectives.	
b. Stakeholder Preference	Initial stakeholder preference for No action plan.	Even though the initial stakeholder preference scores pointed towards the No-Action Plan, additional coordination with state and local entities express strong support for Plan 1	

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Table 3-18
System of Accounts table for Forest Heights Alternatives

Problem Area: #19 - Forrest Heights Project Area, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced flooding; Potential future damages from flooding.

Item	No Action	Plan 1	Plan 2
A. PLAN DESCRIPTION	No Federal Action	Elevation 17FT NAVD88 Levee with limited clearing and snagging of turkey Creek	Elevation 21FT NAVD88 Levee with limited clearing and snagging of turkey Creek
B. IMPACT ASSESSMENT			
1. National Economic Development			
a. Beneficial Impacts			
(1) Damages Prevented	$0	$11,580	$100,540
(2) Emergency Costs Avoided	$0	$1,926	$1,928
(3) Recreation	No change in recreation benefits	No change in recreation benefits	No change in recreation benefits
(4) Total Beneficial Impacts	None.	$13,506	$102,468
b. Adverse Impacts			
(1) Project Cost	$0	$6,100,000	$11,400,000
(2) Interest During Construction	$0	$135,000	$252,000
(3) Average Annual First Cost	N/A	$335,000	$626,000
(4) Annual O&M	$0	$42,000	$114,000
(5) Total Avg. Annual Costs	$0	$377,000	$740,000
2. Environmental Quality (EQ)			
(1) Ecosystem	No Change	Clearing & snagging will improve Turkey	Clearing & snagging will improve

Problem Area: #19 - Forrest Heights Project Area, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced flooding; Potential future damages from flooding.

Item	No Action	Plan 1	Plan 2
Restoration		Creek & adjacent habitats	Turkey Creek & adjacent habitats
(2) Water Circulation	No Change	Improvement in Turkey Creek flow	Improvement in Turkey Creek flow
(3) Noise Level Changes	No change in noise levels	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction
(4) Public Facilities	No change in public facilities.	Moderate improvement to public facilities by reduction in flooding	Significant improvement to public facilities by reduction in flooding
(5) Aesthetic Values	No significant change in aesthetic values	No significant change in aesthetic values	No significant change in aesthetic values
(6) Natural Resources	No change to natural resources.	Existing natural resources would be slightly degraded due to enlarged footprint of levee. Turkey Cheek and bankside resources would be improved	Existing natural resources would be slightly degraded due to enlarged footprint of levee. Turkey Cheek and bankside resources would be improved
(7) Biological Resources	No change to biological resources.	Slight degradation of existing biological resources due to enlarged footprint of levee. Resources of creek would be improved.	Slight degradation of existing biological resources due to enlarged footprint of levee. Resources of creek would be improved.
(8) Air Quality	No anticipated effect on air quality	Air emission would be *de minimus*	Air emission would be *de minimus*
(9) Water Quality	No anticipated effect on water quality	Clearing and snagging within Turkey Creek would improve overall water quality	Clearing and snagging within Turkey Creek would improve overall water quality
(10) Public Services	Continued interruption of public services during storm events	Moderate increase protection for public services.	Significant increase protection for public services.

Problem Area: #19 - Forrest Heights Project Area, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced flooding; Potential future damages from flooding.

Item	No Action	Plan 1	Plan 2
(11) Cultural and Historical Preservation	Continued negative impacts during storm events	Moderate positive impact on the cultural and historical significance of the minority community.	Significant positive impact on the cultural and historical significance of the minority community.
(12) Total Quality of the Environment	Continued negative impacts during storm events	Moderate improvement in overall quality the environmental of Forrest Heights community.	Significant improvement in overall quality the environmental of Forrest Heights community.
3. Regional Economic Development (RED)			
(1) Impact on Sales Volume	No impact to the local economy.	Increase of **$15,484,500** in additional sales volume.	Increase of **$32,77,687** in additional sales volume.
(2) Impact on Income	No impact to the local economy.	Increase of **$3,277,687** in additional local income.	Increase of **$6,440,117** in additional local income.
(3) Impact on Employment	No impact to the local economy.	Increase of **98** new jobs.	Increase of **193** new jobs.
(4) Tax Changes	N/A	N/A	N/A
4. Other Social Effects (OSE)			
a. Beneficial Impacts			
(1) Security of Life, Health, and Safety	Continued risks to life, health and safety	Moderate decrease in risks to life, health and safety.	Significant decrease in risks to life, health and safety.

Problem Area: #19 - Forrest Heights Project Area, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced flooding; Potential future damages from flooding.

Item	No Action	Plan 1	Plan 2
(2) Community Cohesion	Community Cohesion will be significantly challenged due to the inability of residents to rebuild and/or comply with new building codes and flood regulations.	Provides a measured reduction of risk and defense against most storms. Preserves the integrity of the historic and culturally rich minority community.	Provides a higher reduction of risk and defense against extreme storms. Preserves the integrity of the historic and culturally rich minority community.
(3) Tax Values	Tax values could decrease with future damages and inability of the community to rebuild.	Tax values would remain the same	Tax values would remain the same
(4) Community Growth	Area is fully developed	area is fully developed	area is fully developed
(5) Property Values	Property values could decrease with future damages and inability of the community to rebuild.	No increase	No increase
(6) Displacement of Businesses	N/A	N/A	N/A
(7) Public Facilities	Continued risks and incurred costs to public facilities	Moderately reduced risks and incurred costs to public facilities	Significantly reduced risks and incurred costs to public facilities
(8) Injurious Displacement of Farms	N/A	N/A	N/A
b. Preservation of loss of life	Continued risk of loss of life.	Reduced risk to loss of life in major events.	Reduced risk to loss of life in major events.

C. PLAN EVALUATION

Problem Area: #19 - Forrest Heights Project Area, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced flooding; Potential future damages from flooding.

Item	No Action	Plan 1	Plan 2
1. Contributions to Planning Objectives			
a. Flood, Hurricane and/or Storm Damage Reduction	NO	Yes	Yes
2. Response to Planning Constraints			
a. Avoid environmental impacts and minimize induced damages	YES	YES	YES
b. Institutional Acceptability	NO	YES	YES
3. Response to Evaluation Criteria			
a. Acceptability	NO	YES	YES
b. Completeness	N/A	YES, but moderate level of risk remains	YES, but minor level of risk remains
c. Effectiveness	N/A	YES	YES
d. Efficiency (Cost-Effectiveness; i.e., most efficient use of Federal and Non-Federal Funds)	N/A	YES	YES
e. Integration	N/A	Seamless part of overall system.	Seamless part of overall system.
f. Reversibility	N/A	Alternative could be reversible, given means to remove structural features	Alternative could be reversible, given means to remove structural features

Problem Area: #19 - Forrest Heights Project Area, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced flooding; Potential future damages from flooding.

Item	No Action	Plan 1	Plan 2
4. Stakeholder Preference Score (From MCDA weightings analysis)			
a. Summary Score	**56.89%**	**52.89%**	**47.46%**
Cluster Group A	51.72%	50.70%	52.87%
Cluster Group B	48.68%	55.56%	55.92%
Cluster Group C	63.33%	48.88%	41.67%
Cluster Group D	63.83%	56.40%	39.36%
b. Stakeholder Preference	All groups ranked this plan highest.	Plan ranked very high, but less than No Action	Plan ranked the lowest of all plans.
D. Implementation Responsibility	No implementation responsibilities	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.
E. State and other Non-Federal Coordination	No State or other Non-Federal coordination activities	Minor State or other Non-Federal coordination activities	Minor State or other Non-Federal coordination activities
F. Risk Evaluation			
1. Risk and Vulnerabilities			
a. Risk of Failure	N/A	Very low risk of failure	Extremely low risk of failure.

Problem Area: #19 - Forrest Heights Project Area, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced flooding; Potential future damages from flooding.

Item	No Action	Plan 1	Plan 2
b. Residual Risk	Residual risk of all actions will remain substantial due to flooding.	Residual risks associated with this plan would be fairly low	Residual risks associated with this plan would be very low
c. Reliability	N/A	This plan would provide a high degree of reliability, would be unlikely to receive damage from storm events, but would require significant maintenance commitment over long-term.	This plan would provide a very high degree of reliability, would be unlikely to receive damage from storm events, but would require significant maintenance commitment over long-term.
d. Relative Sea Level Rise	Problems will be exacerbated by an increasing relative rise of sea level	This Plan would be somewhat impacted by an increasing relative rise of sea level over the period of analysis due to relatively lower crest relative to potential flood heights	This Plan would be only minimally impacted by an increasing relative rise of sea level over the period of analysis due to slightly lower crest relative to potential flood heights
e. Risk of Ecosystem Damage	N/A	Risk of ecosystem damage will be minimal throughout the period of analysis.	Risk of ecosystem damage will be minimal throughout the period of analysis.
f. Risk to Life and Safety	Significant threats to Life and Safety from flooding will continue.	Some threats to Life and Safety from flooding will continue, in the event that residents do not evacuate and levee is overtopped.	.Some threats to Life and Safety from flooding will continue, in the event that residents do not evacuate and levee is overtopped, but less risks than No-Action or Plan 1
g. Risk to Mental and Physical Health	Continued significant risks to mental and physical health would remain, from even modest flood	Some risks to mental and physical health would remain, but only in event that levee is overtopped	Some risks to mental and physical health would remain, but only in event that levee is

Problem Area: #19 - Forrest Heights Project Area, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced flooding; Potential future damages from flooding.

Item	No Action	Plan 1	Plan 2
	events		overtopped. Fewer risks than all other plans
2. Recommendations and Preferences			
a. Federal Recommendation			Plan 2 achieves greater functional improvement and greater reliability of outcomes when compared to all other plans.
b. Stakeholder Preference	Initial stakeholder preference indicated for No-Action Plan, but preferences are inconsistent between sub-groups.Stakeholders from the community were not available at the initial meetings.		Subsequent meetings with State, local and community leaders expressed strong support for Plan 2.

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Table 3-19
System of Accounts table for Nonstructural Alternatives

Problem Area: High-Risk Zone (High Hazard Area Risk Reduction Plans and High-Risk Structural Application Area)				
Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events in the Highest-Risk Area of the Coastal Zone. **Note: There are no reasonable coast-wide structural alternatives to the HARP, which were advanced beyond preliminary screening. Therefore the 30' HRZ Levee is presented for simple comparison purposes only.**				
Item	**No Action**	**30' HRZ Levee**	**Long-Term HARP**	**High Risk HARP**
A. PLAN DESCRIPTION	No Federal Action	Comparative Beachfront Levee at Elevation 30 feet for High Risk Zone (HRZ)	Provides acquisition opportunities after next devastating storm event	Provides immediate acquisition opportunities for the most high risk areas
B. IMPACT ASSESSMENT				
1. National Economic Development				
a. Beneficial Impacts				
(1) Damages Prevented	$0	≤$209,000,000 *	$209,665,350	$22,000,000 to $33,000,000
(2) Emergency Costs Avoided	$0	$0	$0	$0
(3) Recreation	No change in recreation benefits	Adverse on existing benefits	Very significant opportunity for increase in benefits but not evaluated at this stage	Significant opportunity for increase in benefits but not evaluated at this stage
(4) Total Beneficial Impacts	None.	≤$209,000,000	$209,665,350	$22,000,000 to $33,000,000
b. Adverse Impacts				
(1) Project Cost	$0	>$5,000,000,000 *	$7,999,019,430	$187,500,000 to $397,000,000**
(2) Interest During Construction	$0		$11,930,890,500	$23,744,000 to $50,274,000**
(3) Average Annual First Cost	N/A		$979,978,085	$8,752,000 to $18,532,000**
(4) Annual O&M	$0	>$60,000,000	$476,850	$10,000
(5) Total Avg. Annual Costs	$0	>$300.000,000	$980,454,935	$8,762,000 to $18, 542,000**
2. Environmental Quality (EQ)				
(1) Ecosystem Restoration	No Change	No opportunity for restoration presented	Very significant opportunity for ecosystem restoration but not	Significant opportunity for ecosystem restoration but not

Problem Area: High-Risk Zone (High Hazard Area Risk Reduction Plans and High-Risk Structural Application Area)

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events in the Highest-Risk Area of the Coastal Zone.
Note: There are no reasonable coast-wide structural alternatives to the HARP, which were advanced beyond preliminary screening. Therefore the 30' HRZ Levee is presented for simple comparison purposes only.

Item	No Action	30' HRZ Levee	Long-Term HARP	High Risk HARP
		presented	ecosystem restoration but not evaluated at this stage	ecosystem restoration but not evaluated at this stage
(2) Water Circulation	No Change	Plan may alter water circulation in impounded areas	No Change	No Change
(3) Noise Level Changes	No change in noise levels	Significant increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction
(4) Public Facilities	Continued risk of damage during future storm events	Potential adverse impacts to public facilities due to relocation required for embankment construction contrasted with reduction of level of risk landward of embankment.	Improvement to public facilities through relocation to lower risk zones & opportunity to increase public facilities related to recreation	Improvement to public facilities through relocation to lower risk zones & opportunity to increase public facilities related to recreation
(5) Aesthetic Values	No significant change in aesthetic values	Aesthetic of coastal environment dramatically affected due to presence of large, intrusive embankment, displacement of residences and businesses and negative alteration of visual environment; breaking-up of once cohesive neighborhoods with barrier to movement	Conversion to greenspace could significantly improve the aesthetic values of the coastal area.	Conversion to greenspace could significantly improve the aesthetic values of the coastal area.
(6) Natural Resources	No change to natural resources.	Existing natural resources would be significantly degraded due to large footprint of levee and alteration of traditional flowpaths, wildlife corridors, and loss of habitat. Mitigation would be required to minimize damages	Long-term natural resources would be improved due to removal of select high-risk development, and its potential replacement with coastal wetlands, public parks	Long-term natural resources would be improved due to removal of select high-risk development, and its potential replacement with coastal wetlands, public parks

Problem Area: High-Risk Zone (High Hazard Area Risk Reduction Plans and High-Risk Structural Application Area)

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events in the Highest-Risk Area of the Coastal Zone.
Note: There are no reasonable coast-wide structural alternatives to the HARP, which were advanced beyond preliminary screening. Therefore the 30' HRZ Levee is presented for simple comparison purposes only.

Item	No Action	30' HRZ Levee	Long-Term HARP	High Risk HARP
(7) Biological Resources	No change to biological resources.	Existing biological resources would be impacted during construction due to destruction of habitat during removal activities and construction of embankments and access roads and ramps. Long-term biological resources would be impacted due to presence of large barrier to wildlife movement, fragmentation of habitats, and elimination of habitat on site of embankment.	In the long-term biological resources, including threatened and endangered species, would be significantly improved due to removal of development, and its potential replacement with coastal wetlands or green space.	In the long-term biological resources, including threatened and endangered species, would be significantly improved due to removal of development, and its potential replacement with coastal wetlands or green space.
(8) Air Quality	No anticipated effect on air quality	Air emission during construction would be *de minimus*. Barrier could impact land / sea breeze interaction long term.	Air emission would be *de minimus*	Air emission would be *de minimus*
(9) Water Quality	No anticipated effect on water quality	Temporary negative impacts to water quality due to construction. Potential long-term negative effects on WQ due to alteration of traditional flowpaths, elimination of natural streambeds and adjacent uplands containing natural filtering areas.	Long-term positive improvement expected due to increased flood storage capacity and removal of septic systems.	Long-term positive improvement expected due to increased flood storage capacity and removal of septic systems.
(10) Public Services	Public services would continue to be disrupted during future storms.	Significant adverse impact on public services during construction, long-term Increased protection for public services.	Reduced need for public services.	Reduced need for public services
(11) Cultural and Historical Preservation	Cultural and historical resources	Cultural or Historical sites would either be avoided or	Alternative would have no anticipated effect on cultural	Alternative would have no anticipated effect on cultural

Problem Area: High-Risk Zone (High Hazard Area Risk Reduction Plans and High-Risk Structural Application Area)

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events in the Highest-Risk Area of the Coastal Zone.
Note: There are no reasonable coast-wide structural alternatives to the HARP, which were advanced beyond preliminary screening. Therefore the 30' HRZ Levee is presented for simple comparison purposes only.

Item	No Action	30' HRZ Levee	Long-Term HARP	High Risk HARP
Preservation	historical resources would continue to be at risk from damage from future storm events	would either be avoided or mitigated as required by NHPA.	anticipated effect on cultural and historical preservation	anticipated effect on cultural and historical preservation
(12) Total Quality of the Environment	Environmental resources would continue to be at risk	Significant negative impacts on the overall total quality of the environment	Significant opportunity for improvement of the coastal environment	Significant opportunity for improvement of the coastal environment
3. Regional Economic Development (RED)				
(1) Impact on Sales Volume	Periodic impacts to sales due to hurricane aftermath	$13,374,321,000 **	Increase of **$19,461,185,520** in additional sales volume.	Increase of **$3,238,601,800** in additional sales volume.
(2) Impact on Income	Periodic loss of income due to hurricanes and aftermath	$6,720,736,400 **	Increase of **$4,088,379,614** in additional local income.	Increase of **$706,330,000** in additional local income.
(3) Impact on Employment	Continued destruction of local economy due to periodic elimination of job base due to hurricanes and aftermath	Increase of 93,332 new jobs **	Increase of **119,847** new jobs	Increase of **19,452** new jobs
(4) Tax Changes	Continued periodic loss of some to virtually all tax revenues due to destruction of residential and commercial tax base	Possible loss of casino revenues could significantly impact tax revenues. Could impact taxes by lessening of aesthetic value (being behind levee), thus lower desirability of high-value residential	Moderate decreases in taxes due to land use and ownership changes. Could exceed 10% of residential tax base. Could be offset by eco-tourism and alternate business taxes	Some decreases in taxes due to landuse and ownership changes, but anticipated to be considerably less than 10% of residential tax base. Could be offset by eco-tourism and alternate business taxes
4. Other Social Effects (OSE)				
a. Beneficial Impacts				

Problem Area: High-Risk Zone (High Hazard Area Risk Reduction Plans and High-Risk Structural Application Area)

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events in the Highest-Risk Area of the Coastal Zone.
Note: There are no reasonable coast-wide structural alternatives to the HARP, which were advanced beyond preliminary screening. Therefore the 30' HRZ Levee is presented for simple comparison purposes only.

Item	No Action	30' HRZ Levee	Long-Term HARP	High Risk HARP
(1) Security of Life, Health, and Safety	Continued significant risks to life, health and safety	Moderate decrease in risks to life, health and safety. Implied "protection" of levee may cause people to remain behind during hurricanes, with potential negative outcomes	Significant decrease in risks to life, health and safety, due to elimination of higher risk residential housing from higher risk surge/floodplain.	Significant decrease in risks to life, health and safety, due to elimination of highest risk residential and commercial from highest risk surge/floodplain .
(2) Community Cohesion	Community Cohesion will be periodically disrupted due to continued impacts from hurricane surge and waves on communities, and due to the inability of residents to rebuild and/or comply with new building codes and flood regulations.	Provides a measured reduction of risk and defense against most storms. Preserves a small portion of integrity of the historic and culturally rich community, but may create fragmentation of certain communities due to presence of large embankment.	Provides a higher reduction of risk and defense against most storms, which may enhance community cohesion, but would create significantly changed community in near-term after construction.	Provides a measured reduction of risk and defense against extreme storms, which may enhance community cohesion, but would create changed community in near-term after construction.. Would provide fewer impacts than Long-Term HARP
(3) Tax Values	N/A	Likely to decrease commensurate with property values	Possible increase as property values increase with addition of adjacent greenspace	Possible increase as property values increase with addition of adjacent greenspace
(4) Community Growth	N/A	Growth would be restricted to areas landward of the levee	Growth would be restricted to lower risk zones along the coast	Growth would be restricted to lower risk zones along the coast
(5) Property Values	Property values could decrease with the inability of people to rebuild in the high risk zones and the lack of affordable insurance.	Could be a significant decrease in property values with loss of waterfront views contrasted with possible increase due to reduction of risk provided by the levee	Potential increase due to improved aesthetics and provision of greenspace.	Potential increase due to improved aesthetics and provision of greenspace.

Problem Area: High-Risk Zone (High Hazard Area Risk Reduction Plans and High-Risk Structural Application Area)

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events in the Highest-Risk Area of the Coastal Zone.
Note: There are no reasonable coast-wide structural alternatives to the HARP, which were advanced beyond preliminary screening. Therefore the 30' HRZ Levee is presented for simple comparison purposes only.

Item	No Action	30' HRZ Levee	Long-Term HARP	High Risk HARP
(6) Displacement of Businesses	N/A	Significant displacement of businesses within the levee footprint. Possible loss of casino operations.	Some displacement of businesses within high risk zones. Could be relocated within community. Casino operations would not be impacted.	Some displacement of businesses within high risk zones. Could be relocated within community. Casino operations would not be impacted.
(7) Public Facilities	Continued risks and incurred costs to public facilities	Displacement within footprint of embankment. Reduced risk to facilities within embankment.	Reduced risks and incurred costs to public facilities due to relocation from high risk zones	Reduced risks and incurred costs to public facilities due to relocation from high risk zones
(8) Injurious Displacement of Farms	N/A	N/A	N/A	N/A
b. Preservation of loss of life	Not anticipated to increase possibility of loss of life over that existing today.	Reduced risk to loss of life in major events, but may still incur major loss of life during above-design events in the event of over-topping, due to false sense of security.	Elimination of risks to life within high risk surge/floodplain. Overall greatest reduction is risk of loss of life in major events of all plans.	Elimination of risks to life within highest risk surge/floodplain. Overall reduced risk to loss of life in major events.
C. PLAN EVALUATION				
1. Contributions to Planning Objectives				
a. Flood, Hurricane and/or Storm Damage Reduction	No damage reduction.	Moderate to major improvement in damage reduction.	Major improvement in damage reduction.	Significantly improved level of flood damage reduction, but less than other action plans.
2. Response to Planning Constraints				
a. Avoid environmental impacts and minimize induced damages	YES	NO	YES	YES
b. Institutional Acceptability	NO	NO	YES	YES
3. Response to Evaluation Criteria				
a. Acceptability	NO	NO	Possibly - will require additional public coordination	Possibly - will require additional public coordination

Problem Area: High-Risk Zone (High Hazard Area Risk Reduction Plans and High-Risk Structural Application Area)

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events in the Highest-Risk Area of the Coastal Zone.
Note: There are no reasonable coast-wide structural alternatives to the HARP, which were advanced beyond preliminary screening. Therefore the 30' HRZ Levee is presented for simple comparison purposes only.

Item	No Action	30' HRZ Levee	Long-Term HARP	High Risk HARP
b. Completeness	N/A	NO, as areas outside embankment remain at high risk of future damage	YES, but minor level of risk remains	YES, but moderate level of risk remains
c. Effectiveness	N/A	Partial	YES	YES, but less than long-term plan
d. Efficiency (Cost-Effectiveness; i.e., most efficient use of Federal and Non-Federal Funds)	N/A	NO	YES	YES
e. Integration	N/A	Does not necessarily integrate with local plans, or other measures, particularly non-structural plans	Does not necessarily integrate smoothly with local plans.	Does not necessarily integrate smoothly with local plans.
f. Reversibility	N/A	Reversibility would be extremely limited, due to large size and investment in plan	Plan is physically reversible, but once land is acquired it cannot be resold for development	Plan is physically reversible, but once land is acquired it cannot be resold for development
4. Stakeholder Preference Score (From MCDA weightings analysis)				
a. Summary Score	**41.27%**	*	**46.83%**	**45.26%**
Cluster Group A	47.79%	*	49.65%	50.22%
Cluster Group B	40.79%	*	53.95%	48.13%
Cluster Group C	46.57%	*	36.57%	47.32%
Cluster Group D	29.92%	*	47.15%	35.37%
b. Stakeholder Preference	All groups ranked this plan lowest	Plan not ranked by stakeholders due to initial opposition to large structural measure. Just included for comparison.	Plan ranked marginally higher than high risk area plan and higher than no action. Note that Group C ranked LT Harp less than No Action.	Plan ranked marginally lower than large long term plan, except by Group C which ranked High Risk HARP highest. Each group ranked higher than no action.
D. Implementation	N/A	Joint Federal/Non-Federal implementation responsibility	Joint Federal/Non-Federal implementation responsibility	Joint Federal/Non-Federal implementation responsibility

Problem Area: High-Risk Zone (High Hazard Area Risk Reduction Plans and High-Risk Structural Application Area)

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events in the Highest-Risk Area of the Coastal Zone.
Note: There are no reasonable coast-wide structural alternatives to the HARP, which were advanced beyond preliminary screening. Therefore the 30' HRZ Levee is presented for simple comparison purposes only.

Item	No Action	30' HRZ Levee	Long-Term HARP	High Risk HARP
Responsibility		implementation responsibility.	implementation responsibility.	implementation responsibility.
E. State and other Non-Federal Coordination	N/A	Significant State or other Non-Federal coordination activities required	Significant State or other Non-Federal coordination activities required	Moderate State or other Non-Federal coordination activities
F. Risk Evaluation				
1. Risk and Vulnerabilities				
a. Risk of Failure	N/A	Moderate risk of failure due to possibility of catastrophic overtopping and/or lack of long term maintenance.	Extremely low risk of failure of plan outcomes (none of structural failure) due to elimination of potential damageable properties from surge zone.	Very low risk of failure of plan outcomes (none of structural failure) due to elimination of potential damageable properties from surge zone.
b. Residual Risk	Residual risk would remain extremely high due to failure to address surge and waves in developed areas.	Significant level of residual risk with plan in place would remain due to possibility of overtopping during large hurricane events, and areas remaining outside levee.	Residual risk would be extremely low due to elimination of damageable property from surge zone.	Residual risk would be very low due to elimination of damageable property from surge zone.
c. Reliability	N/A	Plan would provide less reliable means of damage reduction than long term or high risk HARP plans due to need for periodic re-evaluation and could become unreliable in the event of failure to conduct maintenance and repairs on embankment over	Plan would provide highly reliable means of reducing damage to structures and contents, through removal of most risky development and relocation to sites outside of high-risk zones, but only for that area targeted for relocation. Extremely minimal reliability	Plan would provide highly reliable means of reducing damage to structures and contents, through removal of most risky development and relocation to sites outside of high-risk zones, but only for that area targeted for relocation. Extremely minimal

Problem Area: High-Risk Zone (High Hazard Area Risk Reduction Plans and High-Risk Structural Application Area)

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events in the Highest-Risk Area of the Coastal Zone.
Note: There are no reasonable coast-wide structural alternatives to the HARP, which were advanced beyond preliminary screening. Therefore the 30' HRZ Levee is presented for simple comparison purposes only.

Item	No Action	30' HRZ Levee	Long-Term HARP	High Risk HARP
		long-term	issues over long-term.	reliability issues over long-term.
d. Relative Sea Level Rise	No-Action would result in gradually increasing mean sea level effects and increasing damage to structures due to higher surge levels for a given frequency events.	Plan would result in gradually decreasing level of damage reduction due to rise in mean sea level, with subsequent effects on all properties within area encompassed by levees.	Plan would result in slightly diminishing level of damage reduction due to rise in mean sea level, with subsequent effects on development and natural resources, but at lesser level than structural plans due to minimal increases in periphery of floodplain	Plan would result in slightly diminishing level of damage reduction due to rise in mean sea level, with subsequent effects on development and natural resources, but at lesser level than structural plans due to minimal increases in periphery of floodplain
e. Risk of Ecosystem Damage	Risks of ecosystem damage within footprint of other plans would continue to increase due to failure to address problem set	Risk of ecosystem damage would remain higher than non-structural plans, due to destruction of resources within embankment footprint, and negative effects created by embankment on natural environment	Risks of ecosystem damage within footprint of other plans would be less than No-Action and structural plans due to ability to increase ecosystem value within footprint of plan	Risks of ecosystem damage within footprint of other plans would be less than No-Action and structural plans due to ability to increase ecosystem value within footprint of plan
f. Risk to Life and Safety	Continued extreme risks to life and safety due to failure to address development within surge zone, particularly over long-term.	Significant risk to Life and Safety will remain due to implied "protection" of residents behind barrier and subsequent potential failure to evacuate during hurricane event.	Minimal threat to life and safety from storm surge would exist due to evacuation of storm surge zone and removal of threatened properties.	Minimal to moderate threat to life and safety from storm surge would exist due to evacuation of high risk storm surge zone and removal of threatened properties. Threat would still exist in area outside high risk zone during large hurricane events if failure

Problem Area: High-Risk Zone (High Hazard Area Risk Reduction Plans and High-Risk Structural Application Area)

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events in the Highest-Risk Area of the Coastal Zone.
Note: There are no reasonable coast-wide structural alternatives to the HARP, which were advanced beyond preliminary screening. Therefore the 30' HRZ Levee is presented for simple comparison purposes only.

Item	No Action	30' HRZ Levee	Long-Term HARP	High Risk HARP
				to evacuate.
g. Risk to Mental and Physical Health	Significant threats to Mental and Physical Health from storm surge will continue to rise due to continued threats from hurricanes and storms.	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide less risk to Mental and Physical Health than no action plan.	Minimal threats to Mental and Physical Health from storm surge will still exist, but this plan will provide less risk to Mental and Physical Health than the No Action Plan or any levee plan.	Some threats to Mental and Physical Health from storm surge will still exist, and this plan will provide less risk to Mental and Physical Health than the No Action Plan and levee plans.
2. Recommendations and Preferences				
a. Federal Recommendation				High risk Harp Plan is best balanced achievement of publically acceptable outcomes, is most complete, effective, efficient, and acceptable means of addressing problem set and reduction of damages to property, of those evaluated, but also only within footprint of plan. Plan is also least costly plan of those evaluated, that effectively deals with highest risk surge zone problems, and achieves highest net benefit of all plans evaluated including No-Action. Although plan

Problem Area: High-Risk Zone (High Hazard Area Risk Reduction Plans and High-Risk Structural Application Area)

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events in the Highest-Risk Area of the Coastal Zone.
Note: There are no reasonable coast-wide structural alternatives to the HARP, which were advanced beyond preliminary screening. Therefore the 30' HRZ Levee is presented for simple comparison purposes only.

Item	No Action	30' HRZ Levee	Long-Term HARP	High Risk HARP
				does not achieve highest level of damage reduction, this plan is also the only action plan addressing this area that is likely to prove publically acceptable to entire community, and thus, would be implemented.
b. Stakeholder Preference			Large Long-Term HARP non-structural plan achieved marginally highest Stakeholder preference, compared to High Risk Area HARP Plan. Community remains highly divided on plan preferences, but actually appear least bothered by High Risk HARP when discussed with residents of area. Widely varied stakeholder views will require continued discussion and coordination	

NOTES: * Did not fully estimate damages prevented nor total costs of 30-foot levee due to engineering & environmental constraints. Plan shown for comparative purposes only **The High Risk Harp is presented with a range of benefits and costs which depend on the ultimate number of parcels acquired and range of benefits provided under P.L. 91-646.
*** Does not include any negative impacts due to interference with casino operations, model only looks at cash flow from construction.

1 **Table 3-20**
2 **System of Accounts table for Nonstructural Alternatives**

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
A. PLAN DESCRIPTION	No Federal Action	Restore 30 acres of dune, 78 acres of emergent tidal marsh, 78 acres of coastal maritime forests, and 86 acres of beach habitats along the southern shoreline.	Placement of dredged material into the existing containment site and planting 30 acres of emergent tidal marsh.	Extend both the southern and northeastern breakwaters to form a solid line of protection.	Restore 20 acres of emergent tidal marsh via beneficial use of dredged material adjacent to the existing containment site project.	Extend both existing breakwaters, restore 128 acres of emergent tidal marsh habitat, 78 acres coastal maritime forest, 86 acres of beach habitat, and 30 acres of dune habitat.
B. IMPACT ASSESSMENT						
1. National Economic Development						
a. Beneficial Impacts						
(1) Damages Prevented	N/A	N/A	N/A	N/A	N/A	N/A
(2) Emergency Costs Avoided	$0	$0	$0	$0	$0	$0
(3) Recreation	$0	Significant increase in recreation	Possible increase in ecotourism	Moderate increase in recreation	Possible increase in ecotourism	Most significant increase to recreation and ecotourism

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
(4) Total Beneficial Impacts	None.	Significant increase in recreation	Possible increase in ecotourism	Moderate increase in recreation	Possible increase in ecotourism	Most significant increase to recreation and ecotourism
b. Adverse Impacts						
(1) Project Cost	$0	$8,360,000	$4,004,000	$2,910,000	$4,707,000	$14,964,000
(2) Interest During Construction	N/A	N/A	N/A	N/A	N/A	N/A
(3) Average Annual First Cost	N/A	N/A	N/A	N/A	N/A	N/A
(4) Annual O&M	$0	$0	$0	$0	$0	$0
(5) Total Avg. Annual Costs	N/A	N/A	N/A	N/A	N/A	N/A
2. Environmental Quality (EQ)						
(1) Ecosystem Restoration	No Federal Action	Restore 30 acres of dune, 78 acres of emergent tidal marsh, 78 acres of coastal maritime forests, and 86 acres of beach habitats along the southern shoreline.	Placement of dredged material into the existing Section 204 containment site and planting 30 acres of emergent tidal marsh.	Extend both the southern and northeastern breakwaters to form a solid line of protection.	Restore 20 acres of emergent tidal marsh via beneficial use of dredged material adjacent to the existing containment site project.	Extend both existing breakwaters, restore 128 acres of emergent tidal marsh habitat, 78 acres coastal maritime forest, 86 acres of beach habitat, and 30 acres of dune habitat.
(2) Water Circulation	No anticipated effect on water circulation.	No anticipated effect on water circulation.	No anticipated effect on water circulation.	No anticipated effect on water circulation.	No anticipated effect on water circulation.	No anticipated effect on water circulation.

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
(3) Noise Level Changes	No change in noise levels	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction
(4) Public Facilities	N/A	N/A	N/A	N/A	N/A	N/A
(5) Aesthetic Values	No significant change in aesthetic values	Significant increase to aesthetic improvement	Moderate increase to aesthetic improvement	Significant increase to aesthetic improvement	Moderate increase to aesthetic improvement	Most significant increase to aesthetic improvement
(6) Natural Resources	No impact.	Alternative would result in restoration of coastal maritime forests, beach and dune, and emergent marsh habitat resources.	Alternative would result in restoration of emergent tidal marsh resources.	Alternative would result in protection of coastal maritime forests, beach and dune, and emergent marsh habitat resources	Alternative would result in restoration of emergent tidal marsh resources.	Alternative would result in protection and restoration of coastal maritime forests, beach and dune, and emergent marsh habitat resources.
(7) Biological Resources	No impact.	Alternative would moderately improve the Biological resources.	Alternative would moderately improve the Biological resources.	Alternative would moderately improve the Biological resources.	Alternative would moderately improve the Biological resources.	Alternative would most improve the Biological resources.
(8) Air Quality	Alternative would have no anticipated effect on air quality	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
(9) Water Quality	No impact.	Temporary negative impacts to water quality due to construction , significant long-term improvements.	Temporary negative impacts to water quality due to construction , significant long-term improvements.	Temporary negative impacts to water quality due to construction , significant long-term improvements.	Temporary negative impacts to water quality due to construction , significant long-term improvements.	Temporary negative impacts to water quality due to construction , significant long-term improvements.
(10) Public Services	No impact.	No impact.	No impact.	No impact.	No impact.	No impact.
(11) Cultural and Historical Preservation	Cultural resource sites would be lost.	Cultural resource sites would be protected.	No impact.	Cultural resource sites would be protected.	No impact.	Cultural resource sites would be most protected.
(12) Total Quality of the Environment	Total Quality would degrade.	Environmental quality of the environment would be improved.	Environmental quality would be improved.	Environmental quality would be improved.	Environmental quality would be improved.	Environmental quality would be most improved.
3. Regional Economic Development (RED)						
(1) Impact on Sales Volume	No impact.	Increase of **$19,896,800** in additional sales volume.	Increase of **$9,529,521** in additional sales volume.	Increase of **$6,925,800** in additional sales volume.	Increase of **$11,202,660** in additional sales volume.	Increase of **$35,614,320** in additional sales volume.
(2) Impact on Income	No impact.	Increase of **$4,122,761** in additional local income.	Increase of **$1,974,585** in additional local income.	Increase of **$1,435,076** in additional local income.	Increase of **$2,321,272** in additional local income.	Increase of **$7,379,544** in additional local income.

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
(3) Impact on Employment	No impact.	Increase of **123** new jobs.	Increase of **59** new jobs.	Increase of **43** new jobs.	Increase of **69** new jobs.	Increase of **220** new jobs.
(4) Tax Changes	No impact.	Would result in some local tax revenue gain due to recreation and construction.	Would result in some local tax revenue gain due to recreation and construction.	Would result in some local tax revenue gain due to recreation and construction.	Would result in some local tax revenue gain due to recreation and construction.	Would result in some local tax revenue gain due to recreation and construction.
4. Other Social Effects (OSE)						
a. Beneficial Impacts						
(1) Security of Life, Health, and Safety	Continued risks to life, health and safety	Not a significant reduction in potential loss	Not a significant reduction in potential loss	Not a significant reduction in potential loss	Not a significant reduction in potential loss	Not a significant reduction in potential loss
(2) Community Cohesion	Some negative impact on community cohesion due to loss of recreation and ecotourism opportunities.	Some positive impact on community cohesion due to increased recreation and ecotourism opportunities.	Some positive impact on community cohesion due to increased recreation and ecotourism opportunities.	Some positive impact on community cohesion due to increased recreation and ecotourism opportunities.	Some positive impact on community cohesion due to increased recreation and ecotourism opportunities.	Some positive impact on community cohesion due to increased recreation and ecotourism opportunities.

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
(3) Tax Values	No Impact.	Minor impact on tax values due to added recreational and ecotourism resource for the region.	Minor impact on tax values due to added recreational and ecotourism resource for the region.	Minor impact on tax values due to added recreational and ecotourism resource for the region.	Minor impact on tax values due to added recreational and ecotourism resource for the region.	Minor impact on tax values due to added recreational and ecotourism resource for the region.
(4) Community Growth	No Impact.	Minor impact due to added recreational and ecotourism resource for the region.	Minor impact due to added recreational and ecotourism resource for the region.	Minor impact due to added recreational and ecotourism resource for the region.	Minor impact due to added recreational and ecotourism resource for the region.	Minor impact due to added recreational and ecotourism resource for the region.
(5) Property Values	No Impact.	N/A	N/A	N/A	N/A	N/A
(6) Displacement of Businesses	N/A	N/A	N/A	N/A	N/A	N/A
(7) Public Facilities	N/A	Enhances opportunities for additional public facilities for recreation / ecotourism	Enhances opportunities for additional public facilities for recreation / ecotourism	Enhances opportunities for additional public facilities for recreation / ecotourism	Enhances opportunities for additional public facilities for recreation / ecotourism	Enhances opportunities for additional public facilities for recreation / ecotourism
(8) Injurious Displacement of Farms	N/A	N/A	N/A	N/A	N/A	N/A

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
b. Preservation of loss of life	No Impact.	Some reduction in potential loss of life.	Some reduction in potential loss of life.	Some reduction in potential loss of life.	Some reduction in potential loss of life.	Some reduction in potential loss of life.
C. PLAN EVALUATION						
1. Contributions to Planning Objectives						
a. Flood, Hurricane and/or Storm Damage Reduction	No Improvement.	Minor reduction in damages at project site due to reduction in wave energy.	Minor reduction in damages at project site due to reduction in wave energy.	Minor reduction in damages at project site due to reduction in wave energy.	Minor reduction in damages at project site due to reduction in wave energy.	Minor reduction in damages at project site due to reduction in wave energy.
b. Recovery of lost environmental resources	Continued loss of environmental resources.	Significant opportunity to recover environmental resources negatively impacted in past	Moderate opportunity to recover environmental resources negatively impacted in past	Some opportunity to recover environmental resources negatively impacted in past	Moderate opportunity to recover environmental resources negatively impacted in past	Significant opportunity to recover environmental resources negatively impacted in past
2. Response to Planning Constraints						
a. Avoid environmental impacts and minimize induced damages	Continued loss of pre-Katrina environmental resources.	Positive effect on environmental resources.	Positive effect on environmental resources.	Positive effect on environmental resources.	Positive effect on environmental resources.	Positive effect on environmental resources.

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
b. Institutional Acceptability	Not supported by state or local government	Is supported by local and state governments	Is supported by local and state governments	Is supported by local and state governments	Is supported by local and state governments	Is supported by local and state governments
3. Response to Evaluation Criteria						
a. Acceptability	NO	YES	YES	YES	YES	YES
b. Completeness	NO	YES, but continued degradation of environmental resources.	YES, but continued degradation of environmental resources.	YES, but continued degradation of environmental resources.	YES, but continued degradation of environmental resources.	YES, most significant reduction in degradation of environmental resources
c. Effectiveness	NO	YES, moderately effective	YES, moderately effective	YES, moderately effective	YES, moderately effective	YES, significantly effective
d. Efficiency (Cost-Effectiveness; i.e., most efficient use of Federal and Non-Federal Funds)	NO	YES, but continued degradation of other environmental resources.	YES, but continued degradation of other environmental resources.	YES, but continued degradation of other environmental resources.	YES, but continued degradation of other environmental resources.	YES, most cost effective plan
e. Integration	N/A	Part of overall system.	Part of overall system.	Part of overall system.	Part of overall system.	Seamless part of overall system.
f. Reversibility	N/A	N/A	N/A	YES - but at significant cost and degradation to the environment	N/A	N/A
4. Stakeholder Preference Score (From MCDA weightings analysis)						

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
a. Summary Score	These alternatives were not available for the Stakeholder Preference Workshops.					
D. Implementation Responsibility	No implementation responsibilities	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.	Joint Federal/Non-Federal implementation responsibility.
E. State and other Non-Federal Coordination	No State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities	Would require State or other Non-Federal coordination activities
F. Risk Evaluation						
1. Risk and Vulnerabilities						
a. Risk of Failure	N/A	Low	Moderate	Moderate	Moderate	Low
b. Residual Risk	Residual risks (economic) will remain high due to failure to address erosion of island. Island will overtop during large surge events, and will not	Residual risks (economic) will remain high, but may be slightly reduced for area in shadow of island. Alternative will reduce wave energy for small to moderate	Residual risks (economic) will remain high. Alternative will not significantly reduce wave energy during large hurricane events.	Residual risks (economic) will remain high, but may be very slightly reduced for area in shadow of island. Alternative will reduce wave energy for small	Residual risks (economic) will remain high. Alternative will not significantly reduce wave energy during large hurricane events.	Residual risks (economic) will remain high, but would be reduced for area in shadow of island. Alternative will reduce wave energy for small to moderate

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
	provide significant reduction of wave energy.	surge events, but not large hurricane events. Although moderate, would provide for a greater reduction in residual risk than all others but Combination Plan, particularly due to wave impact		to moderate surge events, but not large hurricane events. May provide a very small reduction, and much smaller than either Seaward shoreline or combination plans		surge events, but not large Katrina-like events. Although moderate, would provide for a greater reduction in residual risk than all other plans, particularly due to wave impact
c. Reliability	N/A	This plan would provide a moderate level of reliability, would be resistant to damage from storm events, but would also require some periodic maintenance, particularly after	This plan would provide a low level of reliability, would receive damage from storm events, and would require significant maintenance, particularly after damaging	This plan would provide a moderate level of reliability, would be resistant to damage from storm events, and would not require significant maintenance, particularly after	This plan would provide a lesser level of reliability, would receive damage from storm events, and would require significant maintenance.	This plan would provide the highest level of reliability of any plan, would be most resistant to damage from storm events, and would require less maintenance, but still some, after damaging

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
		damaging storm events.	storm events..	damaging storm events..		storm events..
d. Relative Sea Level Rise	Problems will be substantially exacerbated by an increasing relative rise of sea level	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimallyimpacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis
e. Risk of Ecosystem Damage	Ecosystem damage will continue to accrue at a rate at least that of recent history with substantial negative outcomes.	Some risk of ecosystem damage throughout the period of analysis.	Risk of ecosystem damage will be moderate throughout the period of analysis.	Some risk of ecosystem damage throughout the period of analysis.	Risk of ecosystem damage will be moderate throughout the period of analysis.	Risk of ecosystem damage will be minimal throughout the period of analysis.

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
f. Risk to Life and Safety	Significant threats to Life and Safety from storm surge will continue to rise due to continued deterioration of the Island.	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide a lesser risk to life and safety than the no action plan, for those living in shadow of island..	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide a lesser risk to life and safety than the no action plan, for those living in shadow of island..	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide a lesser risk to life and safety than the no action plan, for those living in shadow of island..	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide a lesser risk to life and safety than the no action plan, for those living in shadow of island.	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide greatest reduction in risk to those living in shadow of island of any plan.
g. Risk to Mental and Physical Health	Significant threats to Mental and Physical Health from storm surge will continue to rise due to continued deterioration of the Island.	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide a lesser risk to Mental and Physical Health than the no action plan, for	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide a lesser risk to Mental and Physical Health than the	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide a lesser risk to Mental and Physical Health than the no action plan, for	Significant threats to Mental and Physical Health from storm surge willstill exist, but this plan will provide a lesser risk to Mental and Physical Health than the no action plan, for those living in shadow of island..	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide the least risk to Mental and Physical Health of all plans, for those living in

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
		those living in shadow of island..	no action plan, for those living in shadow of island..	those living in shadow of island..		shadow of island..
2. Recommendations and Preferences						
a. Federal Recommendation						This Plan produces the most NER benefits, the greatest achievement of OSE outcomes, does not violate any local, state, or Federal statues, laws, and regulations, and is the most cost effective

Problem Area: Deer Island, Harrison County, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Seaward Shoreline	Restore Containment Area	Breakwater Protection	Restore Eastern Marsh	Combination Restoration Plan
						and efficient plan.
b. Stakeholder Preference						Though not scored, this plan has the highest (non-scored; verbal) stakeholder preference, and creates a low risk environment.

1
2

3.21 Risk Assessment and Education in Plan Formulation

3.21.1 Intro to Risk

The USACE Twelve Action Points for Change (date) identify risk as an important component of the USACE planning process. The Twelve Points specifically charge USACE to:

- Employ risk based concepts in planning, design, construction, and major maintenance;
- Effectively communicate risk; and
- Establish public involvement risk reduction strategies.

The fulfillment of these risk-related action points in the MsCIP planning process is discussed below.

3.21.2 Risk in Identification in Technical Analyses

In a technical analysis, risk is defined as the reliability of an estimated value. In this sense, risk is typically identified through probability and confidence intervals. Selection of the parameters used in the technical analyses, which would be appropriate for risk identification, was conducted by the study team, technical experts, and Corps Engineering Research and Development Center (ERDC) staff. Risk was initially identified for stage (the depth to which water could rise during a surge event), frequency, wave height, first floor elevation of structures, structure value, and content value.

Some technical parameters, which may be important to the outcome of the technical analysis, are not estimated in a way that allows for the calculation of probabilities and confidence intervals. The uncertainty that these parameters bring to the analysis is typically addressed by using alternative parameter values in sensitivity or scenario analyses. In this study, this type of uncertainty was addressed by the evaluation of multiple storm tracks (paths), magnitudes (strength), and alignments, to ensure that the appropriate range of potential conditions was incorporated into the assumptions that went into defining future without-, and with-project conditions.

3.21.3 Risk Identification in the Planning Process

In public meetings conducted for this study, attendees raised concerns about potential negative or unwanted impacts on the outcome of planning recommendations. Such negative impacts include damage to culture and historical properties, public service disruption, reduction in the long-term sustainability of measures, potential consequences to individuals and families, and other societal issues.

Public workshops were conducted to get input on the factors the public viewed as the most important. The workshops established *which factors* were important, and also provided input on which factors were of *highest* importance to the public. A full discussion on the identification of risk factors by the public is contained in the appendix on the Risk appendix.

3.21.4 The Risk-Informed Decision Framework (RIDF) Process

The information obtained from the public workshops was used to develop a set of evaluation metrics. These evaluation metrics, which are based on USACE developed technical information and public input, were used to evaluate and compare alternative planning measures.

Evaluation metrics were developed to compare the performance of each measure in an economic context (e.g., cost effectiveness), an environmental context (e.g., preservation of fish and wildlife habitat for ecological stability), and a social context (e.g., societal displacement). The metrics were used to calculate performance scores and rank the measures during the evaluation and comparison steps of the planning process. If a measure did not score well, it would either be screened out

(dropped from further consideration) or taken back to the "drawing board" for refinement. The next section provides additional detail concerning development of the evaluation metrics.

3.21.5 Evaluation Metric Development

A preliminary set of evaluation metrics was developed by the study team and shared with several stakeholder groups. The preliminary set of evaluation metrics was scored (or weighted) and ranked by these stakeholder groups. This stakeholder group input was used to shape the final list of 15 evaluation metrics.

Evaluating measures by a large set of metrics can be complex and very time consuming. With this in mind, the study team sought to develop an efficient set of metrics that would represent the best available information and public input, but would not be so large as to hinder the evaluation process. Metric values depend upon either model estimates, empirical data from a study, or expert opinion. Each of these sources include varying degrees of uncertainty therefore, it was necessary to provide the stakeholder groups with the underlying assumptions that went into calculating each metric value. Estimates of the uncertainty for a metric were quantified where possible (e.g., in terms of the variance or range associated with the estimate).

The following criteria were used in developing metrics:

- Scientifically verifiable. Meaning that two independent assessments would yield similar results.
- Cost-effective. The technology required to generate data for the metrics is economically feasible and does not require an intensive deployment of labor.
- Communicable. Are easy to communicate to a wide audience. The public would understand the scale and context, and be able to interpret the metric with little additional explanation.
- Changeable by human intervention. The metric would describe a dependent relationship between the outcome of the measure and those things that are under a decision-maker's control. Metrics that are independent of human action do little to help evaluate a measure.
- Credible. It would be perceived by most stakeholders as accurately measuring what it is intended to measure.
- Scalable. It would be directional in nature, whether qualitative (best, good, worst) or quantitative (dollars, acres, percent damaged), as appropriate.
- Relevant. It would reflect the priorities of the public and other stakeholders and enhance their ability to execute their stewardship responsibilities. There is no point assembling a metric no one cares about.
- Sensitive. The metric must be able to capture the minimum meaningful level of change, make the smallest distinctions that are still significant, and any uncertainty about the metric is easy to communicate.
- Minimally redundant. What the metric measures is not essentially reflected by another metric.
- Transparent. The use and development of the metric is readily apparent.

It is important to acknowledge here that there will be "conflicts" among metrics, resulting in the need to make tradeoffs. For example, a tradeoff may exist between achieving the maximum benefit from a project and minimizing project cost. As a consequence of such "conflicts", a measure may not take clear precedence over other measures with respect to every evaluation metric. This may present a dilemma to decision-makers, who are trying to choose a single measure. It is important to place development of metrics prior to the development of measures because the "hard thinking" that

goes into developing the metrics can create an improved set of measures. Development of evaluation metrics prior to developing alternative measures permits stakeholders to focus on thinking about the objectives rather than anchoring themselves to their "favorite" measures.

The final set of 15 evaluation metrics, presented below, reflect the combination of technical input from USACE and public input provided by stakeholder groups. The evaluation metrics are grouped according to placement in the four accounts.

3.21.5.1 Environmental Quality (EQ) Metrics

Metric 1) Tidal Habitat Restored - This metric measures (in acres) positive changes to the tidally-influenced wetlands that results from the implementation of a measure or plan. These are positive benefits from implementing a restoration plan or a combination of plans. Ecosystem components included in this metric are tidal wetlands (i.e., tidal fringes), associated threatened and endangered (T&E) and other species, associated essential fish and other tidal habitats (i.e. oysters, submerged aquatic vegetation), and related losses that require mitigation due from implementation of structural plans. There are 5 tidal wetland functions measured: wave energy attenuation (wave energy absorbed by wetland through landscape position, marsh width, and vegetation cover), biogeochemical cycling (receive, transform, and export nutrients through a wetland), nekton (swimming organisms) utilization potential (whether wetland contains suitable habitat for nekton), provide habitat for tidal marsh dependent vertebrate wildlife, and maintain a characteristic tidal marsh plant community. Units for this metric are the percentage increase of quality fish and wildlife habitat in functional habitat units (FHI).

Metric 2) Tidal Habitat Lost - This metric measures adverse impacts to the tidally-influenced wetlands that results from the implementation of a measure or plan. Ecosystem components included in this metric are tidal wetlands (i.e., tidal fringes), associated threatened and endangered (T&E) and other species, associated essential fish and other tidal habitats (i.e. oysters, submerged aquatic vegetation), and related losses that require mitigation due from implementation of structural plans. There are 5 tidal wetland functions measured: wave energy attenuation (wave energy absorbed by wetland through landscape position, marsh width, and vegetation cover), biogeochemical cycling (receive, transform, and export nutrients through a wetland), nekton (swimming organisms) utilization potential (whether wetland contains suitable habitat for nekton), provide habitat for tidal marsh dependent vertebrate wildlife, and maintain a characteristic tidal marsh plant community. Units for this metric are also in acres.

Metric 3) Non-tidal Habitat Restored - This metric measures (as functional units) positive changes to the non-tidal ecosystem that would result from the implementation of a measure or plan. These are positive benefits from implementing a restoration plan or a combination of plans. Ecosystem components included in this metric are maritime forests, beach nourishment, dune restoration and vegetation, and associated threatened, endangered and other species in non-tidal habitats. There are numerous functions provided by upland habitat: wildlife and birds (includes threatened and endangered species) roosting, nesting, and foraging utilization potential, wildlife corridors, sustainability of the Mississippi Flyway, restoration of the natural ecology and aesthetics of the area, and maintenance of plant community composition. Units for this metric are the percentage increase of quality fish and wildlife habitat in acres.

Metric 4) Non-tidal Habitat Lost - This metric measures (as functional units) adverse impacts to the non-tidal ecosystem that results from the implementation of a measure or plan. This has a negative impact of implementation of an array of alternatives as part of the comprehensive plan. Ecosystem components included in this metric are maritime forests, beach and dunes, threatened, endangered and other species and their non-tidal habitats, and related losses that require mitigation due to implementation of structural plans. There are numerous functions provided that will be evaluated and include: breaks in natural wildlife corridors, fragmentation of habitat, loss of critical habitat for

threatened and endangered species, loss of foraging and roosting areas, loss of vegetation resulting in increased erosion, reduction in water quality and air quality. Units for this metric are the percentage decrease of quality fish and wildlife habitat in acres.

3.21.5.2 National Economic Development (NED) Metrics

Metric 5) Monetary Damages Reduced/Avoided (Equivalent Annual Damages) - The amount of storm damages reduced/avoided by a plan expressed as annualized dollars. Annualized dollars are calculated by comparing a future without a project in place versus a future with a project in place. Damages are calculated by using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. This metric has become standard practice in the evaluation of the value of measures with respect to estimating damages to assets (i.e., residential, commercial, and industrial infrastructure and their contents) over the period of analysis. For more detail about the HEC-FDA model see Economics Appendix.

Metric 6) Residual Damage – Residual damage is defined as the storm damage that is not prevented with the implemented plan in place (expressed as annualized dollars). This metric describes what a plan does not account for (or what happens if a plan is exceeded).

Metric 7) Cost to Implement Plan – The amount of money in dollars needed to implement the plan. This metric measures the cost in today's dollars to local and Federal governments to implement the recommended plan.

3.21.5.3 Other Social Effects (OSE) Metrics

These metrics focus on the preservation of people's quality of life. OSE metrics were developed to address impacts to cultural heritage and preservation of historical structures, disruptions to public service and infrastructure and impacts to personal effects.

Metric 8) Cultural and historical heritage impacts – This metric addresses impacts to social groups, church congregations, and groups with common heritages. This metric also includes impacts to aesthetics and the destruction of the human-created landscape such as historical structures. The units for this metric will be a unit less quantitative scale (0-10). A score of 10 is best, 1 is bad.

Metric 9) Public service and infrastructure disruptions – This metric includes disruptions to schools, fire and police service, access to hospitals, libraries and community centers, and use of roads, bridges, and utilities. The units for this metric will be a unit less quantitative scale (0-10). A score of 10 is best, 1 is bad.

Metric 10) Personal impacts – This metric includes loss of family possessions, photographs, and impacts to people's emotional and mental health. The units for this metric will be a unit less quantitative scale (0-10). A score of 10 is best, 1 is bad.

3.21.5.4 Regional Economic Development (RED) Metrics

The RED metrics measure both positive and negative impacts to the regional economy. Positive impacts are captured by impacts to sales volume, personal income and employment and negative impacts by local cost burdens. Sales volume, income and employment will be sub-metrics under RED, and will be equally weighted. This metric is termed Positive regional economic benefits and will combine these 3 sub-metrics. The local cost burdens metric is also a sub-metric under RED and will receive a weight equal to combined weighting of the positive metrics under regional economic benefits.

Metric 11) Local Cost Burdens – This metric represents the costs and burdens to the local governments due to implementing a measure. This includes cost-sharing requirements with the Federal government to implement the plan and local costs for ongoing operations and maintenance (O&M) related to the implemented plan. The local cost burdens may also include those associated

with additional workforce needed to maintain features of an implemented plan. This metric will be based on a unit-less quantitative scale (0-10). A score of 10 is best, 1 is bad.

Metric 12) Positive regional economic benefits – Economic benefits to the region with regards to sales volume, income and employment. This metric was evaluated using the economic impact forecasting system (EIFS) model. This model is an economic analysis tool that given the inputs for a particular plan will assess potential impacts of sales volume change and personal income in dollars and regional employment change in number of jobs to the local economy. Uncertainty will be based on several factors such as population, implementation cost, and social behavior of people in the region. This metric will be based on a unit-less quantitative scale (0-10). A score of 10 is best, 1 is bad.

3.21.5.5 Risk Metrics

The following risk metrics serve as additional information to decision makers. They are a way to address extreme cases of uncertainty.

Metric 13) Long-term Sustainability of Plan – The qualitative likelihood that features associated with the recommended plan will not perform as intended (over time) due to factors such as cost, human behavior, technical level of maintenance required, political concerns, resource availability, local funding per year, and operational reliability. The units for this metric will be a unit-less quantitative scale (0-10). A score of 10 is best, 1 is bad.

Metric 14) Residual Risk – This metric considers potential damages which would occur even with the implemented plan in place. It accounts for the following factors: erosion, wildlife species, wildlife habitat, salt water intrusion, surge damages, drainage, wind, maximum probable intensity (MPI) plan (accounts for more intense storm), cultural heritage, and infrastructure. The units for this metric will be a unit-less quantitative scale (0-10). A score of 10 is best, 1 is bad.

Metric 15) Consequences of Plan Failing – This metric considers the consequences of a plan not functioning as intended. In other words, it describes consequences to humans and the environment due to a catastrophic failure of an implemented plan under design conditions or other sets of circumstances from a storm event. The greatest consequences would result from failure to structural measures, such as levees, flood gates, etc. Consequences and likelihood of failure vary depending on the line of defense. For example, risk of Line 2 failure is more likely, but consequences are relatively low; risk of Line 4 failure is highly unlikely, but consequences are very high. It includes the following factors: injuries to population, loss of infrastructure, loss of habitat, and loss of wildlife species. The units for this metric will be a unit less quantitative scale (0-10). A score of 10 is best, 1 is bad.

Once the 15 metrics were described, the study team developed the values associated with each measure. The team calculated the acres associated with each measure for the metrics within the Environmental Quality Account as discussed above. The NED metrics were developed through the use of the Corps' HEC-FDA program (further described in the Economics Appendix) and are expressed in dollars.

As mentioned above, the RED, OSE, and Risk metrics are based on a scale from 1-10. Guidelines for these metrics were given to the team to help provide consistency amongst the different measures and are defined in the following tables.

3.21.6 "Weighting" of Evaluation Metrics by Stakeholders of Coastal Mississippi

Three sequential "risk weighting" workshops were held in July, September, and December of 2007 with various stakeholder groups. The first workshop was used primarily to make sure that the stakeholders understood the RIDF process and that the metric definitions were sound and easily

understood. At this workshop, the stakeholders were subjected to two different weighting (or scoring) techniques and their feedback helped to refine the process. This process was repeated at the September workshop, where the stakeholders used example metric data to aid their understanding of the measures. Again, feedback from this workshop allowed the team to finalize the weighting process and in the December, the stakeholders were able to see the actual data for the metrics associated with the final list of alternatives. The MsCIP weight elicitation workshops yielded 45 complete sets of weights on fifteen metrics. These initial weights were used to establish the importance of each factor as determined by the stakeholders, and are shown in Table 3-21. Weights are based on 100 points distributed among the 15 categories.

1 **Table 3-21**
2 **Point Allocation to Metrics**

Cluster	Session	Tidal Habitat Restored	Tidal Habitat Lost	Non-Tidal Restored	Non-Tidal Lost	Damage Reduced	Residual Damage	Implementation Cost	Local Cost Burdens	Regional Benefits	Cultural Heritage	Disruptions	Personal Impacts	Sustainability	Consequences	Residual Risk
A	Business	1	1	1	1	35	3	5	5	5	4	2	2	15	16	4
A	Business	5	3	5	3	5	4	9	10	10	6	8	8	15	3	6
A	Federal	2	1	2	1	20	4	10	4	10	1	10	4	17	10	4
A	Local	2	2	2	2	7	7	12	24	10	5	10	5	5	2	5
A	Local	1	1	1	1	3	3	25	25	10	10	5	1	7	3	4
A	Local	1	2	1	2	13	8	1	12	13	1	8	5	12	12	9
A	Local	3	4	1	2	15	5	5	3	4	3	12	8	18	13	4
A	Local	1	1	1	1	20	8	12	9	10	6	7	2	15	5	2
A	Local	1	1	1	1	10	10	10	16	3	7	7	7	15	10	1
B	Business	8	6	6	2	15	6	10	8	8	8	5	7	4	3	4
B	Business	10	8	1	1	7	10	10	12	5	3	8	5	9	6	5
B	USACE	12	12	10	10	12	7	2	2	2	5	5	2	7	7	5
B	USACE	10	12	10	14	10	9	8	5	7	3	2	4	2	3	1
B	USACE	5	5	5	5	10	5	10	10	5	5	5	5	7	15	3
B	Federal	6	6	5	5	20	6	6	4	7	4	5	3	9	8	6
B	Federal	5	5	5	5	10	10	10	5	5	5	5	5	10	10	5
B	Federal	10	10	5	5	10	1	10	7	5	1	5	1	5	5	20
B	Local	1	10	1	10	10	12	18	1	8	4	8	3	1	12	1
B	Local	15	9	5	2	8	5	6	8	3	8	5	5	8	5	8
B	NGO	5	10	5	10	17	1	10	5	2	3	3	3	18	7	1
B	State	5	5	5	5	10	10	10	10	10	5	10	5	10	0	0
B	State	7	12	7	12	6	3	11	6	3	3	2	2	16	5	5
B	State	5	4	5	3	9	5	5	7	6	5	10	10	8	6	12
B	State	3	15	2	2	8	10	8	8	7	1	5	12	5	6	8
C	Business	8	30	1	1	5	1	10	10	9	5	5	3	10	1	1
C	USACE	11	12	11	12	5	7	6	6	4	2	3	2	9	8	2
C	Federal	12	12	12	12	5	5	3	3	2	5	5	5	10	5	4
C	Federal	10	10	12	15	4	4	1	1	1	15	1	1	5	15	5
C	NGO	16	16	11	11	4	3	3	1	1	2	1	1	18	8	4
C	NGO	10	20	5	20	6	3	5	3	5	2	5	2	5	8	1
C	State	12	15	11	13	9	1	10	9	2	2	1	2	10	2	1
C	State	8	15	8	16	5	5	5	10	2	5	4	4	8	3	2
C	State	15	20	10	10	5	0	10	0	3	2	3	2	10	10	0
C	State	15	15	5	5	5	5	5	5	5	5	10	10	4	4	2
D	Federal	15	20	15	15	10	5	1	2	3	4	2	4	1	1	2
D	Federal	30	25	12	8	1	1	1	1	1	1	1	1	7	5	5
D	Federal	50	1	20	2	6	5	2	2	1	2	2	2	2	1	2
D	NGO	14	20	14	20	1	1	1	3	7	2	1	1	5	8	2
D	NGO	14	25	15	24	2	1	3	2	1	2	2	3	2	3	1
D	State	5	15	2	40	1	10	5	1	1	2	1	1	10	1	5

3

An exploratory data reduction technique called a cluster analysis was used to group stakeholders with similar preference patterns expressed through their allocation of weights to metrics. These results, as shown in Figure 3-14, enabled the MsCIP team to compare the different stakeholder preferences that exist for potential solutions. This stakeholder preference information was used in the systems of accounts analysis and is included in the Systems of Accounts tables as the "stakeholder risk score". A more detailed description of how the weights of these metrics were developed can be found in the RIDF Appendix.

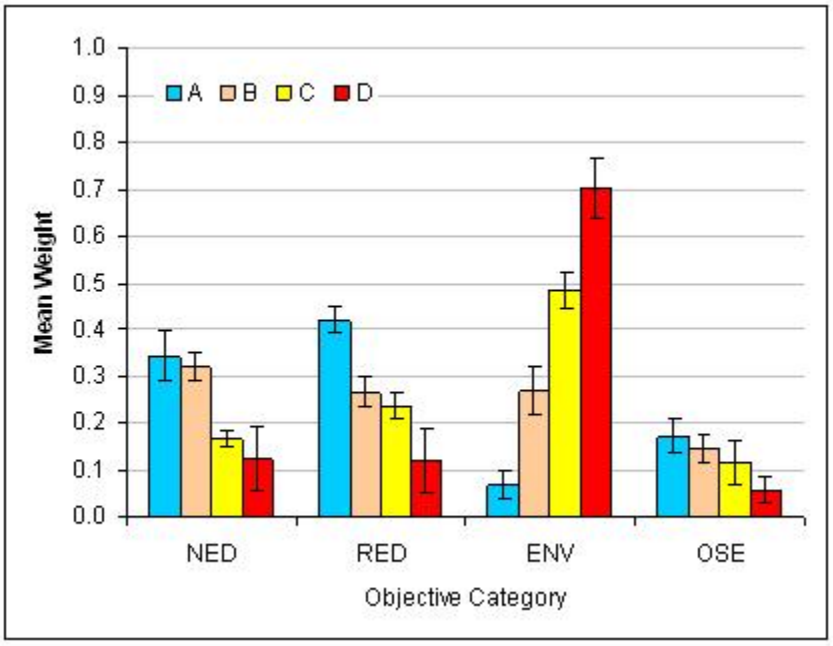


Figure 3-14
Stakeholder Weights for Clusters by Planning Objective

The stakeholder preferences were included as part of the System of Accounts' "trade-off" analysis. While these preferences to not determine the actual recommended plan, they are taken into consideration, and would make a difference especially where plans' other benefits are nearly equal. Table 3-22 illustrates that the preference pattern groups agree on several plans, but care must be taken not to discount those with differing opinions. The MsCIP team continued communicating with the stakeholder groups to make sure their concerns and ideas were considered during the comparison step and are reflected in the System of Accounts tables.

Table 3-22
System of Accounts - Summary of Stakeholder Preferences

	Preference Pattern			
Location	**A**	**B**	**C**	**D**
Barrier Islands	Barrier Island Plan H	Barrier Island Plan H	Barrier Island Option A	Barrier Island Option A
LOD2	LOD2 Option K	LOD2 Option K	LOD2 Option K	LOD2 Option K
Turkey Creek	Turkey Creek No Action	Turkey Creek No Action	Turkey Creek No Action	Turkey Creek Ecosystem Plan 1
Bayou Cumbest	Bayou Cumbest Acquisition	Bayou Cumbest Acquisition	Bayou Cumbest Acquisition	Bayou Cumbest Ecosystem Plan 1
Admiral Island	Admiral Island No Action	Admiral Island No Action	Admiral Island No Action	Admiral Island Ecosystem Plan 1
Dantzler	Dantzler No Action	Dantzler No Action	Dantzler No Action	Dantzler Ecosystem Plan 1
Franklin Creek	Franklin Creek No Action	Franklin Creek No Action	Franklin Creek No Action	Franklin Creek Ecosystem Plan 1
Forrest (Forest) Heights	Forrest (Forest) Heights Plan 2	Forrest (Forest) Heights Plan 2	Forrest (Forest) Heights No Action	Forrest (Forest) Heights No Action
Non-Structural	Phase I High Hazard Risk Reduction Plan	Long-term High Hazard Risk Reduction Plan	Phase I High Hazard Risk Reduction Plan	Long-term High Hazard Risk Reduction Plan

3.22 Selection of Recommended Alternatives

The final phase of the plan formulation and selection process involved the use of the more refined information on each of the final array of alternatives, in side-by-side comparison of no-action and final alternative plans, in a presentation of plan benefits, impacts, potential outcomes, stakeholder input, and potential inherent and residual risks, by display in the “System of Accounts” tables, presented in Section 3.18 (Table 3-25). The objective of the final phase was to generate a complimentary and comprehensive package of tentatively selected plan features, which would act as the system-wide Comprehensive Plan for improvement for coastal Mississippi.

The initial part of this final phase had two parallel efforts. The first of these was the effort to solicit public and stakeholder input, through the presentation of measures and preliminary alternatives, to all stakeholder groups, at a series of public workshops. This was the second part of the “Risk-Informed Decision Framework” (RIDF) process. The workshops were designed to elicit “stakeholder preferences” on potential solutions to each identified problem area. Stakeholders were asked to “score” measures and preliminary alternatives, in comparison to one another. Scores were then placed into the Multi-Criteria Decision

Analysis (MCDA) model, and sub-group and summary scores were derived. This process is discussed in greater detail in Attachment 1 to the Risk Appendix, and in final summary form in sections 3.19.4, 5 and 6 of this report. The results of this process were presented in the System of Accounts tables, as both “Stakeholder Preference” scores, and a summary of stakeholder preferences (the final row in each problem area’s account summary). This information both informed the larger plan selection process, provided support for selection of some plan features, and may also

be used by decision-makers outside the Corps to inform further development of Locally-Preferred Plan alternatives, should those be desired at a later phase of study.

The second parallel effort involved the comparison of the entire array of detailed plan information presented in the System of Accounts tables, and the consideration of all apparent risks, uncertainties, potential consequences and outcomes, of each final array directed at a specific problem area, to determine the plan that provided the best balance of positive outcomes. The screening and selection process involved the multi-agency study team, expert elicitation, and vertical team input; comparison and identification of the most cost-effective plans that achieved plan objectives; and full consideration of all of the criteria presented in the System of Accounts tables. The plan that provided the best balance of all these factors was selected for Federal recommendation as a tentatively selected plan feature. This process ultimately led to determination of the "Federally-recommended" package of "tentatively selected plan features", each of which is an integral element of the comprehensive package of tentatively selected plans, directed at achieving a lower-risk, higher sustainability environment for coastal Mississippi.

The Accounts displayed and used in this final part of the process, included the standard four accounts identified in Federal plan formulation guidance: "National Economic Development" (NED), "Regional Economic Development" (RED), "Environmental Quality" (EQ), "Other Social Effects" (OSE). In addition a "Risk" (RISK) account, directed at public safety issues, was added to fully identify the inherent risks associated with No-Action or the implementation of any one of the alternatives. The System of Accounts tables also display the "Stakeholder Preference "scores resulting from the public and agency RIDF process, as well as a final discussion of the selection result, based on those factors of greatest importance in that selection, for both "Stakeholder", and "Federally-Recommended" actions. In the case of the "Stakeholder Preference "scores, the number presented rates each alternative, in concept, as a percentage of a theoretical "perfect plan" (in the eyes of the stakeholder group). The higher the score reflects the stakeholder belief that the alternative provides the best fit to their value judgments of the metrics. In other words, the higher the score, the more acceptable the alternative should be to that stakeholder group.

In no case was the tentatively selected plan feature determined solely by stakeholder preference scores. These scores were used to inform that process, but consideration of risks to life and public safety, uncertainties, and cost-effectiveness, were in some cases, over-riding considerations in the selection of a particular plan element. It should be noted that even though the initial stakeholder preference scores pointed towards the No-Action Plan for several of the ecosystem restoration plans, additional consultation with local and state authorities also showed strong support for the tentatively selected plans. The goal of the entire process was to generate a full range of tiered, implementable plans for further action aimed at achievement of the study objectives, and identification of those measures for immediate or longer-term action as a result of the decision document being acted upon by Congress.

Ultimately, because the stakeholders may possess very different life experiences and also may not have possessed full information on the nature and magnitude of potential risks associated with any plan of action, the process required that the study team have ultimate responsibility for a Federally-recommended "tentatively selected plan feature" selection, based on full consideration of risk factors and potential consequences of plan implementation. This was determined to be especially important in the consideration of alternatives that had potentially hazardous outcomes under various future scenarios.

3.22.1 Alternatives Recommended for Construction Authorization

The following components of the Comprehensive Plan, which are described in this report, are ready for advanced design and implementation. These projects are presented in support of a recommendation for construction:

- Coastal Wetland and Forest Restoration:
    - Turkey Creek – An essential component necessary when selecting the tentatively selected plan at Turkey Creek was the need for burning. Burning allows the wet pine savannah environment to continue naturally as a functioning system. Although mowing does effectively keep understory plants from over colonizing the area, it does not simulate the natural conditions (i.e. seed germination, heating the pine bark, etc.) Therefore, the environmental PDT ranked the burning measure higher than that of the mowing. Plan 5 was not determined cost effective due to its small size of only 190 acres. When evaluating between Plan 1 and 3, the AAFU units were very different. The acreages were also very different due to Plan 1 including both the north and south parcels while Plan 3 included only the south parcel. The team noted that the man-made barrier within the project site produced hydrology constraints. Dominant flora species in wet pine savannah habitats are dependent upon burning; thus, the MsCIP environmental team selected the following plan knowing that most of these plant species would colonize the area upon establishment of routine burning and hydrology. The Environmental PDT then noted that the desired environmental restoration outputs (i.e. a functioning wet pine savannah) could be achieved by selecting Plan 3 which would also provide a cost-effective plan. Plan 3 (Restoration of 689 Acres South of the Railroad and Maintained by Burning) was selected as the federal recommendation, because it achieves best balance of plan outcomes, at lower costs than Plan 1, and it achieves the objectives for problem solving at this site with much higher benefits than either Plan 5 or the No-Action Plan. Even though the stakeholder preference scores pointed towards the No-Action Plan, follow up communication with stakeholders determined there is strong local and state support for Plan 3.
    - Bayou Cumbest – The environmental MsCIP team selected the 1.0 meter spacing based on field experience by the Corps, universities, NGOs, State, and other Federal agencies with restoration of emergent marsh habitats. Past experience in Coastal Mississippi has proven that spacings, elevation, and hydrology are the three key essential components to obtain a successful emergent marsh site. The three spacing scenarios (i.e. 0.5, 1.0, 2.0 meters) have been used at a local Coastal Mississippi project (i.e. Deer Island, Harrison County). Upon assessing the propagation of those different spacings, the environmental PDT determined that although the 0.5 meter spacing is the desired planting technique, the overall goal of the restoration project can be achieved by spacing the tidal emergent plants out to 1.0 meters per plant. The 2.0 meter spacing was determined to leave the site too vulnerable to storms and/or hurricanes; thus, this spacing technique proofed to be rather risky. Marsh restoration along Coastal Mississippi will provide nursery habitat for various vertebrates and invertebrates while also providing a natural storm protection buffer from future storms. Plan 2 (Restoration of 110 acres by excavating filled in areas, removing exotic species, planting native species at a 1.0 meter density, filling in ditches, and acquisition of properties) was selected as the federal recommendation because it achieves the best balance of outcomes at a similar cost to Plans 1, 3, and 6, but with substantially greater functional improvement and greater reliability when compared to all other plans. Even though the stakeholder preference scores pointed towards the No-Action Plan, follow up communication with stakeholders determined there is strong local and state support for Plan 2.
    - Dantzler – Reasoning for selecting Plan 1 for Dantzler was based upon similar Turkey Creek reasoning described above. In order to restore this area to a wet pine savannah habitat, the higher areas will be designated as wet pine savannah. These areas have depression areas within them which will enable water to flow downward

to the depression areas; thus, holding water. The wet pine savannah habitat will be restored with wet pine flatwoods, such as *P. elliotti, M. cerifera, L. glabra, S. patens and P. virgatum.* Plan 1 (Restoration of 385 acres and maintained by burning) Plan 1 was selected as the federal recommendation because it achieves greater functional improvement and greater reliability of outcomes when compared to all other plans. Even though the stakeholder preference scores pointed towards the No-Action Plan, follow up communication with stakeholders determined there is strong local and state support for Plan 1.

- Admiral Island – Plan 2 (Restoration of 123 acres by excavating filled in areas, removing exotic species, planting native species at a 1.0 meter density, filling in ditches, and acquisition of properties) Plan 2 was selected as the federal recommendation for the same reasons as described above in Bayou Cumbest, and at similar cost to Plans 1,3, and 6, but with substantially greater functional improvement and greater reliability outcomes when compared to all other plans. Even though the stakeholder preference scores pointed towards the No-Action Plan, follow up communication with stakeholders determined there is strong local and state support for Plan 2.
- Franklin Creek – Reasoning for selecting Franklin Creek Plan 1 was based upon similar burning benefits as described in Turkey Creek and furthermore, the MsCIP Interim Project already incorporated the 194 acre site; therefore, Plan 1's large contiguous area provided additional benefits while those costs associated with property purchasing were included in the MsCIP Interim Project. Plan 1 (Restoration of 149 Acres North and South of the Railroad and maintained by burning) was selected as the federal recommendation because it achieves greater functional improvement and greater reliability of outcomes when compared to all other plans. Even though the stakeholder preference scores pointed towards the No-Action Plan, follow up communication with stakeholders determined there is strong local and state support for Plan 1.

- Submerged Aquatic Vegetation Restoration – For the SAV effort, limited knowledge of the functional restoration prohibited the team in developing cost effective alternatives; thus, a pilot project was identified at Bayou Cumbest to obtain the much needed described data. The federal recommendation is to construct a pilot project which would restore the SAV beds lost in Bayou Cumbest. The information gained from this pilot study could then be used to develop a plan to implement larger scale SAV restoration.
- Coast-wide Beach and Dune Restoration – Plan K (Construction of a 2' high x 60' wide dune through the existing berm expansion, and placing sand fencing and plantings) was selected as the federal recommendation because it provides the best balance of ecosystem and damage reduction benefits at a considerably lower cost than Plans I & J, and at similar risk. It also provides considerable benefits compared to No-Action Plan. The stakeholder preference scores for Plan K were also higher than any of the other plans.
- Moss Point Municipal Structure Relocation – The federal recommendation is to construct a pilot project involving relocating municipal services to higher ground within Moss Point. The information gained from this effort could help other communities in relocating their facilities to reduce the risk from future storm surge.
- Waveland Flood Proofing - The federal recommendation is to construct a pilot project involving new methods for elevating structures in the hardest hit areas of Waveland. The information gained from this effort could help other communities in elevating structures using FEMA's new 550 guidelines, thereby reducing their risk from future storm surge.

- Forrest (Forest) Heights Hurricane and Storm Damage Reduction – Plan 2 (Construction of a levee at an elevation of 21 feet (NAVD88) with clearing and snagging of channel) was selected as the federal recommendation because it achieves greater functional improvement and greater reliability of outcomes when compared to all other plans. Even though the stakeholder preference scores pointed towards the No-Action Plan, follow up communication with stakeholders determined there is strong local and state support for Plan 2.
- Deer Island Restoration – The existing Deer Island FHI evaluation from the Section 204 and WRDA Section 528 were used to develop the cost effective alternatives. Combination Plan (Restoration of Extend both existing breakwaters, restore 128 acres of emergent tidal marsh habitat, 78 acres coastal maritime forest, 86 acres of beach habitat, and 30 acres of dune habitat.) was selected as the federal recommendation because it produces the most NER benefits, the greatest achievement of OSE outcomes, does not violate any local, state, or Federal statues, laws, and regulations, and is the most cost effective and efficient of all other plans. Though not scored by preference groups, communication with stakeholder on this plan showed strong support, and creates a low risk environment.
- Barrier Island Restoration – Early coordination with the NPS narrowed potential restoration measure at the barrier islands, such as the reshaping/constructing dunes. Plan H (the restoration of Ship Island, littoral zone sand additions at the east ends of Petit Bois and East Ship Island, changes in maintenance dredging practices that meet the requirements of the Regional Sediment Management Practice, and a study to define the best restoration option for Cat Island) was selected as the federal recommendation because it has the highest NED benefits, substantial RED benefits, substantial EQ benefits, the greatest achievement of OSE outcomes, does not violate any local, state, or Federal statues, laws, and regulations, and is the most cost effective and efficient recommendation of the Barrier Island component of the Comprehensive Plan. This Plan also has the highest stakeholder preference score, and creates a low risk environment.

  High Hazard Area Risk Reduction Plan Phase I (provides immediate buyout opportunities for the most high risk areas for approximately 2000 parcels) was selected as the federal recommendation because it is the best balanced achievement of publicly acceptable outcomes, the most complete, effective, efficient, and acceptable means of addressing the problem set, and provides long-term reduction of damages to property. This plan is also the least costly of those evaluated, it effectively deals with highest risk surge zone problems, it achieves highest net benefit of all plans evaluated including No-Action and is considered to be compliant with USACE policy.

3.22.2 Alternatives Recommended for Further Study Prior to Implementation

The MsCIP team also supports a recommendation for initiating studies to accomplish the intent of Section 3083 of the Water Resources Development Act of 2007 to design a freshwater diversion project to be located in the vicinity of Violet, LA. The comprehensive goal to be attained through the initiation of these studies would provide sufficient inflows to the western Mississippi Sound area to support oyster reef health and productivity in coastal Mississippi.

- Freshwater Diversion at Violet, Louisiana

Other site-specific and system-wide components of the Comprehensive Plan, which have been developed in this feasibility study, are not presented in support of a specific project construction recommendation at this time. However, they are addressed as reasonably foreseeable actions for the consideration of cumulative effects. Additional engineering and design investigations have to be

completed in order to complete feasibility level designs and accurately quantify the benefits, costs, and impacts of these alternatives. As a result, these site-specific and system-wide elements of the Comprehensive Plan are not yet ripe for decision-making.

There are four system-wide elements of the Comprehensive Plan which require additional investigation and evaluation prior to the recommendation of site-specific plans for construction or implementation. These system-wide elements of the Comprehensive Plan include:

- Long-term High Hazard Risk Reduction Plan (HARP)
- Additional Damage Reduction Alternatives
- Coastal Mississippi Ecosystem Restoration Program
- Escatawpa River Freshwater Diversion.

3.22.3 Additional Comprehensive Plan Elements

While not compared in a system of accounts analysis, there are other areas that warrant either additional feasibility study or implementation by others. These include:

- education on hurricane risk,
- hurricane and storm warning,
- evacuation plans,
- flood insurance,
- zoning changes, and
- saltwater intrusion plans.

4 ENVIRONMENTAL EFFECTS*

The Mississippi Coastal Improvements Program Comprehensive Plan, as developed in this feasibility analysis, consists of system-wide elements and site-specific elements. Some site-specific components of the Comprehensive Plan have been developed sufficiently for a construction authorization recommendation. These components of the Comprehensive Plan are ready for advanced design and implementation. The following site-specific components are presented in support of a Record of Decision for construction:

- Coastal Wetland and Forest Restoration:
  - Turkey Creek
  - Bayou Cumbest
  - Dantzler
  - Admiral Island
  - Franklin Creek
- Submerged Aquatic Vegetation Restoration;
- Coast-wide Beach and Dune Restoration;
- Moss Point Municipal Structure Relocation
- Waveland Flood Proofing; and
- Forrest (Forest) Heights Hurricane and Storm Damage Reduction.

The restoration project at Deer Island also has been developed sufficiently for a construction authorization recommendation and is presented in support of a Record of Decision for construction. Should the Corps proceed with this action, additional decisions may be made with regard to additional Deer Island project components at a later date (such as a breakwater and westward expansion of the former Section 204 wetland site). Each of these future decisions will be subject to appropriate documentation to comply with NEPA.

Additionally, other site-specific and system-wide components of the Comprehensive Plan, which are developed in this feasibility study, are not presented in support of a Record of Decision for construction, but are addressed as reasonably foreseeable actions for the consideration of cumulative effects. Because additional engineering and design investigations have yet to be completed, these site-specific and system-wide elements of the Comprehensive Plan are not yet ripe for decision-making. Supplemental NEPA information will be presented as necessary to ensure compliance with the appropriate environmental laws and regulations:

- High Hazard Area Risk Reduction Plan
- Freshwater Diversion at Violet, Louisiana
- Additional Damage Reduction Alternatives
- Barrier Island Restoration
- Coastal Mississippi Ecosystem Restoration Program.

The analysis of environmental effects section of the report first presents a broad qualitative overview of potential environmental effects of the overall Comprehensive Plan. The presentation of broad program-wide impacts is followed by a more detailed and quantitative discussion of the impacts of projects presented in support of a Record of Decision for construction.

4.1 Comprehensive Plan

There are three system-wide elements of the Comprehensive Plan which require additional investigation and evaluation prior to the recommendation of site-specific plans for construction or implementation. These system-wide elements of the Comprehensive Plan include:

- High Hazard Area Risk Reduction Plan (HARP);
- Additional Damage Reduction Alternatives,
- Coastal Mississippi Ecosystem Restoration Program.

A Record of Decision for construction is not being requested for these Comprehensive Plan components, but their potential environmental effects are presented as reasonably foreseeable actions for the consideration of cumulative effects. The environmental effects of the Additional Damage Reduction Alternatives and Coastal Mississippi Ecosystem Restoration Program are presented in this section. The Environmental effects of the HARP are presented separately in Section 4.2.

The environmental effects analysis is conducted on three different levels, which provide various details based on the information available. A more qualitative analysis is conducted for those components of the Comprehensive Plan that require Advanced Study and Design for further project development. Two projects are being recommended for Advanced Engineering and Design and an environmental analysis is conducted using the most information that is available. Supplemental environmental documentation will be prepared for the barrier islands effort and will provide a greater level of detail at that time.

As a result of the diversity of potential projects that have come forth as a part of the Comprehensive Plan, further environmental considerations and analyses will be required prior to projects being implemented. There could be supplemental environmental impact statements to evaluate projects that would result in significant impacts and further environmental assessments for projects that are less complex in nature and do not have significant impacts. During development of NEPA documentation, detailed discussions of potential impacts and subsequent mitigation will be incorporated as measures and alternatives are being developed.

Provisions for “tiering” of EISs are found in 40 CFR 1502.20 whenever a broad environmental impact statement has been prepared (such as a program or policy statement) and a subsequent statement or environmental assessment would then be prepared on an action included within the entire program or policy. This EIS will serve as the basis from which further required environmental analyses and documentation could be tiered from.

A third level of detailed analyses has been conducted to determine the impacts associated with projects being recommended for construction. It is expected that no further environmental analysis is required prior to the projects being constructed. The following table depicts potential projects and their analyses.

4.1.1 Comprehensive Plan - No Action Alternative

Hurricanes are a way of life along the Mississippi Gulf coast region. From 1715 to 1985, approximately forty hurricanes struck the Gulf Coast region stretching from Texas to the Florida Keys. Though differing in size, strength and intensity, those hurricanes greatly affected the environment and its inhabitants on the Gulf of Mexico. The hurricane season of 2005 was the most devastating in recent times, when Hurricane Katrina struck.

Unfortunately, coastal lands are typically places where higher population densities are concentrated. Typically, there is a higher influx of population than that leaving the coastal areas. In fact, many of these residents have only recently settled this vital coastal environment. Thus, developmental

pressures are typically found in coastal environments, which was also true of coastal Mississippi. Wet pine savannah and emergent tidal marsh habitats were increasingly having development encroach upon them in Mississippi; thus, causing unnatural stresses upon those vital environmental features. Bulkheads, such as those at Belle Fontaine, and other man-made navigational features along the Mississippi coast were actually altering natural littoral drift systems along the only natural Mississippi beach. Such stresses like these on this thin vital coastal environment were affecting the area and when Hurricane Katrina made landfall it just accelerated environmental degradation. In mere hours, some 100 square miles of marshes along the Gulf coast were converted into open water as a consequence of erosion during storm surges.

Following the hurricane season of 2005, those already stressed environmental habitats are now experiencing even more accelerated degradation. Prior to the hurricane season of 2005, the barrier islands had been adversely impacted by numerous continual storms and hurricanes - without a period of time for recovery. These coastal systems provide an array of habitats – coastal maritime forests, beaches/dunes, and emergent tidal marshes – for various fish and wildlife and also important migratory birds. These islands are also essential habitats for some T&E species, such as piping plover and sea turtles. In addition, they create the fertile Mississippi Sound that is one of the most productive fishery grounds in the world. Implementation of the No Action plan would result in the continual erosion of the barrier islands; thus, increasing Mississippi Sound's salinity and eventually losing the Sound all together.

Undesirable exotic species, such as Chinese Tallow and Phragmites, are provided an excellent opportunity to out-compete native species by the newly opened spaces in habitats, such as wet pine savannah and emergent marsh habitats. These exotic species out-compete native, more productive flora and eventually become the primary, if not the only species, found in these vital habitats. These exotic species do not provide the sources of food benefiting Mississippi Flyway's migratory birds and associated wildlife as those native species do. Without intervention, coastal areas in Mississippi, such as wet pine savannahs, beaches and dunes, coastal maritime forests, and emergent tidal marsh habitats, would continue accelerated degradation. Without project - the No Action plan – for future development scenarios are provided in Table 4-1.

Table 4-1
Overview of Future Scenarios

Future Scenario	Redevelopment Type	Relative Sea Level Rise	Description
Future Scenario 1	Residential	None	Rebuild structures as existed pre-Hurricane Katrina with no relative sea level rise over the period of analysis. This future scenario applies to all three planning units (counties).
Future Scenario 2	Mixed Residential & Commercial	None	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, no relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.
Future Scenario 3	Residential	Expected	Rebuild structures as existed pre-Hurricane Katrina with up to 2.4-feet relative sea level rise over the 100-year period of analysis. This future scenario applies to all three planning units.
Future Scenario 4	Mixed Residential & Commercial	Expected	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, an up to 2.4-feet relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.
Future Scenario 5	Residential	High	Rebuild structures as existed pre-Hurricane Katrina with up to 3.4-feet of relative sea level rise over the period of analysis. This future scenario applies to all three planning units.
Future Scenario 6	Mixed Residential & Commercial	High	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, up to 3.4-feet of relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.

Future Scenarios One and Two are included only to evaluate the effects of relative sea level rise. These Future scenarios will not be used in the evaluation of potential measures. Futures Three, Four, Five, and Six will be the future scenarios by which potential measures will be evaluated depending on the planning unit.

4.1.2 Comprehensive Plan Description

The MsCIP Comprehensive Plan presents a very complex challenge to identify Mississippi coast recovery plans. The investigation was focused on 3 components – environmental, non-structural and structural plans – to achieve an array of protection and restoration measures. While developing these components, the team ensured that the specific measure or a compilation of measures addressed the 2005 congressional authorization of:

a) future hurricane storm and flood damage reduction;

b) prevention of saltwater intrusion;

c) prevention of coastal erosion;

d) preservation of fish and wildlife; and

e) other water related resources (reduction of flooding).

Ultimately, several hundred measures were identified ranging from restoring the barrier islands at varying levels, raising existing structures' elevation, constructing ring levees around communities, building surge gates across water bodies, restoring dune and beaches, developing housing assistance and relocation programs, and restoring wet pine savannah, emergent tidal marsh, and scrub shrub habitats. These measures were screened throughout the plan formulation process in order to develop alternatives. The comprehensive nature of the MsCIP effort resulted in the ability to implement certain alternatives while others required additional study.

Large structural components of the comprehensive plan, such as surge gate barriers and ring levees, were evaluated; however, additional details and further study will be required prior to making a determination of their feasibility as effective measures to reduce damages from future hurricane and storm surge events. Additionally, smaller viable alternatives, such as smaller ring levees, have the potential of providing cost effective solutions. Several options being recommended for future study include environmental restoration of barrier islands for increased biodiversity within existing habitats. Potential projects being considered include marsh restoration, re-planting of maritime forests, and large scale beach/dune and seagrass restoration projects. Other structural options that are being considered include elevated roadways across the mainland shoreline, interior drainage projects, and construction of a continuous levee crossing the mainland near the shoreline and surge barriers crossing Bay of St. Louis and Biloxi Bay. Various smaller levees around various coastal communities and cities that include Belle Fontaine, Gulf Park Estates, Pascagoula and Moss Point, Pearlington, Gautier, Ocean Springs, and Bay St. Louis are being considered. Projects for reduction of saltwater intrusion are being considered that would consist of freshwater diversion within the eastern portion of coastal Mississippi in the Grand Bay Savannah and Wetland and the western portion of the state in conjunction with a recently authorized project near Violet, Louisiana. Various non-structural projects are being considered that include relocations of residences, businesses, communities, municipal buildings, etc. Additional non-structural options include flood-proofing structures within communities, educational programs and evacuation planning. These measures will be evaluated further and developed into cost-effective solutions in coordination with Federal, State, and local governments as well as interested members of the public.

4.1.3 Comprehensive Plan Soils Impact

Alteration of soils would occur under levee footprints and within environmental restoration projects; however, in some instances, old fill material would be removed for reestablishment of more native types soils generally found in the natural system. In cases where fill material for levee construction is obtained onsite, impacts to soils could be significant. Further environmental studies during project development and implementation of measures will determine specific impacts.

4.1.4 Comprehensive Plan Sediments Impact

Re-suspension of sediments would likely occur within specific project sites. Containment structures, silt curtains, and other Best Management Practices (BMP) would be used to contain sediment deposition at construction and environmental restoration sites in order to minimize adverse impacts during construction activities. Projects that are located within or adjacent to Mississippi Sound might cause sediments to remain suspended in the water column; however, it is anticipated they would eventually settle out or migrate via littoral drift. The use of BMPs should ensure any impacts that might occur would be isolated to each construction site, minor and of short duration.

4.1.5 Comprehensive Plan Geology Impact

No geological changes are anticipated to occur by implementation of these type projects. Potential projects have been or would be designed to avoid impacts to current geological formations.

4.1.6 Comprehensive Plan Climate Impact

There should be no effects to the existing climate.

4.1.7 Comprehensive Plan Air Quality Impact

Currently all areas within coastal Mississippi are in attainment with the National Ambient Air Quality Standards (NAAQS). Air quality in the immediate vicinity of project construction would be slightly affected for a period of time by the fuel combustion and resulting engine exhausts. The standards would not be violated by the implementation of the proposed project.

4.1.8 Comprehensive Plan Noise Impact

Noise from construction type equipment is expected to increase during the proposed operations in project vicinities. Noise levels will resume to existing conditions as construction activities are completed. It is anticipated there would be no significant impacts to noise levels during implementation of these measures.

4.1.9 Comprehensive Plan Vegetation Impact

Vegetation within coastal Mississippi would be altered as projects are constructed as a result of implementing components of the Comprehensive Plan. Measures were developed to address congressional authorization of storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife habitats, and prevention of coastal erosion. Restoration of the barrier islands would provide a benefit to vegetation. Generally, removal of existing vegetation would occur under footprints of structures or within restoration sites. Exotic and invasive species would be removed as applicable and replaced with native vegetation. Re-vegetation of damaged habitats would be part of the overall environmental effort. Further studies during project development would determine specific impacts to vegetation.

Restoration at the barrier islands would consist of shaping existing sand into dunes on the beaches. Dune features would be planted with native vegetation on the barrier islands and along the mainland shoreline. Planting of marshes, maritime forests, and seagrasses in the nearshore areas of the islands and mainland would serve to restore or enhance lost habitat. Implementation of this measure would provide significant benefits to the existing damaged vegetation. Many marine species depend on seagrass beds for foraging opportunities and cover. Restoration of this vital habitat would provide significant benefits to fish and wildlife and their habitats. Diversion of freshwater into Mississippi Sound would possibly alter vegetation species to fresher types. Establishment of a comprehensive program would allow for further education regarding the sustainability of the resource. Further studies during project development would determine the specific benefits and any adverse impacts associated with barrier island restoration.

Impacts to vegetation as a result of LOD 3 implementation should be minor and temporary in nature during construction. The existing beach front roadways are within developed areas and although elevating increases the overall footprint, the area is comprised of predominantly paved surfaces. Repairs and modification to existing seawalls, if necessary, would result in relatively minor alterations as the entire beachfront consists of previously constructed seawalls along the southern edge of existing roadways. Of the approximately 85 miles of LOD 3, it is believed about 15.7 acres of coastal wetland vegetation, which includes some open-water habitats, would be lost.

Construction of ring levees around communities or cities would result in changes to existing vegetation. Impacts could be avoided or minimized by alternate alignments and/or elevations resulting in less linear footage of levee constructed and/or less acreage of required footprint. Although native vegetation under the levee footprint would be lost, the levee itself would be vegetated with non-native species for stabilization of the structure. Up to approximately 265 acres of wetland vegetation could be lost based on the initial alignments. Specific losses would be field verified prior to construction and during project development to determine functions of wetlands lost.

The general alignment of the proposed inland barrier, LOD 4, would be along the existing railway that crosses coastal Mississippi. In order to protect much of the developed areas around Biloxi Bay and Bay of St. Louis, the inland barrier would need to cross the mouths of these bays, which would necessitate construction of structural surge barriers. Construction of the inland barrier would permanently alter vegetation within the project footprint. Impacts could be avoided or minimized by alternate alignments or by elevating the structure. Although native vegetation under the levee footprint would be lost, the levee itself would be vegetated with non-native species for stabilization of the structure. Approximately 344 acres of wetland vegetation would be lost based on potential alignments. Specific losses and potential secondary and indirect impacts would need to be field verified prior to construction and during project development to determine the extent of wetland functions lost.

It is anticipated there would be some possible effects to vegetation associated with construction of the surge barriers crossing the mouths of the two bays. Further studies would be needed during project development to determine primary and secondary effects to emergent tidal marsh and SAVs and other estuarine vegetation to determine the full extent of impacts associated with implementation of this measure.

Implementation of the non-structural alternatives may result in alteration to vegetation throughout coastal Mississippi as emergency and critical facilities are relocated and constructed in the northern portions of the counties. As buildings are relocated, however, adverse impacts to vegetation could occur within newly developed areas that are currently more natural undeveloped land located nearby. It is anticipated properties to be purchased as part of a HARP program would be restored to historical conditions, which would actually provide a benefit to vegetation. Future studies during project development would determine specific impacts associated with implementation of these type measures.

4.1.10 Comprehensive Plan Fish and Wildlife Impact

Fish and wildlife would be altered by implementation of potential measures associated with the Comprehensive Plan. Generally, important habitat for fish and wildlife species would be lost and altered as a result of the structure footprints. Fragmentation of habitat would occur as a result of levee and/or surge gate construction. Environmental restoration along the barrier islands and the mainland would result in vital habitat being restored that would benefit species found within coastal Mississippi. Several measures have been developed, which would allow for storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife habitats, and prevention of coastal erosion. Additional study would determine the extent of adverse or beneficial impacts to fish and wildlife resources.

Generally, restoration of barrier islands would entail filling of existing water bottoms to pre-Hurricane Camille conditions, restoring dunes along beaches, and re-planting of native vegetation within the island interiors. The barrier islands currently provide EFH for managed fisheries under the Magnuson Fishery Conservation and Management Act and critical habitats for the Gulf sturgeon and piping plover under ESA. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. It is anticipated additional sand along the shoreline would provide additional opportunities for nesting for sea turtles. Additionally, barrier island restoration would provide

additional over wintering critical habitat for the piping plover. Many other shorebird species use the barrier islands for nesting and foraging while migratory birds use the islands as stopovers and temporary feeding grounds. Filling of water bottoms would remove foraging areas for sea turtles and other marine species, such as the Gulf sturgeon and EFH species. Restoration of seagrasses once prevalent throughout the barrier islands would benefit numerous marine species for foraging opportunities and cover. Establishment of a comprehensive program would provide further educational opportunities as to the importance of this disappearing resource.

The sand would be obtained from an offshore source, St. Bernard Shoals, approximately 45 miles south of the islands. Dredging to obtain the material source will impact epibenthic crustaceans and infaunal polychaetes within the immediate area. However, impacts are primarily short-term in nature and consist of a temporary loss of benthic invertebrate populations in the areas of dredging. Adjacent benthic communities are anticipated to move into the dredged site and begin recolonization. The area is characterized as a relic sand shoal at approximate elevation -60 NGVD 88 and once dredging is complete, will remain similar in character as dredged depths would not exceed an additional 10 feet in depth. Therefore, because similar habitat, in terms of both sediment composition and depth, will be present pre- and post dredging, it is anticipated the benthic biota in the dredging areas will recover and recolonize. Further study during project development would determine the extent of impacts and benefits associated with implementation of this measure.

Existing beachfront roadways present hazards to shorebird species utilizing corridors to and from beach habitat and adjacent upland habitat. Elevating the roadways could pose an increased risk of bird strikes by vehicles; however it also would help sustain beach habitat by preventing sand from migrating into the adjacent roadway. In fact, the roadway could be an indirect benefit to the shorebirds by the hindering northward movement of sand. Modification and repairs to existing seawalls should have minimal impacts to fish and wildlife resources.

Overall, construction of ring levees would result in fragmentation of fish and wildlife habitat, which would limit availability of travel corridors for a variety of wildlife species. This could result in geographic isolation of populations. Continued maintenance of the levee reduces natural habitats that are currently available for numerous wildlife species. Unnatural crossings of water bodies by culverting, etc., reduces in-stream habitat for various life stages of fish. Impacts to wetland crossings remove essential lifecycle requirements for numerous fish and wildlife species. It is anticipated that construction of the levees could result in significant changes to existing hydrology and possibly impact the water table. Subterranean species that use the area would then abandon the habitat as these changes occur. This would result in less habitat available to species. Implementation of this measure would require further study during project development to determine the full extent of impacts to fish and wildlife and their habitat. Various alignments could reduce or avoid impacts to fish and wildlife.

Construction of inland barriers could result in alterations to current runoff and sheet flow drainage patterns resulting in altered hydrology. Overall, construction of the inland barrier would result in fragmentation of fish and wildlife habitat, which would limit availability of travel corridors for a variety of wildlife species. This could result in geographic isolation of populations. Continued maintenance of the levee would reduce natural habitats that are currently available for numerous wildlife species. Unnatural crossings of water bodies by culverting, etc., reduces in-stream habitat for various life stages of fish. Impacts to wetland crossings remove essential lifecycle requirements for numerous fish and wildlife species. It is anticipated that construction of these structures could result in changes to existing hydrology and could impact the water table. Subterranean species that use the area would then abandon the habitat as these changes occur. This would result in less habitat that is available to species. Implementation of this measure would require further study during project development to determine the full extent of impacts to fish and wildlife and their habitat. Various alignments could reduce or avoid impacts to fish and wildlife.

Construction of the surge barriers across bays would alter circulation and flow patterns at the confluence of the bay and Mississippi Sound. Constricting the mouth of the bay would create a bottleneck for any species utilizing the area. Tidal flows would be changed as freshwater input is reduced, which could cause impacts to many species of shellfish. Limiting freshwater inflows into the estuary could result in further saltwater intrusion. EFH would be lost during construction as well as permanent losses to EFH by installation of the structure. Filling of water bottoms by construction of abutments on either end would result in permanent losses to EFH. Installation of the structure would disturb bottom substrate releasing possible contaminants into the water column. There would be impacts to the natural flushing actions that occur within existing tidal marshes. Implementation of this measure would require further study during project development to determine the full extent of impacts to fish and wildlife and their habitat.

Overall, implementation of non-structural measures would have minimal impacts to fish and wildlife; however, as properties would be bought out and existing development relocated, additional impacts to fish and wildlife and their habitat would be felt in other area. Existing habitats that could be affected by implementation of this measure currently remain intact. They are in rural areas and predominantly natural. The main threat that exists today is by increased development and this planning guide would heighten this threat. Valuable habitat could be lost, which could result in losses to the species themselves. Additionally, as development occurs within this natural habitat, potential conflict between wildlife and human population increases. Although impacts to valuable habitat in the existing rural areas would occur, the bought out properties would be restored back to its natural condition resulting in a benefit to fish and wildlife. However, it is anticipated that secondary development in the newly relocated areas could offset benefits gained by restoration of the bought out property.

Environmental restoration is expected to result in a benefit to fish and wildlife resources. Overall, environmental restoration projects would help to correct problems within the natural system, such as restoration of historical wetlands that have been filled during prior development and introduction of freshwater into areas suffering from saltwater intrusion. It is important to establish a program to investigate all impacts associated with such actions to ensure no further degradation would occur to other habitats and resources, such as impacts to SAVs by the introduction of freshwater into a saline environment. Further study would be needed during specific project development.

4.1.11 Comprehensive Plan Threatened and Endangered Species Impact

Close coordination with resource agencies has allowed for better planning and development of alternatives in order to further avoid potential significant impacts to listed species. A more detailed assessment of these T&E species issues can be found in the Environmental Appendix. Adverse impacts to T&E species were part of an initial screening process used during early planning. Further consultation with appropriate resource agencies would occur during future project development and subsequent biological opinions are anticipated to be issued prior to construction activities.

Restoration of the barrier islands would benefit piping plover and its critical habitat by the increased amount of over wintering foraging areas. Temporary impacts could occur during construction but could be avoided during the times the piping plover are on the over wintering grounds. Brown pelicans could utilize the project areas; however, it is anticipated these species would avoid the construction area due to noise and activity. This species nests mostly on offshore islands, but has been known to nest in onshore estuaries; however, based on surveys by FWS biologist, there is no known nesting in Mississippi. Should nesting brown pelicans be discovered, the area would be avoided to ensure no impacts occur. Manatees, Gulf sturgeon and sea turtles could be in the project area and there is potential for adverse impacts to occur. It is anticipated these species would primarily avoid the construction areas due to noise and activity resulting in less risk for harm or harassment. Methods of dredging would be utilized to avoid adverse impacts to listed species. Placement activities would be accomplished using appropriate BMPs to reduce turbidity and other

potential adverse impacts to species and its critical habitat. Further consultation would be required to determine adverse impacts to critical habitat for the Gulf sturgeon. It is anticipated whale species would avoid the project area during construction activities due to noise and activity and no collisions should occur.

Elevated Roadways

Elevating existing beachfront roads throughout coastal Mississippi for use as structural barriers or in combination with an associated seawall defines a portion of LOD 3. These structures would be the first hard engineered structure that would not be affected by erosion from storm events. There is potential for the brown pelican and piping plover to be present within the project area; however, these species should avoid the area during construction activities due to noise and equipment activity. It is anticipated minimal impacts would occur during construction. Once the project is completed, the elevated roadways would present hazards to shorebird species utilizing corridors to and from beach habitat and adjacent upland habitat. Elevated roadways could pose an increased risk of bird strikes by vehicles.

Seawalls

There is potential for the brown pelican and piping plover to be present within the project area; however, these species should avoid the area during construction activities due to noise and activity. It is anticipated minimal impacts would occur during construction.

Ring Levees

Pearlington

Louisiana quillwort is known to be present within the project area and can be found in flowing streams or other wet habitats. Surveys would be conducted during project development to determine its presence. Alternate levee alignments could reduce or avoid impacts to Louisiana quillwort; however, should it be present within the levee alignment, further consultation would be required and adverse impacts could occur. Louisiana black bears and gopher tortoises could be present within the project area. The Louisiana black bear is a transient species within the area and should avoid the project area during construction activities due to noise and activity. There is a potential for gopher tortoises to be found within the immediate vicinity uplands. Surveys could be conducted to determine the presence of gopher tortoises or burrows. If evidence of gopher tortoises is found to be within the project area, further consultation would be required. Relocation of gopher tortoises may be necessary. Alternate levee alignments could reduce adverse impacts to listed species. Further study during project development would determine the full extent of adverse impacts to species.

Bay St. Louis

Louisiana quillwort is known to be present within the project area and can be found in flowing streams or other wet habitats. Surveys could be conducted during project development to determine its presence. Alternate levee alignments could reduce or avoid impacts to Louisiana quillwort; however, should it be present within the levee alignment, further consultation would be required and adverse impacts could occur. Brown pelicans could be found within the project area; however, it is anticipated the species would avoid the project area during construction activities due to noise and activity. There should be no adverse impacts to the brown pelicans associated with implementation of this measure. Alternate levee alignments could reduce adverse impacts to listed species. Further study during project development would determine the full extent of adverse impacts to species.

Ocean Springs

Louisiana quillwort is known to be present within the project area and can be found in flowing streams or other wet habitats. Surveys could be conducted during project development to determine its presence. Alternate levee alignments could reduce or avoid impacts to Louisiana quillwort; however, should it be present within the levee alignment, further consultation would be required and adverse impacts could occur. Brown pelicans could be found within the project area; however, it is

anticipated the species would avoid the project area during construction activities due to noise and activity. There should be no adverse impacts to the brown pelicans associated with implementation of this measure. Alternate levee alignments could reduce adverse impacts to listed species. Further study during project development would determine the full extent of adverse impacts to species.

Gulf Park Estates

Louisiana quillwort is known to be present within the project area and can be found in flowing streams or other wet habitats. Surveys could be conducted during project development to determine its presence. Alternate levee alignments could reduce or avoid impacts to Louisiana quillwort; however, should it be present within the levee alignment, further consultation would be required and adverse impacts could occur. Brown pelicans could be found within the project area; however, it is anticipated the species would avoid the project area during construction activities due to noise and activity. There should be no adverse impacts to the brown pelicans associated with implementation of this measure. Alternate levee alignments could reduce adverse impacts to listed species. Further study during project development would determine the full extent of adverse impacts to species.

Belle Fontaine

Louisiana quillwort is known to be present within the project area and can be found in flowing streams or other wet habitats. Surveys could be conducted during project development to determine its presence. Alternate levee alignments could reduce or avoid impacts to Louisiana quillwort; however, should it be present within the levee alignment, further consultation would be required and adverse impacts could occur. Brown pelicans could be found within the project area; however, it is anticipated the species would avoid the project area during construction activities due to noise and activity. There should be no adverse impacts to the brown pelicans associated with implementation of this measure. Alternate levee alignments could reduce adverse impacts to listed species. Further study during project development would determine the full extent of adverse impacts to species.

Gautier

Louisiana quillwort is known to be present within the project area and can be found in flowing streams or other wet habitats. Surveys could be conducted during project development to determine its presence. Alternate levee alignments could reduce or avoid impacts to Louisiana quillwort; however, should it be present within the levee alignment, further consultation would be required and adverse impacts could occur. Brown pelicans could be found within the project area; however, it is anticipated the species would avoid the project area during construction activities due to noise and activity. There should be no adverse impacts to the brown pelicans associated with implementation of this measure. The Mississippi Sandhill crane could be found within the project vicinity; however, it is anticipated the species would avoid the area during project construction due to noise and activity. Alternate levee alignments could reduce adverse impacts to listed species. Further study during project development would determine the full extent of adverse impacts to species.

Pascagoula

Louisiana quillwort is known to be present within the project area and can be found in flowing streams or other wet habitats. Surveys could be conducted during project development to determine its presence. Alternate levee alignments could reduce or avoid impacts to Louisiana quillwort; however, should it be present within the levee alignment, further consultation would be required and adverse impacts could occur. Louisiana black bears and gopher tortoises could be present within the project area. The Louisiana black bear is a transient species within the area and should avoid the project area during construction activities due to noise and activity. There is a potential for gopher tortoises to be found within the immediate vicinity uplands. Surveys could be conducted to determine the presence of gopher tortoises or burrows. If evidence of gopher tortoises is found to be within the project area, further consultation would be required. Relocation of gopher tortoises may be necessary. Brown pelicans and bald eagles could be found within the project area; however, it is anticipated the species would avoid the project area during construction activities due to noise and

activity. There should be no adverse impacts to the brown pelicans associated with implementation of this measure. The Mississippi Sandhill crane could be found within the project vicinity; however, it is anticipated the species would avoid the area during project construction due to noise and activity. Alternate levee alignments could reduce adverse impacts to listed species. Further study during project development would determine the full extent of adverse impacts to species.

The general alignment of the inland barrier would be along the path of the existing railway that crosses the coast of Mississippi. This railway is located atop of a constructed berm. In order to protect much of the developed areas around Biloxi and St. Louis Bays, the inland barrier would need to cross the mouths of these bays, which would necessitate construction of structural surge barriers.

Hancock County Inland Barrier

Louisiana quillwort is known to be present within the project area and can be found in flowing streams or other wet habitats. Surveys could be conducted during project development to determine its presence. Alternate levee alignments could reduce or avoid impacts to Louisiana quillwort; however, should it be present within the levee alignment, further consultation would be required and adverse impacts could occur. Louisiana black bears and gopher tortoises could be present within the project area. The Louisiana black bear is a transient species within the area and should avoid the project area during construction activities due to noise and activity. There is a potential for gopher tortoises to be found within the immediate vicinity uplands. Surveys could be conducted to determine the presence of gopher tortoises or burrows. If evidence of gopher tortoises is found to be within the project area, further consultation would be required. Relocation of gopher tortoises may be necessary. Brown pelicans could be found within the project area; however, it is anticipated the species would avoid the project area during construction activities due to noise and activity. There should be no adverse impacts to the brown pelicans associated with implementation of this measure. Alternate levee alignments could reduce adverse impacts to listed species. Further study during project development would determine the full extent of adverse impacts to species.

Bay of St. Louis Surge Barrier

Gulf sturgeon, manatee, and various sea turtles could be found within the project vicinity. Additionally, brown pelicans could be found within the project vicinity. It is anticipated that adverse impacts during construction is unlikely as the species would avoid the project area due to noise and activity. Further consultation would be necessary during project development to determine the full extent of adverse impacts to species.

Harrison County Inland Barrier

Louisiana quillwort is known to be present within the project area and can be found in flowing streams or other wet habitats. Surveys could be conducted during project development to determine its presence. Alternate levee alignments could reduce or avoid impacts to Louisiana quillwort; however, should it be present within the levee alignment, further consultation would be required and adverse impacts could occur. Brown pelicans could be found within the project area; however, it is anticipated the species would avoid the project area during construction activities due to noise and activity. There should be no adverse impacts to the brown pelicans associated with implementation of this measure. Alternate levee alignments could reduce adverse impacts to listed species. Further study during project development would determine the full extent of adverse impacts to species.

Back Bay of Biloxi Surge Barrier

Gulf sturgeon, manatee, various sea turtles, and brown pelicans could be found within areas considered for surge barrier crossings. It is anticipated that adverse impacts during construction is unlikely as the species would avoid the project area due to noise and activity. The Alabama red-bellied turtle could be found within the project or its immediate vicinity. Implementation of this measure could result in destruction of nesting areas along the banks, feeding areas among SAVs, and result in reduced water quality within the project site. Surveys could determine the presence of

the species and BMPs during construction could reduce adverse impacts to water quality within and around the construction site. Further consultation would be necessary during project development to determine the full extent of adverse impacts to listed species.

Louisiana quillwort is known to be present within the project area and can be found in flowing streams or other wet habitats. Surveys could be conducted during project development to determine its presence. Alternate levee alignments could reduce or avoid impacts to Louisiana quillwort; however, should it be present within the levee alignment, further consultation would be required and adverse impacts could occur. Louisiana black bears and gopher tortoises could be present within the project area. The Louisiana black bear is a transient species within the area and should avoid the project area during construction activities due to noise and activity. There is a potential for gopher tortoises to be found within the immediate vicinity uplands. Surveys could be conducted to determine the presence of gopher tortoises or burrows. If evidence of gopher tortoises is found to be within the project area, further consultation would be required. Relocation of gopher tortoises may be necessary. Brown pelicans could be found within the project area; however, it is anticipated the species would avoid the project area during construction activities due to noise and activity. There should be no adverse impacts to the brown pelicans associated with implementation of this measure. The Mississippi Sandhill crane could be found within the project vicinity; however, it is anticipated the species would avoid the area during project construction due to noise and activity. Alternate levee alignments could reduce adverse impacts to listed species. Further consultation would occur to determine potential impacts to listed species. Biological Assessments of particular project components would determine the extent of impacts under future programmatic consultations.

Overall, implementation of non-structural and environmental restoration measures would provide benefits while having minimal impacts to listed species during construction activities. It is anticipated that purchasing of property would require relocation and possibly further development of rural properties. This could result in additional impacts to listed species and their habitat. An example of concern would be the gopher tortoise and Louisiana quillwort. Existing habitats that could be affected by implementation of this measure currently remain intact. They are in rural areas and predominantly natural. The main threat that exists today is by increased development resulting in valuable habitat losses, which could result in losses to the species themselves. Additionally, as development occurs within this natural habitat, potential conflict between wildlife and human population increases. Although development of valuable habitat in the existing rural areas would occur, the bought out properties would be restored back to its natural condition resulting in a benefit to fish and wildlife. However, it is anticipated that secondary development in the newly relocated areas could offset the benefits gained by restoration of the bought out property. It would be necessary to conduct surveys to determine the presence of listed species prior to construction during project development. Programmatic consultation would address impacts to listed species in association with implementation of this measure.

4.1.12 Comprehensive Plan Water Quality Impact

Water quality within coastal Mississippi being evaluated as part of their ongoing program and monitoring data are compared to the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* in order to make decisions on whether a water body is supporting or not supporting its designated uses, such as aquatic life support, water contact recreation, fish/shellfish consumption, and drinking water. A more detailed assessment pertaining to water quality issues in coastal Mississippi can be found in the Environmental Appendix. There are specific problems in certain water bodies throughout the study area; however, many are isolated, associated with certain conditions due to industrial discharge, historical problems, and increased run-off in conjunction with development.

Restoration of the barrier islands would require a large amount of high quality sand being placed on or around the sandy string of barrier islands. Overall, this should not cause significant impacts to

existing water quality within Mississippi Sound. Restoration of the barrier islands would actually ensure estuarine conditions within Mississippi Sound remain. This is essential for the continual existence of Mississippi Sound and its vital importance (i.e. productive estuarine fishery ground). The sand found at St. Bernard Shoals is of a quality similar to what is found in the present day Mississippi barrier islands and sufficient quantity to meet the need. There should be no problems associated with turbidity at the borrow site in association with the dredging. The sandy material should pose no turbidity problems during placement activities as sand settles quickly. BMPs would be utilized in order to decrease any impacts associated with water quality. It is expected no impacts to water quality would result from implementation of this measure.

Environmental restoration and construction of a dune feature on islands and mainland beaches would provide indirect positive impacts to water quality due to increased functions of wetlands and marshes on the islands (i.e. continual existence). It is anticipated there would be a benefit to water quality as a result of this measure. Although there may be a slight increase in turbidity during construction, it is anticipated this would be localized and short in duration. Improved water quality within Mississippi Sound would help to establish sea grasses.

Elevating existing beachfront roads throughout coastal Mississippi for use as structural barriers or in combination with an associated seawall defines a portion of the LOD 3. These structures would be the first hard engineered structure that would not be affected by erosion from storm events. Prevention of coastal erosion would result in positive impacts to overall water quality. Modification and necessary repairs to existing seawalls would result in positive benefits in overall water quality by prevention of coastal erosion. The use of BMPs would ensure stabilization of bare soils during construction of ring levees. Interior drainage would be accomplished by the removal of stored water through culverted crossings of small water bodies and by the use of pump stations where necessary. BMPs would be utilized during all construction activities and no run-off material would be allowed to enter adjacent waters. It is anticipated there would be no significant impacts to water quality as a result of implementation of this measure. Environmental restoration of properties purchased as part of non-structural implementation would result in positive impacts to water quality as lost wetland functions would be replaced.

4.1.13 Comprehensive Plan Water Supply Impact

There should be no effect on water supply. Potential projects have been or would be designed to avoid impacts to existing public water supply infra-structure and operating facilities.

4.1.14 Comprehensive Plan Socio-Economic Impact

The socio-economic impacts that result from the MsCIP Comprehensive Plan are several fold and have been fully discussed and evaluated in the Economic Appendix. They include impacts to populations, sales-volume, income, and employment as represented in Table 4-2. Recognizing that the Comprehensive Plan for coastal Mississippi has multiple tiers of features, project impacts to socio-economics are as follows: for all of the recommended projects, except for the HARP, positive RED benefits would be anticipated and include sales, income, and employment. For the HARP, all of the four above RED benefits would possibly be impacted; however, further NEPA documentation woul be required before construction of this project. For the ecosystem restoration and ring levee areas in Pearlington, Bay St. Louis, Ocean Springs, Gautier, Gulf Park Estates, Belle Fontaine, and Pascagoula/Moss Point, which are being recommended for further study, further data collection and coordination through the NEPA and the Corps evaluation processes would need to be conducted, and socio-economic impacts would be addressed and evaluated in much greater detail at that time.

4.1.15 Comprehensive Plan Land Use Impact

Over the last several decades, coastal Mississippi has experienced large development and, as a result, the environmental landscape has undergone significant changes. High-density urban land in coastal Mississippi has increased twice as much as the population has between 1992 and 2000. Impervious surfaces have increased about 50 percent more than developed land but less than population. Hurricane Katrina devastated coastal Mississippi, which could result in potential changes in land uses. Rebuilding is currently underway at moderate levels. Potential components of the Comprehensive Plan could dramatically alter current land uses.

Barrier Island Restoration

Alteration of land use is expected due to the change from filling in of water bottoms being converted to sandy barrier islands resulting in expanded acreage. It is anticipated this change in land use would be insignificant as the islands would be expanded to historical sizes and the relative size of the project to the surrounding land use. Environmental restoration and construction of a dune feature would provide a benefit to current land use as restoration would provide enhancement to the existing environment. Restoration of sea grasses would result in an enhancement of the water bottoms and existing seagrass beds as a result of implementation of this measure. The project would result in a positive benefit to land use.

Table 4-2
Summaries of Benefits and Costs for Measures Recommended for Implementation

	Expected Annual Damages Reduced Future [1] (Annual $)	Recreation (Annual $)	Environmental Impacts	Changes in Sales Volume ($)	Changes in Income ($)	Changes in Employment	Total First Cost with IDC ($)	Average Annual Cost (Annual $)
Barrier Island Restoration	$18,028,000	$466,000	$43,618,000 Fishery Losses Avoided	$798,984,000	$167,850,000	4,920	$370,439,000	$20,372,000
Beach and Dune Placement	Moderate Reduction	N/A	736 Functional Habitat Index (FHI) Score	$33,413,200	$7,307,000	208	$15,890,800	$854,000
Acquisition in High Risk Areas	$22,000,000 to $33,000,000	Potential Recreational Opportunities	Potential Restoration Opportunities	$3,238,602,000	$706,330,000	19,452	$447,274,000	$18,532,000
Forrest Heights 21-FT Ring Levee	$89,000	N/A	3.6 Acres Impacted	$30,425,000	$6,440,000	193	$11,652,000	$740,000
Admiral Island Ecosystem Rest.	Increased Surge Storage	N/A	60 Average Annual Functional Units (AAFU)	$49,750,000	$ 11,996,000	301	$24,320,000	$1,364,000
Turkey Creek Ecosystem Rest.	Increased Surge Storage	N/A	1,565 Average Annual Functional Units (AAFU)	$15,237,000	$3,226,000	97	$6,017,000	$370,000
Bayou Cumbest Ecosystem Rest.	Increased Surge Storage	N/A	188 Average Annual Functional Units (AAFU)	$54,073,000	$ 10,546,000	306	$23,870,000	$1,396,000
Dantzler Ecosystem Rest.	Increased Surge Storage	N/A	1,244 Average Annual Functional Units (AAFU)	$ 5,054,000	$ 986,000	29	$1,922,000	$129,000
Franklin Creek Ecosystem	Increased Surge Storage	N/A	516 Average Annual Functional Units (AAFU)	$3,890,000	$ 759,000	22	$1,670,000	$101,000

1/ Average annual damages reduced and costs are based on a 50-year period of analysis and an FY 08 discount rate of 4.875-percent. Dollar values are rounded to the nearest thousand

Notes: A) These measures were analyzed for economic benefits and do not represent all of the tentatively selected plans for implementation. See discussions of individual alternatives for more detail.

B) Implementation costs are based on an FY 08 price level and do not include escalation. See the cost appendix for more details on the costs.

Elevated Roadways and Seawalls

There should be no significant changes to current land use as the potential measure would modify existing beachfront roadways. The existing roadways are within developed areas and impacts from expanding the footprint to gain in elevation should be minimal due to the highly developed nature of the site. Within Hancock County, existing crossings of marsh areas create opportunities for expansion of existing bridged areas, which would result in more natural conditions. This would result in slight changes to existing land use as old fill material could be removed resulting in enhanced natural marsh systems. Within Harrison County, it is expected current land use would remain unchanged as the project site is currently comprised of a 4-lane U.S. Highway throughout the length of the beachfront. No significant impacts to current land use are anticipated. Modification to existing seawalls, if necessary, would not result in changes to current land use as the entire beachfront consists of previously constructed seawalls along the southern edge of existing roadways.

Ring Levees

Implementation of this measure could result in changes in land use under the footprint and outside the levee construction. Impacts could be avoided or minimized by alternate alignments resulting in less linear footage of levee constructed. There could be impacts to developed areas, such as established residential neighborhoods, as well as more natural areas, such as drainage ways and wetlands. Current land use within the boundary of the ring levee could remain the same or potentially improve. Construction of the ring levee would provide additional protection for citizens and would allow the community to rebuild inside the ring levee rather than relocate. Further studies during project development would determine the full extent of impacts associated with this measure.

Inland Barriers

The inland barrier would involve construction of a continuous levee aligned atop the existing elevated railroad berm. Changes in land use would occur in areas where the proposed levee would align over existing neighborhoods, which may result in fracture of communities; however, much of the residential areas within this portion of coastal Mississippi experienced catastrophic destruction resulting from the storm surge associate with Hurricane Katrina and remain in a state of disrepair. Construction of this measure would allow neighborhoods to safely rebuild landward of the levee which would help repair existing devastated neighborhoods. Further studies prior to project development and design would determine the extent of damage to current land use.

Surge Barriers

Construction of surge barriers would require the direct filling and construction of surge gates on water bottoms across the Bay of St. Louis and Biloxi Bay. This would result in losses to productive water bottoms. This measure would have adverse impacts to current land use. Further studies prior to project development and design would determine the extent of damage to current land use.

Non-Structural

The non-structural approach takes into account existing conditions within different areas of coastal Mississippi. The measure recommended within an area is very site specific based on existing conditions, objectives of the non-structural approach, and expectant public benefits. Elevation of buildings would result in a benefit to current land use by increased elevations above flood levels as appropriate. Flood-proofing measures would not have a significant impact to current land use as the projects would occur on existing structures. Potential purchases of properties could have a significant impact to current land use as large areas would be purchased and existing residential or businesses would be relocated elsewhere outside of high hazard areas. Implementation of this measure could result in fractured communities, relocation of central areas that hold public sentiment, etc. Further consideration is warranted in conjunction with development of this program, in order to identify specific impacts to each small intricate part of larger communities. Although the measure

would provide these benefits, there would be adverse impacts associated with relocation construction and secondary development. Further studies would determine the extent of impacts and benefits to current land use.

Environmental restoration

The environmental restoration approach identifies problems within the natural system and recommends several measures that could be implemented based on existing conditions and objectives. Restoration of historical wetlands could cause a significant impact to current land use by the purchase of areas that have been developed. Impacts could involve relocation of neighborhoods, businesses, etc., which could impact the overall character of small nuances within communities. Positive impacts would include restoration of primary land use that once existed naturally prior to development. Freshwater diversion projects would enhance existing degraded estuarine habitats by introduction of freshwater into areas suffering from saltwater intrusion. This would provide a benefit to current land use. Further studies would warrant specific impacts as potential projects are being developed.

4.1.16 Comprehensive Plan Aesthetic Resources Impact

As projects would be constructed, aesthetics would be temporarily reduced in the immediate vicinity of the proposed project sites. Many recreational vessels utilize Mississippi Sound within the project vicinities and it is believed some residents and visitors may be disturbed by the presence of required heavy equipment during any construction phases. However, construction activities would be temporary in nature so the disturbance would be anticipated to be minimal at each potential project site. There could be times when numerous projects throughout coastal Mississippi would be occurring at once or potential project phases could be scheduled upon completion of requisite projects which would take extended amounts of time. The completed projects should provide residents and visitors with an overall more aesthetically pleasing view as projects are completed. Environmental restoration projects would provide additional fish and wildlife habitat to numerous shore birds and various wildlife species which would enhance coastal Mississippi and its diverse aquatic habitats while providing future sustainability of the natural system.

4.1.17 Comprehensive Plan Cultural Resources Impact

Cultural building and site assessments began almost immediately after the storm in early September 2005. The NPS and the Mississippi Department of Archives and History have led efforts in damage assessments to cultural properties and still have much work ahead of them. Additionally, the Mississippi Heritage Trust, and the National Trust for Historic Preservation have been working closely with assessment teams. The National Center for Preservation Training and Technology (NCPTT), a branch of the NPS, developed a series of checklists designed to be used by Federal Emergency Management Agency (FEMA) volunteers and professional preservationists to compile uniform data on the post-storm condition of cultural properties. The checklists, known as a “Rapid Building and Site Condition Assessment” and a “Detailed Building and Site Condition Assessment” incorporate information including the property description, potential safety hazards that would prevent someone from getting near the property, basic evaluations of structural integrity or the presence of exposed archaeological material, recommendations, and graphs for a field sketch of the site. These forms made it possible for a task force to gather enough data to create an initial status report for Hancock, Harrison, and Jackson counties as well as several other counties to the north. Although the report released by the NPS Task Force is general in nature, the extreme extent of the damage recorded is readily noticeable (Table 4-3). Most efforts have been directed at studying the architectural rather than archaeological resources, but the amount of damage suffered by both types is staggering. The efforts documented in Table 4-3 below are some of the earliest accounts, and much more work remains to be done to fully account for and assess the damage sustained to Mississippi’s coastal cultural properties.

Table 4-3
General Cultural Property Assessment for the Mississippi Coast

STATE OF MISSISSIPPI	INSTITUTION OR SITE	STATUS
Hancock County		
Bay St. Louis	Multiple properties	Two of 5 National Register Districts destroyed. 90% of remaining properties that were assessed are judged salvageable.
Harrison County		
Biloxi	Beauvoir, The Jefferson Davis Home and Presidential Library	Home: Aerial photo shows holes torn in slate roof and galleries (porches) missing. Library: Built to withstand category 5 hurricane; first floor washed out by storm surge. Portraits salvaged after event additional recovery of artifacts begun. Archeologist assisting in recovering artifacts from debris scattered over 60-acre site. Historic library pavilion, Hayes cottage, Soldier's Home Barracks replica, Confederate Soldier's Museum, Gift shop, and director's home destroyed. Replicas of destroyed buildings will be built after restoration of Beauvoir and Presidential Library. Sewage contamination to pond behind Beauvoir to be addressed (as of 11/14).
Biloxi	Breilmaier House (c. 1895)	Destroyed.
Biloxi	Biloxi Cemetery	Many trees uprooted; markers broken.
Biloxi	Dantzler House	Destroyed.
Biloxi	Maritime and Seafood Industry Museum	A portion of the building remains. Some artifacts salvaged, including lens from Ship Island lighthouse.
Biloxi	Ohr-O'Keefe Museum of Art	Aerial photo shows two of five buildings in new museum complex left (JLH). Pleasant Reed House destroyed (DP).
Biloxi	Tullis-Toledano Manor	Aerial photo shows Tullis-Toledano House (c. 1860) destroyed (under the displaced casino barge); Tullis Slave Quarters (c. 1860) destroyed; Crawford House (c. 1850) destroyed
East Ship Island	Gulf Islands National Seashore, French Warehouse and associated cemetery, Quarantine Station	Quarantine Station site submerged, under 5-6 feet of water; French Warehouse site and cemetery sustained damage but are accessible.
Jackson County		
Ocean Springs	Gulf Coast Research Laboratory	Coast Guard permitted access to collections on 9/15/05. Collections flooded. NPS Incident Management Team assisting with recovery of herbarium and hazardous tree and debris removal.
Ocean Springs	Gulf Islands National Seashore	Storm surge flooded exhibits and museum collections at Davis Bayou Visitor Center. Museum Emergency Response Team is stabilizing collections. Collections moved to NPS Southeast Archeological Center and Timucuan Ecological and Historic Preserve. Frozen archives to be shipped and treated off-site. See report for Gulf Coast Research Laboratory where some park herbarium specimens are stored.
Ocean Springs	Shearwater	Most of the work of Anderson Family potters destroyed;

STATE OF MISSISSIPPI	INSTITUTION OR SITE	STATUS
		12 of 15 buildings destroyed
West Ship Island	Gulf Islands National Seashore Ft. Massachusetts; reconstructed Ship Island Lighthouse	Storm surge flooded and damaged fort: earthen berm damaged, large granite blocks dislodged and in moat, interior filled with mud and debris several inches thick. Most of the mud removed by 10/13/05. Extent of damage to Rodman cannon, artifacts and exhibits unknown. Conservator visit scheduled. Reconstructed lighthouse destroyed. Archeologist surveyed 9/19. Parts of the fort's rampart were breached by storm surge. Domed surface of casements exposed when earthen berm removed by storm. Sally Port damaged, extensive beach erosion. Cannon carriage flooded by salt water, but not cannon. Brick foundation and scattered brick, probably associated with archeological remains of lighthouse, identified.

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4.1.17.1 Expected Impacts to Resources

Once a full assessment of damage is complete, we can expect to see the destructive impacts to cultural properties caused by Hurricane Katrina to fall under two categories: direct and indirect. Direct impacts should include damage directly caused during the storm by surging water, wind and flying debris, while indirect impacts would be those caused largely by the effects of standing water, exposure to the elements, or mold and decay due to water saturation. These impacts will differ slightly between archaeological and architectural resources.

4.1.17.2 Direct Impacts

Properties directly in the path of the storm surge appear to have suffered the most damage. Many of the historic homes and mansions that lined the shoreline highways were completely demolished. Some of the more well known historic properties along Beach Boulevard in Biloxi that are now completely gone include the Dantzler House, the Breilmaier House, the Pleasant Reed House, and the Tullis-Toledano mansion.

The Dantzler House lay in splinters behind the bronze statue of Pierre Le Moyne d'Iberville. The Breilmaier House, built in 1895, was reported missing and may have been sighted "floating down the street during the storm" (Williams 2005). The only remaining evidence of the Pleasant Reed House, a shotgun style house built in 1887, is the chimney (ibid). Also, the Tullis-Toledano mansion was found flattened under a casino barge (ibid). Reassuringly, the Beauvoir Mansion, Jefferson Davis's home designated as a National Historic Landmark is substantially damaged, but the main portion of the house remains standing. The first floor of the presidential library is destroyed as well as several cottages on the grounds, but many of the most valuable artifacts were removed prior to Katrina's landfall and survive. Additionally, because of Beauvoir's status as a National Historic Landmark, funds will be set aside eventually for its refurbishment.

Because archaeological sites are unique resources in that they cannot be recreated or restored, the damage many have sustained is irreparable. Several have had huge chunks gouged out by wayward fishing vessels beached on top of the remains of ancient American Indian coastal settlements. Wave scour, and giant uprooted trees have cleared 2,000 year old mounds immediately along the coastline of vegetation and exposed them for further erosion and looting. Shipwrecks that were once buried under several feet of sand have been exposed, and will suffer accelerated degradation as the wooden hull timbers dry into dust. The full extent of the loss is yet to be fully documented, and the work and funding required to salvage any remaining information is yet to be fully estimated.

4.1.17.3 Indirect Impacts

Archaeological resources where most of the resources lie below the ground or on the ground surface can be expected to suffer indirect effects from exposure of materials to sunlight that previously were kept in the dark moist earth. Materials, such as bone, oxidized metal, and organic remains, will dry and become brittle or may disintegrate. Also, the loss of vegetation that once held a site in place and obscured artifacts from view will cause site erosion. Other issues will occur as a result of materials becoming exposed that may be attractive to looters. Alternately, archaeological resources that were close to the shore and located on dry ground before the storm may now be permanently inundated, or in a surf zone and subject to constant erosion by sand and tidal action. Conversely, architectural resources where most of the resource lies above the ground can be expected to suffer from mold and mildew, and the rotting of wood and other materials. Additionally, sunlight and air can access portions of the structure and allow vegetation to take over and cause damage with the roots. Wood and cellulose eating insects will cause a loss of structural integrity and irreversible damage to furnishings that otherwise made it through the storm intact. As with archaeological resources, the threat of theft is present when objects of value are exposed to the outside or left unattended.

Mobile District archaeologists are closely coordinating with the State of Mississippi Department of Archives and History regarding potential impacts associated with potential measures being considered in the Comprehensive Plan. Additionally, FEMA and the Mississippi Development Authority are conducting individual cultural resources analyses in conjunction with their identified projects. Mobile District archaeologists will be given access to other agency's findings and reports and will be informed as additional projects are being analyzed regarding cultural resources. Once specific projects become funded, cultural resources analysis would occur on an individual project basis to ensure compliance.

Many of the current analyses that might be needed could actually be in duplication of what is currently being conducted by other agencies. Ongoing coordination with SHPO and other agency representatives will help to prevent duplication of efforts for cultural resources compliance.

4.1.18 Comprehensive Plan Hazardous, Toxic, and Radioactive Wastes Impact

Quickly after Hurricane Katrina, the EPA working with the National Strike Team and other national search and rescue teams began identification and cleanup of the HHW and other hazardous type debris. The EPA established partnerships with various national and local teams involved with debris cleanup. The Corps team coordinated with them regularly and provided coordinates/locations of HHW and HTRW that were located during vegetative and construction type debris cleanup. The EPA working with others were charged with the responsibility of final cleanup of this type debris after the storm event.

Site inspections would be conducted at and adjacent to the various components of the Comprehensive Plan during development of specific plans and specifications in accordance with the requirements of ER 1165-2-132 entitled, HTRW Guidance for Civil Works Projects, and the American Society of Testing and Materials Standard E 1527. Inspections would be accomplished to determine the presence or evidence of landfills, surface areas unable to support vegetation, visible sheens of petroleum product, nearby contaminated industrial facilities, or any type of visible indication that HTRW concerns exist that may impact any component of the recommended plans during specific project development. Site inspections of adjacent properties, reviews of historic aerial photographs, on site interviews, and environmental database record searches would be conducted to determine any evidence of HTRW concerns that may impact any component of the recommended plans during specific project development.

Based on the findings of the HTRW site assessments, specific or unusual environmental concerns that are identified that could affect construction of any proposed projects would be addressed appropriately. Additional supplemental environmental impacts statements or environmental analyses may be necessary once specific projects have been identified and development of project plans has begun. HTRW issues and concerns would be addressed during the required NEPA compliance and documentation.

4.1.19 Comprehensive Plan Unavoidable Adverse Environmental Effects

Initial screening criteria were established and applied to potential projects based on their technical and environmentally feasibility. This initial screening resulted in certain measures not being considered further, for example, surge gates crossing of Pascagoula and Pearl Rivers and across expanse marshes on the eastern and western boundaries of the state. Additional screening criteria were applied to potential projects which further still eliminated potential projects early on. Additional study would be needed in order to further develop potential projects identified in the Comprehensive Plan and a multi-disciplined project delivery team would analyze alternatives in order to further reduce adverse impacts associated with specific project components. Every reasonable effort will be made to ensure that unavoidable adverse environmental effects that could not be avoided would be temporary and localized, minor and short term in nature, or fully mitigated as necessary to reduce impacts.

4.1.20 Comprehensive Plan Irreversible and Irretrievable Commitments of Resources

The potential for significant irreversible or irretrievable commitments of resources involved in all of the proposed projects have been considered and are unanticipated at this time. Further evaluation will be conducted to determine if any of the proposed plans would present minor impacts in this area.

4.1.21 Comprehensive Plan Environmental Justice Impact

On February 11, 1994, President Clinton issued EO 12898, *Federal Actions to Address Environmental Justice in Minority and Low-Income Populations*. The EO is designed to focus attention of Federal agencies on the human health and environmental conditions in minority communities and low-income communities. Environmental Justice analyses are performed to identify potential disproportionately high and adverse impacts to these communities and to identify alternatives that might mitigate these impacts. EO 12898 requires that Federal agencies conduct their programs, policies, and activities that substantially affect human health or the environment in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under such programs, policies, and activities because of their race, color, or national origin.

On February 11, 1994, the President also issued a memorandum for heads of all departments and agencies, directing that EPA, whenever reviewing environmental effects of proposed actions pursuant to its authority under Section 309 of the CAA, ensure that the involved agency has fully analyzed environmental laws, regulations, and policies.

The MsCIP Comprehensive Plan is not designed to create a benefit for any specific group or individual. Any potential measures would not create disproportionately high or adverse human health or environmental impacts on minority or low-income populations within the study area. Review and evaluation of the overall comprehensive plan have not disclosed the existence of identifiable minority or low-income communities that would be adversely impacted by proposed measures. Further studies during project development would determine specific impacts associated

with implementation of potential measures. The following analysis will serve as a beginning point from which further analyses can be built upon during the comprehensive plan components.

Data from the U.S Department of Commerce, Census of Population and Housing were used for the Environmental Justice analysis. The population in 2005 for Mississippi was 2,908,456. Minority populations included in the census are identified as Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and other Pacific Islander, Hispanic, of two or more races, and other. Mississippi is second to the District of Columbia as having the largest Black or African American population. In 2005, Mississippi ranked number one out of the 50 states for individuals living below the poverty level in the past 12 months. Mississippi had 21.3% of its population living in poverty in 2005.

Coastal Mississippi has a lower percentage of minority residents than the State of Mississippi and the U.S. In 2000 (the most up-to-date data available), 79.6 percent of the population was white and 16.3 percent was black. All other racial groups combined totaled approximately 4.1 percent of the population, while 2.2 percent were of Hispanic origin. In Mississippi, 61.4 percent of the population was white, 36.3 percent was black, 2.3 percent was of another minority racial group, and 1.4 percent was of Hispanic origin. For the U.S., 75.1 percent of the population was white, 12.3 percent was black, and 12.6 percent was of other minority racial groups. Approximately 12.5 percent of the U.S. population was Hispanic.

The Census Bureau bases the poverty status of families and individuals on 48 threshold variables, including income, family size, number of family members under the age of 18 and over the age of 65, and amount spent on food. In 1997, approximately 14.6 percent of the residents were classified as living in poverty, lower than the State of Mississippi but slightly higher than the poverty rate for the U.S. as a whole.

As of 2006, the population in Mississippi was 2,910,540 – of this 135,940 individuals live in Jackson County, 193,810 live in Harrison County, and at this time a population count for Hancock County was not available. Hurricane Katrina drew focus on the number of residents unable to flee the Gulf coast due to lack of funds. There is a longstanding legacy of unfair and disproportionate harmful exposures to low income, predominantly African American communities in much of Mississippi. Predominantly in the Biloxi area but also in other coastal Mississippi communities, there was a large population of Asian Americans that depended upon fishing for their livelihood. Adverse impacts from Hurricane Katrina have resulted in a large number of these individuals leaving the area.

Environmental Justice concerns in coastal Mississippi have arisen from years of industrial activity and waste disposal practices that hit these vulnerable communities harder than higher income, predominantly white communities. Impacted areas, such as superfund facilities, are found more often in low-income areas and therefore are at greater risk to post-Katrina exposure. As clean-up proceeds and rebuilding begins, every effort must be made to remedy these environmental injustice inequities through full clean-up, fair rebuilding practices, and full partnership with affected communities. Over 30,000 families are being helped through Administration on Children and Families Temporary Assistance for Needy Families (TANF) program by the provision of short term, non-recurrent cash benefits to families who traveled to another State from the disaster designated States. The hurricane-damaged States of Mississippi, Louisiana, and Alabama also received additional funding for the TANF program to provide assistance and work opportunities to needy families ($69 million for loan forgiveness and $25 million in contingency funds for State Welfare Programs.) Counties along the Mississippi Gulf coast lost a sizeable share of their white residents and homeowners immediately following Hurricane Katrina, while other Gulf Coast metropolitan areas, especially those that gained residents, experienced little overall shifts in their demographic profiles. Coastal counties of Mississippi, which include Gulfport-Biloxi and Pascagoula metropolitan areas, in contrast to New Orleans, were left with a population that had a larger share of minority residents, a lower level of homeownership, and no significant decline in poverty. In essence, while

the poor and less well-off residents of New Orleans bore the greatest brunt of Katrina, the storm had a more egalitarian effect on the population of coastal Mississippi. Examination of the data for other hurricane impacted areas in the Gulf Coast region reveals that while a great deal of population shifting had occurred, only minor changes have taken place in the race and ethnic, economic and socio-demographic profiles for most of these areas.

Every measure or alternative (e.g., Forrest (Forest) Heights) examined in the MsCIP study was evaluated for its potential for adverse impacts to minority and/or low-income populations, in adherence with EO 12898. In no case was there any identified negative impact to any of these communities in regards to human health and environmental conditions, from any proposed actions or projects. However, because no plans for structural or non-structural protection of residences or businesses have been vetted by community leaders or the public at more than a concept level, it is impossible to say at this time whether or not any of these measures, as ultimately acted on over the long-term, would have a significant effect, either positive or negative, on low-income or minority populations.

In fact, the realities of living in a high hazard area, which grows more hazardous as one approaches the shoreline, will supersede the effect of any plans or projects pursued under any outside authority. The reality is that most low-income populations, some of whom are also minorities, will have a hard time rebuilding in high hazard areas simply due to the cost of homeowners or business insurance, which will be a requirement of the vast majority of lending institutions. In the more than three years since the hurricanes of 2005, the majority of rebuilding has been undertaken by those that can self-insure their homes or businesses, and also can afford to rebuild with their own resources, something the vast majority of the population, in addition, to the low income families cannot do. Therefore, the economic nature of communities along the coast of Mississippi is changing largely due to the economic status of those that can afford to rebuild and insure their properties, versus those that cannot.

And, while some structural measures might protect areas in which low-income residents might rebuild, those measures would only provide damage reduction for surge events, and not wind. The cost of insurance against wind damage, which would continue to be a requirement of lending institutions, may continue to drive the economics of whether one can or cannot afford to rebuild traditional residences or businesses within the highest hazard zones.

Non-structural measures intended for acquisition and removal of the most risky structures would tend to affect all residents or businesses located in those zones, low-income and high-income alike. However, well-armored structures, such as high-rise concrete complexes, would likely be the most survivable structures in highest hazard zones. The income levels required to live in those complexes will also likely drive a change in the socioeconomic and racial mix of residents in these zones. A question remains whether any of the complexes would contain apartments that have low / subsidized rental rates. This is a decision that would be made by local governments, who are responsible for zoning ordnances, land-use and development decisions. This is outside of the MsCIP study team's authority or ability; therefore, it will not be affected by the Comprehensive Plan. Ultimately, the plan adopted for the Mississippi coast will not be a plan forced on them by the Corps or other Federal agencies, but a plan coordinated, discussed, and finally adopted by the numerous entities and individuals that will live with that plan, the residents and local government of coastal Mississippi.

4.1.22 Comprehensive Plan Protection of Children Impact

The EO 13045, Protection of Children from Environmental Health Risks and Safety Risks (April 21, 1997), recognizes a growing body of scientific knowledge that demonstrates that children may suffer disproportionately from environmental health risks and safety risks. These risks arise because children's bodily systems are not fully developed; because children eat, drink, and breathe more in

proportion to their body weight; because their behavior patterns may make them more susceptible to accidents. Based on these factors, the President directed each Federal agency to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children. The President also directed each Federal agency to ensure that its policies, programs activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

It is anticipated that no disproportionate risks to children would occur as a result of implementation of the Comprehensive Plan. Further studies during project development phase would determine any activities that might pose any disproportionate environmental health risks or safety risks to children and would be conducted during project development.

4.1.23 Comprehensive Plan Cumulative Effects

Council on Environmental Quality (CEQ) regulations stipulate that the cumulative effects analysis within an environmental document should consider the potential environmental impacts resulting from "the incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions" (40 Code of Federal Regulations [CFR] 1508.7). CEQ guidance in *Considering Cumulative Effects under the National Environmental Policy Act* (CEQ 1997) affirms this requirement, stating that the first steps in assessing cumulative effects involve defining the scope of the other actions and their interrelationship with the proposed action. The scope must consider geographic and temporal overlaps among the proposed action and other actions. It must also evaluate the nature of interactions among these actions. Cumulative effects are most likely to arise when a relationship or synergism exists between a proposed action and other actions expected to occur in a similar location or during a similar time period. Actions overlapping with or in close proximity to the proposed action would be expected to have more potential for a relationship than those more geographically separated. Similarly, actions that coincide, even partially, in time would tend to offer a higher potential for cumulative effects.

To identify cumulative effects, the analysis needs to address three fundamental questions:

1. Does a relationship exist such that affected resource areas of the proposed action might interact with the affected resource areas of past, present, or reasonably foreseeable actions?

2. If one or more of the affected resource areas of the proposed action and another action could be expected to interact, would the proposed action affect or be affected by impacts of the other action?

3. If such a relationship exists, then does an assessment reveal any potentially significant impacts not identified when the proposed action is considered alone?

The scope of the cumulative effects analysis involves both the geographic extent of the effects and the timeframe in which the effects could be expected to occur. For this Integrated EIS, the region of influence (ROI) consists of all of coastal Mississippi, also into the adjacent states, such as Alabama and Louisiana, and extending southward into Mississippi Sound and the Gulf of Mexico. Numerous other activities exist in the ROI. The activities described here are not completely inclusive, but they do serve to highlight some major influences in the region and to provide perspective on the contribution to any impacts generated by the proposed action.

Within coastal Mississippi, recovery work to clean up and rebuild following the landfall of Hurricane Katrina in August 2005 would continue to occur. The majority of this work would occur onshore, where there would be potential for interaction with the proposed action. The MsCIP PDT has been coordinating with the responsible entities to ensure that no significant adverse direct cumulative impacts would result.

Plans are in place to increase the size of the Gulfport and Pascagoula Federal Navigation Channels, within the Mississippi Sound to their authorized dimensions. These Federal navigation channels were excluded from Gulf sturgeon critical habitat (FR Vol. 68, No. 53). The Gulfport Harbor project plans to utilize beneficial use sites for a portion of new work material (Chandeleur Islands) and the ODMDS site offshore. The proposed Pascagoula River Harbor Dredged Material Management Plan involves raising the existing dike height of Triple Barrel, constructing the 425-acre site adjacent to SRI, using the revised open-water disposal site #5, continuing utilization of existing open-water disposal sites, and where feasible, utilizing beneficial use sites. Based on this and the fact that the construction of these projects would improve the economic benefits to the ROI, no significant direct cumulative impacts are expected to result.

Plans under the MsCIP Interim Projects are in place to beneficially utilize material from maintenance dredging of a segment of navigation channels and/or approved upland sites to create beaches and/or emergent tidal marsh habitats, such as Bayou Caddy, Pascagoula Beach, Harrison County dunes/beaches. In addition, other MsCIP Interim Projects restore channels that meander through communities in order to increase flushing of those streams. Other projects still repair and/or purchase damaged structures, such as Franklin Creek and Bay St. Louis. It is possible that construction of these projects would occur close in time to the MsCIP Comprehensive effort; however, no significant adverse direct cumulative impacts are expected to result. Table 4-4 provides an overview of the cumulative effects associated with components of the Comprehensive Plan being recommended for construction.

Table 4-4
MsCIP Comprehensive Plan Cumulative Effects

Proposed Restoration Project	Portion of the Ecotone to be Addressed	Ecological/Societal Functions to be Addressed	Acres of Habitat to be Restored
Moss Point Municipal Relocation Component	Restore natural flooding buffer	Restore natural buffer zone, relocation of human development out of the coastal ecotone for public safety	NA
Waveland Floodproofing	Restore natural flooding buffer	Restore natural buffer, relocation of human development out of the coastal ecotone for public safety zone	NA
Forest Heights Hurricane and Storm Damage Reduction Component	Reduces flooding	Adds protection to human development out of the coastal ecotone for public safety zone	NA
Turkey Creek Ecosystem Restoration	Wet Pine Savannah Wetlands	Enhanced productivity of wetlands Removes structures from project area	689 acres of wet pine savannah
Dantzler Restoration Area Ansley	Wet Pine Savannah Wetlands	Enhanced productivity of wetlands	385 acres of wet pine savannah
Franklin Creek Ecosystem Restoration	Wet Pine Savannah Wetlands	Moves Residents out of Harms Way (MsCIP Interim Project) Enhanced productivity of wetlands	149 acres of wet pine savannah

Proposed Restoration Project	Portion of the Ecotone to be Addressed	Ecological/Societal Functions to be Addressed	Acres of Habitat to be Restored
Bayou Cumbest Ecosystem Restoration	Emergent Tidal Marsh Scrub/Shrub	Enhanced productivity of emergent tidal wetland, habitat enhancement, relocation of human development out of the coastal ecotone for public safety	110 acres of emergent tidal 38 acres of scrub/shrub
Admiral Island Ecosystem Restoration	Emergent Tidal Marsh Scrub/Shrub	Enhanced productivity of emergent tidal wetland, habitat enhancement, relocation of human development out of the coastal ecotone for public safety	62 acres of emergent tidal marsh 61 acres of scrub shrub habitats
SAV Pilot Project at Bayou Cumbest	SAV – *Ruppia maritime*	Enhance fishery production	5 acres of SAVs
Beach and Dune Ecosystem Restoration	Coastal Dune Habitat	Buffer mainland from storm surge and waves energy	105 acres of dune
Barrier Island Restoration	Littoral zones, beach, dunes, emergent tidal marsh	Buffer mainland from storm surge and waves energy, enhanced productivity of emergent tidal marsh, enhance productivity of SAVs in littoral areas, enhance fisheries production	456 acres of tidal habitat 694 acres of nontidal habitat
Deer Island Ecosystem Restoration	Coastal Forests, Emergent Tidal Marsh	Enhanced productivity of wetlands	50 acres of emergent tidal marsh 116 acres of dune and beach habitat 78 acres of coastal maritime forest

4.2 High Hazard Area Risk Reduction Plan

The HARP would provide an effective means to induce and assist devastated and displaced property owners in relocating outside of high hazard surge-plain throughout coastal Mississippi. Acquisition of those properties where the residential owners have not yet rebuilt and continue to be displaced presents a unique window of opportunity to assist landowners while minimizing cost to the U.S. Government. The HARP, an acquisition strategy, would provide a non-structural alternative for reducing future property damage resulting from hurricanes, storm surge and flooding, and by extension, reducing threats to lives in those areas, in the most hazardous areas throughout coastal Mississippi.

A Record of Decision for construction is not being requested for the HARP, but the potential environmental effects are presented as reasonably foreseeable actions for the consideration of cumulative effects

4.2.1 No Action

Houses will either be rebuilt in place or the people will relocate to other areas for various personal or financial reasons. This would likely impact undeveloped lands in the Mississippi area. Should the residences not be rebuilt by original owners, it is believed the land would be sold and redeveloped by other people moving into the area. Thus, it is anticipated that coastal Mississippi would be rebuilt to pre-Hurricane Katrina conditions with more possible condominium development.

4.2.2 HARP Soils Impact

Alteration of soils is anticipated as relocation of properties spurs new development within rural undeveloped areas and fill material is brought in; however, the extent of impacts remain unclear but could be insignificant should small acreages be involved.

4.2.3 HARP Sediments Impact

Silt fences and other BMPs would be used to minimize adverse impacts to the environment during construction activities to the maximum extent practicable. Containment structures, silt curtains, and other BMPs would be used to contain sediment deposition at construction sites. Overall, the physical sediment will not be altered and it is anticipated impacts to sediments would be insignificant.

4.2.4 HARP Geology Impact

There should be no effects to geology. Projects have been designed to avoid impacts to current geological formations.

4.2.5 HARP Climate Impact

There should be no effects to the existing climate.

4.2.6 HARP Air Quality Impact

There should be no change in the existing air quality conditions. Currently all areas within coastal Mississippi are in attainment with the NAAQS. Air quality in the immediate vicinity of project construction would be slightly affected for a period of time by the fuel combustion and resulting engine exhausts. The standards would not be violated by the implementation of the proposed projects.

4.2.7 HARP Noise Impact

Noise from the construction type equipment is expected to increase during the proposed operations in the project vicinities. Noise levels will resume to existing conditions as construction activities are completed. It is anticipated there would be no significant impacts to noise levels during implementation of these measures.

4.2.8 HARP Vegetation Impact

Temporary and minimal effects to vegetation could occur during implementation of this measure; however, properties that would be purchased as part of a HARP program could be restored to historical environmental conditions. This would provide a more natural setting to the coastal environment via planting of native species. It is anticipated that this measure could provide benefits to vegetation. As buildings are relocated, however, adverse impacts could be felt within newly developed areas that are proposed for more natural undeveloped land located nearby. An assessment of potential locations would be conducted prior to redevelopment of those areas in order to minimize adverse impacts.

4.2.9 HARP Fish and Wildlife Impact

Overall, implementation of this measure would have minimal impacts initially to fish and wildlife; however, as properties would be purchased and existing development would be relocated, additional impacts to fish and wildlife and their habitat would be felt in nearby areas in Mississippi. Existing natural habitats that could be affected by implementation of this measure currently remain intact. They are in rural areas and predominantly natural. The main threat that exists today is by increased development and this planning guide would heighten this threat. Valuable habitat could be lost, which could result in losses to the species themselves. Additionally, as development occurs within this natural habitat, potential conflict between wildlife and human population increases. Although impacts to valuable habitat in the existing rural areas would occur, the purchased properties would be restored back to its natural condition resulting in a benefit to fish and wildlife. However, it is anticipated that secondary development in the newly relocated areas could offset benefits gained by restoration of the purchased property. It is expected that environmental measures would result in positive impacts to fish and wildlife and their habitat.

4.2.10 HARP Threatened and Endangered Species Impact

Overall, implementation of this measure would have minimal impacts to listed species; however, as properties would be purchased and existing development relocated, additional impacts to listed species and their habitat would be felt in adjacent areas. An example of concern would be the gopher tortoise. Existing habitats that could be affected by implementation of this measure currently remain intact. They are in rural areas and predominantly natural. There are several other T&E species that could possibly be adversely impacted by implementation of this measure. Initial alternatives will be developed to avoid and minimize impacts to any T&E species. In addition, assessment surveys, in close coordination with the USFWS, of the proposed relocation areas would be conducted prior to implementation to further reduce potential impacts.

The main threat that exists today is encroachment of development on these valuable T&E habitats and this planning guide would heighten this threat. Valuable habitat could be lost, which could result adverse impacts to the species. Valuable habitat would be restored along the coastal areas where the properties are purchased but possible impacts are still anticipated in adjacent areas. Programmatic consultation would address impacts to listed species in association with implementation of this measure.

4.2.11 HARP Water Quality Impact

BMPs would be utilized during construction activities to ensure stabilization of bare soils in order to reduce run off in adjacent water bodies. The purchase of properties and subsequent environmental restoration, where appropriate, would result in positive impacts to water quality within coastal Mississippi. Emergent tidal marsh, wet pine savannah, and other wetland habitats would be restored in this vital ecotone. A direct positive correlation exists between increased water quality benefits and the presence of wetlands as a result of natural filtering of the runoff prior to entering the coastal water bodies. It is anticipated no significant impacts to water quality would occur as a result of implementation of this measure.

4.2.12 HARP Water Supply Impact

There should be no effect on water supply. Potential projects have been or would be designed to avoid impacts to existing public water supply infra-structure and operating facilities.

4.2.13 HARP Socio-Economic Impact

The HARP will look at the acquisition of 2,000 structures within the high risk area. The implementation cost is estimated to be between 187,000,000 and $397,000,000. It is estimated that

the 2,000 structures would take 5 years to acquire, or about 400 structures per year. Based on an FY 08 federal discount rate of 4.875% and a 50-year period of analysis, interest during construction (IDC) would be approximately $50,274,000 for a total first cost of $447,274,000. This First cost equates to an average annual cost of $18,532,000. The benefits of the HARP were calculated using the HEC-FDA program. The program uses a Monte Carlo simulation to estimate average annual damages. The 2,000 structures were evaluated using a moderate relative sea level rise scenario and were determined to be between $22,000,000 and $33,000,000, or between $11,000 and $16,500 average annual damages per structure. Further, the implementation of this measure would not only move property from these high risk areas, but would also reduce the risk to human health and safety as well as reduce Federal and non-Federal emergency costs resulting from future storm events, and opportunities for recreation or ecosystem restoration exist as alternate uses of the lands.

4.2.14 HARP Land Use Impact

Non-structural projects would result in a positive benefit to current land use by raising buildings above flood elevations where appropriate. Implementation of this measure could have a significant impact to current land use as large areas would be purchased and existing residential or businesses would be relocated elsewhere outside of high hazard areas. Implementation of this measure could result in fractured communities, relocation of central areas that hold public sentiment, etc. Further consideration is warranted in conjunction with development of this program, in order, to identify specific impacts to each small intricate part of larger communities. Although the measure would provide these benefits, there would be adverse impacts associated with relocation construction and secondary development.

4.2.15 HARP Aesthetic Resources Impact

As projects would be constructed, aesthetics would be temporarily reduced in the immediate vicinity of the proposed project sites. It is believed those few residents and visitors still located in the vicinity may be disturbed by the presence of required heavy equipment during any construction phases. However, construction activities would be temporary in nature so the disturbance would be anticipated to be minimal at each potential project site. There could be times when numerous projects throughout coastal Mississippi would be occurring at once or potential project phases could be scheduled upon completion of requisite projects, which would take extended amounts of time. The projects should provide residents and visitors with an overall more aesthetically pleasing view as projects are completed.

4.2.16 HARP Cultural Resources Impact

Significant cultural resources as defined by the NHPA are those sites that are considered eligible for or are included in the National Register. These sites are known as historic properties. Historic properties can include buildings or other standing structures; historic or prehistoric districts (such as the historic districts in Biloxi and Ocean Springs); archaeological sites such as Indian mounds or other remains of prehistoric life; objects such as statues or paintings; or sunken vessels. Traditional cultural properties can also be considered significant cultural resources because of their traditional religious or cultural importance to an Indian tribe or other traditional community.

Properties such as cemeteries or buildings that are less than 50 years old are usually not considered eligible for the National Register, but there are exceptions. For example, certain buildings associated with the Cold War are considered so important to our history that they are eligible for the National Register.

Along the Mississippi Gulf Coast, historic properties can be roughly defined within two categories. The categories are the built environment (standing structures) and archaeological sites. The vast majority of historic properties listed on the National Register are those of the built environment. To

date 62 standing structures, 14 historic districts, and one ship have been listed. Many more standing structures are considered eligible for the National Register, but have not been formally nominated. These are also considered potential historic properties. Historic districts have been designated in Biloxi, Ocean Springs, and Bay St. Louis.

In contrast, very few archaeological sites have been formally nominated to the National Register. However, numerous sites still meet the criterion of definition as historic properties. These include prehistoric earthworks and mounds, shell middens, village sites, and historic occupation areas including extinct town sites. Currently over 200 recorded archaeological sites are considered potential historic properties.

In addition to National Register eligible properties, the Mississippi Coast also contains several National Historic Landmarks and designated Mississippi Landmarks. These include Beauvoir and the Mullato Bayou prehistoric earthworks.

The vast majority of historic and prehistoric sites are found along the immediate coastal strand and adjacent to estuarine systems. Preference for well drained, sandy soils adjacent to water sources is apparent. Coast wide survey work performed by both state (Giliberti n.d.) and private researchers (Blitz and Mann 2000) have found a distinctive focus on the immediate coastal and estuarine locations. Unfortunately, the geographic placement of these resources has made them extremely vulnerable to destruction from continued occupation and development, as well as vulnerable to the effects of tropical storms and hurricanes.

Modern development along the Mississippi coast has affected both archaeological sites and standing structures, including individual structures and historic districts in the project area. Key issues are soil disturbance and construction. Soil disturbance affects archaeological sites, and construction of new buildings and associated infrastructure can affect the view shed and “feel” of a historic building or district or cause demolition or alteration of historic buildings.

From the early 1970s to the present, construction in the project area has greatly increased. In fact, more development and construction has occurred in the three counties that are part of the project area than anywhere else in the state. Land use studies show that between 1972 and 2000 both medium-density and high-density urban land use areas increased by more than 90 percent in the study area; overall, developed land use increased by almost 70 percent during that period (MARIS, 1992, 2000; USGS, 1972; USGS and USEPA, 1992). This sizeable increase in developed land is caused in part by the casinos and related infrastructure, residential, and commercial construction. The development involves large areas of soil disturbance, which destroys archaeological sites.

Previous archaeological and architectural studies along the Mississippi Gulf Coast have documented the destruction caused by natural forces, most notably hurricanes. Standing structures are often the most dramatic and visible witnesses to this destruction. However, prehistoric and historic archaeological sites are also extremely vulnerable. Shell middens, found along the immediate shoreline and within coastal marshes and estuaries, often are flipped and re-deposited by the storm surge and wave action of hurricanes. This effectively destroys much of the value of the sites. Sites such as Indian villages and historic town sites such as those along the bluff on Bay St. Louis can also be destroyed by such wave action. In addition, post storm activities offer many more mechanisms for site destruction. These include clearing of timber by use of skidders and other heavy equipment, debris removal, and reconstruction. The destructiveness of these activities is well documented from the years following hurricane Camille which struck the area in 1969.

Mobile District Archaeologists, through long standing coordination relationships developed throughout the years, coordinated closely with the Mississippi Department of Archives and History staff in determining effects of the storm event. Hurricane Katrina has been documented to have destroyed a vast majority of the standing historic properties within Hancock County, and a large number of those within Harrison and Jackson Counties. The size and strength of the storm surge

has also undoubtedly had as much destruction on archaeological sites. Post hurricane activities have further impacted the remaining historic properties.

Protection from the immediate and post-effects of hurricanes should be considered as beneficial to cultural resources. While some historic properties may be adversely affected by protection plans, long term prevention of damage should be considered a positive measure for historic properties, in particular standing structures. Mobile District archaeologists are closely coordinating with the State of Mississippi Department of Archives and History regarding potential impacts associated with implementation of the various components of the Comprehensive Plan. Plans are underway to develop an overall process through which potential impacts to cultural and historic resources would be addressed during specific project development. Specific projects would be closely coordinated with the State of Mississippi Department of Archives and History prior to beginning of construction activities.

4.2.17 HARP Hazardous, Toxic, and Radioactive Wastes Impact

Site inspections would be conducted at and adjacent to the various components of the MsCIP Comprehensive Plan during development of specific plans and specifications in accordance with the requirements of ER 1165-2-132 entitled, HTRW Guidance for Civil Works Projects, and the American Society of Testing and Materials Standard E 1527.

Inspections would be accomplished to determine the presence or evidence of landfills, surface areas unable to support vegetation, visible sheens of petroleum product, nearby contaminated industrial facilities, or any type of visible indication that HTRW concerns exist that may impact any component of the recommended plans during specific project development. Site inspections of adjacent properties, reviews of historic aerial photographs, on site interviews, and environmental database record searches would be conducted to determine any evidence of HTRW concerns that may impact any component of the recommended plans during specific project development.

Based on the findings of the HTRW site assessments, specific or unusual environmental concerns that are identified that could affect construction of any proposed projects would be addressed appropriately. Additional supplemental environmental impacts statements or environmental analyses may be necessary once specific projects have been identified and development of project plans has begun. HTRW issues and concerns would be addressed during the required NEPA compliance and documentation.

4.2.18 HARP Unavoidable Adverse Environmental Effects

Although BMPs would be utilized during construction activities, some adverse environmental effects could result during implementation of projects; however, it is anticipated any effects that cannot be avoided should be temporary and localized and would be minor and short-term in nature.

4.2.19 HARP Irreversible and Irretrievable Commitments of Resources

Any irreversible or irretrievable commitments of resources involved in any potential proposed projects have been considered and are either unanticipated at this time or will be considered to determine if any would present minor impacts.

4.2.20 HARP Environmental Justice Impact

EO 12898, Federal Actions to address Environmental Justice in Minority and Low-Income Populations (February 11, 1994) requires that Federal agencies conduct their programs, policies, and activities that substantially affect human health or the environment in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or

subjecting persons (including populations) to discrimination under such programs, policies, and activities because of their race, color, or national origin. On February 11, 1994, the President also issued a memorandum for heads of all departments and agencies, directing that EPA, whenever reviewing environmental effects of proposed actions pursuant to its authority under Section 309 of the CAA, ensure that the involved agency has fully analyzed environmental laws, regulations, and policies.

A detailed assessment of the historical and existing conditions from the U.S. Department of Commerce, Census of Population and Housing was presented in Section 4.1.21. Non-structural measures intended for acquisition and removal of the most risky structures would tend to affect all residents or businesses located in those zones, low-income and high-income alike. However, well-armored structures, such as high-rise concrete complexes, would advisedly be the most survivable of those that might exist in the most high hazard zones. But, the choice of income level of those that would be able to afford to live in those complexes will also likely be driven by economics of those that can or cannot afford to do so. A question remains whether any of the complexes would contain apartments that have low rental rates. This is a decision that would be made by local governments, whose responsibility it is to control zoning ordnances, land-use and development decisions. This is outside of the MsCIP study team's authority or ability; therefore, it will not be affected by the Comprehensive Plan Report. Ultimately, the plan adopted for the Mississippi coast will not be a plan forced on them by the Corps or other Federal agencies, but a plan coordinated, discussed, and finally adopted by the numerous entities and individuals that will live with that plan, the residents and local government of coastal Mississippi.

The HARP is not designed to create a benefit for any specific group or individual. In fact, it would help many individuals, including minorities and low-income, that are currently unable to rebuild their homes finding housing. Any potential HARP efforts would not create disproportionately high or adverse human health or environmental impacts on minority or low-income populations within the study area. Review and evaluation of the overall MsCIP Comprehensive Plan have not disclosed the existence of identifiable minority or low-income communities that would be adversely impacted by proposed measures. Further studies during project development would determine specific impacts associated with implementation of potential measures.

4.2.21 HARP Protection of Children Impact

The EO 13045, Protection of Children from Environmental Health Risks and Safety Risks (April 21, 1997), recognizes a growing body of scientific knowledge that demonstrates that children may suffer disproportionately from environmental health risks and safety risks. These risks arise because children's bodily systems are not fully developed; because children eat, drink, and breathe more in proportion to their body weight; because their behavior patterns may make them more susceptible to accidents. Based on these factors, the President directed each Federal agency to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children. The President also directed each Federal agency to ensure that its policies, programs activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

It is anticipated that no disproportionate risks to children would occur as a result of implementation of the HARP. Further studies during project development phase would determine any activities that might pose any disproportionate environmental health risks or safety risks to children.

4.3 Site-Specific Components of the Comprehensive Plan

Two very large site-specific components of the Comprehensive Plan were developed in this feasibility study, which are not presented in support of a Record of Decision for construction. These very large site-specific Comprehensive plan components are:

- Freshwater Diversion at Violet, Louisiana; and
- Barrier Island Restoration.

These Comprehensive Plan components are addressed as reasonably foreseeable actions for the consideration of cumulative effects. Because additional engineering and design investigations have yet to be completed, these projects and programs are not yet ripe for decision-making. Supplemental NEPA information will be presented as necessary to ensure compliance with the appropriate environmental laws and regulations:

4.3.1 Freshwater Diversion at Violet, La.

Increased salinity problems originated as a result of the Mississippi River being contained in levees and not allowed to migrate back and forth across southeast Louisiana. As the river naturally migrated, it deposited sediment in the form of deltaic marshes. The river overflowed its banks every spring, flooding and supplying the area with nutrients and sediments to sustain the deltas and maintain the marshes and their vegetative characteristics. Since the river's channelization, the only freshwater flowing into the western Mississippi Sound has been from the opening of the Bonnet Carre Spillway during flood conditions, and from rainfall runoff from the uplands adjoining the project area. It is unknown the effects of various channels, canals and diversion projects have had on salinities within western Mississippi Sound.

A detailed discussion regarding the diversion of freshwater into Mississippi Sound has been presented in the Environmental Appendix. It will be necessary to supplement this Integrated EIS with additional NEPA documentation during project development and design to determine the range of benefits and adverse impacts associated with a project of this magnitude.

4.3.1.1 No Action

Upon implementing the No Action plan, the problems are anticipated to continue within western Mississippi Sound. The area would be deprived of the annual freshwater from the river. The natural processes of subsidence, compaction, erosion, and saltwater intrusion along with manmade actions, such as channel dredging and levee building activities, would result in further losses to coastal marshes, annual harvestings of oysters, and various other adverse impacts to habitats for commercially important fisheries. The No Action plan would result in the continual degradation of the oyster habitat, which many of the residents of Mississippi and Louisiana depend their livelihood upon.

4.3.1.2 Freshwater Diversion Description

Changing freshwater contributions to Mississippi Sound caused the western area of coastal Mississippi to suffer greatly from increased saltwater intrusion; especially hit hard are oyster resources. Hancock County marshes, located within the western portion of coastal Mississippi, have suffered increased saltwater intrusion as well as lack of sediment. Furthermore, the State of Louisiana's marshes experience continual erosion from the lack of sediment influx. Additionally, historic oyster reefs located within western Mississippi Sound have declined from lack of freshwater flows resulting from increased saltwater intrusion. Oyster predators, thriving in salty waters, destroy the beds.

A detailed description of the freshwater diversion has been presented in the Environmental Appendix. Diversion of Mississippi River freshwater and sediments in the vicinity of Violet, Louisiana has strongly been considered because of a number of positive environmental benefits – oysters, marsh, water quality, etc. In addition, these include proximity of the river to target coastal wetlands, public support, and high confidence in potential environmental benefits. MDMR has been working with the Mississippi congressional delegation in order to address the increased saltwater intrusion

within this portion of Mississippi Sound. Joint efforts between the States of Mississippi and Louisiana congressional delegates resulted in the identification of potential freshwater diversion projects from the Mississippi River as a mechanism for reversing historic high salinity concentrations in the western portion of coastal Mississippi. A freshwater diversion project near Violet, Louisiana, was identified as an authorized project. Preliminary results from modeling a simulated diversion of 7,500 cubic feet per second of freshwater near Violet, Louisiana, suggest salinities were lowered in Western Mississippi Sound sufficiently to warrant additional examination (Dortch et al 2007). Further refinement of the models should address current limitations and must be made to estimate potential beneficial or deleterious effects on oysters, sea grasses, marsh systems, and other coastal resources. Further engineering and design is needed prior to project development.

4.3.1.3 Freshwater Diversion Soils Impact

Alteration of soils is anticipated within the footprint of the diversion structure. Fill material would be introduced during construction in order to ensure a solid foundation for the construction of the diversion structure. Further analysis would be required during project development to determine the associated impacts.

4.3.1.4 Freshwater Diversion Sediments Impact

Silt fences and other BMPs would be used to minimize the adverse impacts to the environment during construction activities to the maximum extent practicable. Containment structures, silt curtains, and other BMPs would be used to contain sediment deposition at the construction site. The diversion of freshwater would increase sediments and nutrients into areas that have historically suffered as a result of reduced transport via freshwater input. Further analysis would be required during project development to determine the associated impacts.

4.3.1.5 Freshwater Diversion Geology Impact

There should be no effects to geology. Projects have been designed to avoid impacts to current geological formations.

4.3.1.6 Freshwater Diversion Climate Impact

There should be no effects to the existing climate.

4.3.1.7 Freshwater Diversion Air Quality Impact

There should be no change in the existing air quality conditions once construction of the diversion project is complete. Air quality in the immediate vicinity of project construction would be slightly affected for a period of time by the fuel combustion and resulting engine exhausts. Current standards would not be violated by the implementation of the proposed projects.

4.3.1.8 Freshwater Diversion Noise Impact

Noise from the construction type equipment is expected to increase during the proposed operations in the project vicinities. Noise levels will resume to existing conditions as construction activities are completed. It is anticipated there would be no significant impacts to noise levels during implementation of these measures.

4.3.1.9 Freshwater Diversion Vegetation Impact

It is expected vegetation under the footprint of the structure would be lost completely; however, any bare soils would be vegetated to reduce future erosion. The exact location of the structure and waterway is unknown at this time but it is anticipated that emergent tidal marsh habitat would likely be impacted, as indicated by review of aerial photography. The freshwater diversion project would result in increased sediments and nutrients into areas that have suffered losses of marsh. Advanced

engineering and design is needed to determine impacts to vegetation. Additionally, potential negative impacts to SAVs could occur as salinities are reduced due to the introduction of freshwater into the system. Further analysis and additional model runs during project development would determine both positive and negative impacts associated with the freshwater diversion project.

4.3.1.10 Freshwater Diversion Fish and Wildlife Impact

The impacts to fish and wildlife habitats associated with the diversion project are unknown at this time. Pre- and post-construction water quality monitoring would be required to inform structure operations and assess the effects of the diverted freshwater on fish and wildlife populations. Monitoring would need to capture hydrological, water quality, chemical, physical, and biological data as a component of the project's regular operation and maintenance. An adaptive operations strategy would be required to ensure flexibility in the operation of diversions, including frequency, duration, time of year, and quantities. One of the project goals is to create salinity conditions favorable for fish and wildlife productivity, especially increased annual oyster production in the State of Mississippi. Productivity of other species, such as white shrimp, blue crab, croaker, and menhaden, should greatly increase. Further analysis and additional model runs during project development would determine impacts associated with the project.

4.3.1.11 Freshwater Diversion Threatened and Endangered Species Impact

The impacts to fish and wildlife habitats associated with the diversion project are unknown at this time. Several species, such as sea turtles and Gulf sturgeon, are known to be present within this portion of Mississippi Sound that could be impacted by the proposed freshwater diversion effort. Critical habitat for the Gulf sturgeon has been designated within western Mississippi Sound. Impacts of diverting freshwater at this area need to have further analysis and additional model runs during project development to develop a more detailed assessment, including the primary constituent elements of the Gulf sturgeon, such as sediment, water quality, and prey abundance. There could also be T&E species and/or critical habitat located in the vicinity of the proposed diversion structure, currently location unknown at this time. In addition, a possibility of newly designated species, such as the Pallid sturgeon, could be identified by the USFWS and/or NOAA, PRD during the modeling and design phase. As a result of this assessment, the T&E impacts would be assessed in greater detail and appropriate level of coordination would commence at that time with USFWS and/or NOAA, PRD.

4.3.1.12 Freshwater Diversion Water Quality Impact

The freshwater diversion project could cause an increase in turbidity, coliform counts, nitrate and phosphorous levels, and other types of chemical concentrations. Temperatures could be slightly lowered. The impacts of diverting freshwater into this area are unknown at this time but further analysis and additional model runs would provide the anticipated water quality impacts as a result of the project implementation. Detailed assessment of water quality would occur during the supplemental environmental documentation.

4.3.1.13 Freshwater Diversion Water Supply Impact

There should be no effect on water supply. Potential projects have been or would be designed to avoid impacts to existing public water supply infra-structure and operating facilities.

4.3.1.14 Freshwater Diversion Socio-Economic Impact

Oyster reefs were seriously impacted by Hurricane Katrina and all reefs in Coastal Mississippi were closed immediately following the storm, with some of them still remaining closed almost 2 years later. There are signs the reefs are beginning some of the healing processes on their own; however, much work will be needed to restore the oyster reefs to their former prime condition. Extensive

sampling of the reefs is currently being conducted by the MDMR to provide information needed to plan extensive long-term recovery activities. Initial assessments of the reef conditions are underway but at present, are incomplete. Conditions of the reefs are highly variable. Generally, offshore areas were heavily scoured. Recent very heavy oyster spat set (less than one inch in length) was found in some of these areas with no spat set in other areas. Inshore reefs generally had moderate to very low numbers of live oysters in some areas with other areas revealing no live oysters. The preservation of the Mississippi Sound habitat that is vital to both local fisheries and economies, but also a large source of national oyster production, and the continued use of the barrier islands as a recreational resource. Many of the Mississippi and Louisiana residents depend their livelihood upon oyster harvesting. Diverting water into Mississippi would enhance that production.

4.3.1.15 Freshwater Diversion Land Use Impact

The freshwater diversion project would take place at or near Violet, Louisiana; however, the exact location is unknown at this time. It is expected that a significant change in current land use would occur as the area presently consists of a small town, associated homes and businesses, and rural lands. Further analysis during project development would determine the impacts to land use associated with the project.

4.3.1.16 Freshwater Diversion Aesthetic Resources Impact

The freshwater diversion project would cause a change in aesthetic resources within the area at or near Violet, Louisiana. Further analysis during project development would determine the extent of impacts to aesthetics within the surrounding area.

4.3.1.17 Freshwater Diversion Cultural Resources Impact

Potential impacts to cultural resources are unknown. A phase one archaeological survey would need to be conducted during project development and design to determine if any cultural resources are located within the project area and then further analysis would determine the impacts associated with the project.

4.3.1.18 Freshwater Diversion Hazardous, Toxic, and Radioactive Wastes Impact

Site inspections would be accomplished in accordance with the requirements of ER 1165-2-132 entitled, HTRW Guidance for Civil Works Projects, and the American Society of Testing and Materials Standard E 1527 during project development. The inspections would be conducted to determine the presence or evidence of landfills, surface areas unable to support vegetation, visible sheens of petroleum product, nearby contaminated industrial facilities, or any type of visible indication that HTRW concerns exist that may impact the relocations and subsequent restoration of the site. Based on the findings of the HTRW site assessments, specific or unusual environmental concerns that are identified that could affect construction of any proposed projects would be addressed appropriately. Additional supplemental environmental impacts statements or environmental analyses may be necessary once specific projects have been identified and development of project plans has begun. HTRW issues and concerns would be addressed during the required supplementation NEPA compliance and documentation.

4.3.1.19 Freshwater Diversion Unavoidable Adverse Environmental Effects

Initial screening of alternatives based on environmental acceptability would help avoid adverse environmental effects. Further analysis during project development and design would determine if any unavoidable adverse environmental effects would occur as a result of the project.

4.3.1.20 Freshwater Diversion Irreversible and Irretrievable Commitments of Resources

Any irreversible or irretrievable commitments of resources involved in any potential proposed projects have been considered and are either unanticipated at this time or will be considered to determine if any would present minor impacts.

4.3.1.21 Freshwater Diversion Environmental Justice Impact

A detailed description of Environmental Justice has been provided in Section 4.1.21. Potential impacts to Environmental Justice issues are unknown at this time. A detailed assessment would be conducted in the supplemental environmental documentation during project development and design to determine if any impacts are anticipated.

4.3.1.22 Freshwater Diversion Protection of Children Impact

A detailed description of Protection of Children has been provided in Section 4.1.22. Potential impacts to Protection of Children issues are unknown at this time. A detailed assessment would be conducted in the supplemental environmental documentation during project development and design to determine if any impacts are anticipated.

4.3.2 Restoration of Barrier Islands

Several measures have been developed, which would allow for storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife habitats, and prevention of coastal erosion. Screening criteria were based on comprehensive goals and objectives, technical feasibility, and environmental effectiveness. Measures considered include restoration of the island footprints to pre-Hurricane Camille conditions, replenishment of sand within the littoral zone, environmental restoration consisting of dune construction and planting of native species, seagrass restoration, and repair of the Ship Island breach. A detailed explanation of these measures is presented in the Environmental Appendix. After screening, the PDT developed the following alternatives for further analysis.

The Proposed Action recommended for construction will consist of the combination of two options – filling of Ship Island breach and littoral placement of sand - combined with recommended changes in the local RSM practices. This alternative is recommended to help prevent the accelerated erosion of the barrier islands, especially what is now considered West and East Ship Island (a single island prior to Hurricane Camille) as well as Petit Bois Island to the east.

To provide needed data on some aspects of completing this plan, additional studies will be conducted during the Engineering and Design (E&D) phase of this project. It is generally understood that the loss of these islands will change the entire ecosystem of Mississippi Sound as well as having affects on the amount of storm damage incurred along the mainland coast. Since the islands form the Mississippi Sound estuary, continued loss of the islands will allow a different salinity interface as freshwater from the mainland river systems and the saltwater from the Gulf of Mexico adjust to new tidal and littoral currents. Under E&D, additional storm surge, wave, water quality, and sediment transport modeling will be conducted to predict the affects of not having West and East Ship Island in place during future hurricanes. Initial modeling indicates that taking Ship Island(s) out of the system will not have a great effect on surge, but will have a major impact on waves that affect the mainland. The additional sediment transport modeling will also be used to optimize the placement of sand in the littoral zone under this plan. Water quality models will also be conducted to predict the changes to salinity levels in the Sound without Ship Island.

The proposed action consists of placement of 22 million cubic yards of sand within the littoral zone and restoration of the breach at Ship Island. The sand to be placed in the littoral zone would be obtained from dredging sand from an offshore site located at the St. Bernard Shoals. Additionally, river sands could be used and would be obtained from upland disposal areas adjacent to inland

rivers. Sand used for the repair of the Ship Island breach would be obtained from St. Bernard Shoals offshore site.

4.3.2.1 No Action

The No Action alternative involves the continuation of existing conditions and no new solutions for existing problems. This alternative avoids both the monetary investment and potential adverse impacts associated with improvements. Future conditions associated with not restoring the barrier islands would result in the continued degradation of the valuable beach ecosystem and loss of these types of habitats. The immediate area would remain particularly vulnerable to wave and storm activity that continually threaten and prevent the re-establishment of this vital natural resource. The No Action Plan would result in continued erosion to the barrier islands, increased saltwater intrusion, continued degradation and possible lack of suitable fish and wildlife habitats including numerous federally protected species. It is unclear as to the extent and rate of degradation the natural resources would suffer as a result of implementation of the No Action Plan.

4.3.2.2 Barrier Island Restoration Vegetation Impact

It is anticipated that placement of sandy material within the littoral zone would cause no adverse impacts vegetation because site would be identified to minimize impacts. Filling in the breach at Ship Island could provide a benefit to vegetation because it is believed that natural recolonization of the beach and dune system would occur. Additionally, it is believed the adjacent areas would consist of sandy shallows that could support sea grasses. It is anticipated that implementation of this project would provide a benefit to vegetation. The vegetation impacts resulting from each of the alternative plans evaluated varied only in the level of benefits due to the amount and type of planning used in each alternative.

4.3.2.3 Barrier Island Restoration Fish and Wildlife Impact

Option A: Restore Island Footprint Fish and Wildlife Impact

Generally, restoration of the island footprint would entail filling of existing water bottoms to pre-Hurricane Camille conditions. The barrier islands currently provide essential fish habitat for managed fisheries, designated critical habitat for the threatened Gulf sturgeon, and designated critical habitat for piping plover. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. It is anticipated additional sand along the shoreline would provide additional opportunities for nesting for sea turtles. Additionally, the potential measure would provide additional over wintering critical habitat for the piping plover. Many other shorebird species use the barrier islands for nesting and foraging. Filling of water bottoms would remove foraging areas for sea turtles and other marine species.

The sand would be obtained from an offshore source, St. Bernard Shoals, approximately 45 miles south of the islands. Dredging will impact epibenthic crustaceans and infaunal polychaetes within the immediate area. However, the impacts are primarily short-term in nature and consist of a temporary loss of benthic invertebrate populations in the areas of dredging. Adjacent benthic communities are anticipated to move into the dredged site and begin recolonization. The area is characterized as a relic sand shoal approximately at elevation -60 ngvd 88 and once dredging is complete, will remain similar in character as dredged depths would not exceed 10 feet in depth. Therefore, because similar habitat, in terms of both sediment composition and depth will be present pre- and post dredging, it is anticipated the benthic biota in the dredging areas will recover and recolonize. Further study during project development would determine the extent of impacts and benefits associated with implementation of this measure.

Option B: Replenish Sand in Littoral Zone, Inland Source Fish and Wildlife Impact

This measure would result in less direct impacts to the islands themselves by introduction of sand into the littoral zone where the islands are located. A large amount of water bottoms would be filled as a result. These areas currently provide essential fish habitat for managed fisheries and designated critical habitat for the threatened Gulf sturgeon. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. Filling of water bottoms would remove foraging areas for sea turtles and other marine species including the Gulf sturgeon. Sand would be obtained from inland sources comprised of previous dredged river sands. Past analyses and comparisons have found the river sands are typically a finer grain size than native beach sands, which are mostly medium-sized. Additionally, these comparisons determined the beach sands are slightly more rounded than river sands. One factor that would warrant further analysis is the differences in color of the two sands with the river sands having a slight brown tint compared to the beach sand samples which are described as white or light grey. It is believed the river sands would undergo bleaching from the ultraviolet radiation from the sun if the color variation was caused by a mineral staining. Adding this sand into the littoral system would diminish the differences between the natural sands by spreading it over large areas with shallow thicknesses. The natural sediment transport process would blend the two sands together while removing staining from the sand grains and rounding the individual particles through abrasion. Further study during project development would determine the extent of impacts of incorporating river sands into the marine system and filling of water bottoms.

Option C: Replenish Sand in Littoral Zone, Offshore Source Fish and Wildlife Impact

This measure would result in less direct impacts to the islands themselves by introduction of sand into the littoral zone where the islands are located. A large amount of water bottoms would be filled as a result. These areas currently provide essential fish habitat for managed fisheries and designated critical habitat for the threatened Gulf sturgeon. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. Filling of water bottoms would remove foraging areas for sea turtles and other marine species including the Gulf sturgeon. Sand would be obtained from an offshore source and would consist of high quality beach sands. The natural sediment transport process would blend this sand into the existing littoral system. Further study during project development would determine the extent of impacts of filling of water bottoms and incorporation of the offshore sands.

The sand would be obtained from an offshore source, St. Bernard Shoals, approximately 45 miles south of the islands. Dredging will impact epibenthic crustaceans and infaunal polychaetes within the immediate area. However, the impacts are primarily short-term in nature and consist of a temporary loss of benthic invertebrate populations in the areas of dredging. Adjacent benthic communities are anticipated to move into the dredged site and begin recolonization. The area is characterized as a relic sand shoal approximately at elevation -60 ngvd 88 and once dredging is complete, will remain similar in character as dredged depths would not exceed 10 feet in depth. Therefore, because similar habitat, in terms of both sediment composition and depth will be present pre- and post dredging, it is anticipated the benthic biota in the dredging areas will recover and recolonize. Further study during project development would determine the extent of impacts and benefits associated with implementation of this measure.

Option D: Environmental Restoration With 2-Foot Dune Fish and Wildlife Impact

It is anticipated that implementation of this measure would provide significant benefits to fish and wildlife by restoration of existing damaged and lost habitat. Dunes provide natural island habitat and by restoration, the island dwelling species gain lost habitat. The barrier islands provide important stopover habitat for many species of migratory birds. The barrier islands currently provide essential fish habitat for managed fisheries, designated critical habitat for the threatened Gulf sturgeon, and designated critical habitat for piping plover. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. It is anticipated additional sand along the shoreline

would provide additional opportunities for nesting for sea turtles. Additionally, the potential measure would provide additional over wintering critical habitat for the piping plover. Many other shorebird species use the barrier islands for nesting and foraging. Further studies during project development would determine specific benefits resulting from implementation of this measure.

Option E: Environmental Restoration With 6-Foot Dune Fish and Wildlife Impact

It is anticipated that implementation of this measure would provide significant benefits to fish and wildlife by restoration of existing damaged and lost habitat. Dunes provide natural island habitat and by restoration, the island dwelling species gain lost habitat. The barrier islands provide important stopover habitat for many species of migratory birds. The barrier islands currently provide essential fish habitat for managed fisheries, designated critical habitat for the threatened Gulf sturgeon, and designated critical habitat for piping plover. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. It is anticipated additional sand along the shoreline would provide additional opportunities for nesting for sea turtles. Additionally, the potential measure would provide additional over wintering critical habitat for the piping plover. Many other shorebird species use the barrier islands for nesting and foraging. Further studies during project development would determine specific benefits resulting from implementation of this measure.

Option F: Environmental Restoration of Sea Grass Beds Fish and Wildlife Impact

Many marine species depend on sea grass beds for foraging opportunities and cover. Restoration of this vital habitat would provide significant benefits to fish and wildlife and their habitats. Establishment of a comprehensive program would allow for further education regarding the sustainability of the resource.

Option G: Restoration of Ship Island Breach Fish and Wildlife Impact

Generally, restoration of the island footprint would entail filling of existing water bottoms to circa 1916-17 geomorphic conditions. These areas currently provide essential fish habitat for managed fisheries, designated critical habitat for the threatened Gulf sturgeon, and designated critical habitat for piping plover. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. It is anticipated additional sand along the shoreline would provide additional opportunities for nesting for sea turtles. Additionally, the potential measure would provide additional over wintering critical habitat for the piping plover. Filling of water bottoms would remove foraging areas for sea turtles and other marine species. Further study during project development would determine the extent of impacts and benefits associated with implementation of this measure.

The sand would be obtained from an offshore source, St. Bernard Shoals, approximately 45 miles south of the islands. Dredging will impact epibenthic crustaceans and infaunal polychaetes within the immediate area. However, the impacts are primarily short-term in nature and consist of a temporary loss of benthic invertebrate populations in the areas of dredging. Adjacent benthic communities are anticipated to move into the dredged site and begin recolonization. The area is characterized as a relic sand shoal approximately at elevation -60 ngvd 88 and once dredging is complete, will remain similar in character as dredged depths would not exceed 10 feet in depth. Therefore, because similar habitat, in terms of both sediment composition and depth will be present pre- and post dredging, it is anticipated the benthic biota in the dredging areas will recover and recolonize. Further study during project development would determine the extent of impacts and benefits associated with implementation of this measure.

4.3.2.4 Barrier Island Restoration Proposed Actions Fish and Wildlife Impact

The Proposed Action would result in less direct impacts to the islands themselves by introduction of sand into the littoral zone where the islands are located; however, a large amount of water bottoms would be filled as a result. These areas currently provide EFH for managed fisheries and designated critical habitat for the threatened Gulf sturgeon. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. Filling of water bottoms would remove foraging

areas for sea turtles and other marine species including the Gulf sturgeon. Sand could be obtained from inland sources comprised of previous dredged river sands. Past analyses and comparisons have found the river sands are typically a finer grain size than native beach sands, which are mostly medium sized. However, there may be some large gravel intermixed within the river sands. Additionally, these comparisons determined the beach sands are slightly more rounded than river sands. One factor that would warrant further analysis is the differences in color of the two sands with the river sands having a slight brown tint compared to the beach sand samples, which are described as white or light grey. It is believed the river sands would undergo bleaching from the ultraviolet radiation from the sun if the color variation was caused by a mineral staining. Adding this sand into the littoral system would diminish the differences between the natural sands by spreading it over large areas with shallow thicknesses. The natural sediment transport process would blend the two sands together while removing staining from the sand grains and rounding the individual particles through abrasion. Further study during project development would determine the extent of impacts of incorporating river sands into the marine system and filling of water bottoms.

Sand could be obtained from an offshore source and would consist of high quality beach sands. The natural sediment transport process would blend this sand into the existing littoral system. Further study during project development would determine the extent of impacts of filling of water bottoms and incorporation of the offshore sands.

The sand would be obtained from an offshore source, St. Bernard Shoals, approximately 45 miles south of the islands. Dredging will impact epibenthic crustaceans and infaunal polychaetes within the immediate area. Adjacent benthic communities are anticipated to move into the dredged site and begin recolonization. The area is characterized as a relic sand shoal approximately at elevation -60 NGVD 88 and once dredging is complete, will remain similar in character as dredged depths would not exceed 10 feet in depth. Therefore, because similar habitat, in terms of both sediment composition and depth will be present pre- and post-dredging, it is anticipated the benthic biota in the dredging areas will recover and recolonize. Further study during project development would determine the extent of impacts and benefits associated with implementation of this measure.

Generally, restoration of the island footprint would entail filling of existing water bottoms to circa 1916-17 geomorphic conditions. It is anticipated that barrier island restoration would provide significant benefits to fish and wildlife by restoration of existing damaged and lost habitat. Dunes provide natural island habitat and by restoration, the island dwelling species gain lost habitat. The barrier islands provide important stopover habitat for many species of migratory birds.

4.3.2.5 Barrier Island Restoration Threatened and Endangered Species Impact

Overall barrier island restoration would benefit piping plover and its critical habitat (refer to the Environmental Appendix) by the increased amount of over wintering foraging areas. There are no substantive differences in impacts to threatened and endangered species among the alternative plans evaluated. Temporary impacts could occur during construction but could be avoided during the times the piping plover are on the over wintering grounds. Impacts associated with construction activities should be temporary and isolated to actual construction limits. Brown pelicans could utilize the project areas, however, it is anticipated these species would avoid the construction area due to noise and activity. These impacts would be temporary and isolated to actual construction limits. Surveys to determine if nesting brown pelicans are present could be conducted to avoid any impacts. Manatees could be in the project area also and there is potential for adverse impacts to occur. It is anticipated these species would primarily avoid the construction areas due to noise and activity resulting in less risk for harm or harassment. Methods of dredging would be utilized to avoid adverse impacts to listed species. Placement activities would be accomplished using appropriate BMPs to reduce turbidity and other potential adverse impacts to species. Further consultation would be required to determine adverse impacts to critical habitat for the Gulf sturgeon. It is anticipated

whale species would avoid the project area during construction activities due to noise and activity and no collisions should occur

Potential impacts to listed sea turtles and Gulf sturgeon and its critical habitat could occur during dredging of sand and placement activities. To reduce the possibility of protected species interactions, the dredge drag heads would be equipped with sea turtle deflectors devices. In addition, 100% of the material dredged would pass through 4-inch screening boxes for screening by approved observers for evidence of protected species interactions. The precautionary steps taken when utilizing hopper dredges will ensure restoration of the barrier islands will not jeopardize the continued existence of listed species.

Alteration of Gulf sturgeon critical habitat is likely. Unit 8 is listed due to its containing four of the primary constituent elements that identify critical habitat. These constituent elements consist of the following: "abundant prey items", "sediment quality", "water quality", and "migration habitat." The non-motile benthic community within the project area would be temporarily, adversely impacted as a result of the dredging and disposal operations. However, these impacts will not result in permanent habitat alteration due to the fact that the areas will re-colonize with similar benthic species within a few months upon completion of the project remaining functionally identical to the existing habitat. The project area constitutes a fraction of one percent of the total available forage habitat for the species in that area. The sandy dredged material will be of the same composition as that of the adjacent sandy placement areas since the material is characterized as sand. Therefore, no long-term change in community structure is expected to occur.

Prey Abundance: Activities associated with placement cover epibenthic crustaceans and infaunal polychaetes within the littoral zones and breach areas that serve as potential prey items for the Gulf sturgeon. The impacts are considered short-term in nature and consist of a temporary loss of benthic invertebrate populations where the shoreline extends seaward. It is believed that this will not alter critical habitat. The beach placement area has suffered erosion due to highly dynamic wind and wave action within the area, especially during recent hurricane and storm events. The area was above mean high water and was not contributing to the benthic productivity of the coastal system.

Past observances have recorded subpopulations found within the Pearl and Pascagoula Rivers utilize the project area located within and around Ship Island. NOAA, PRD, in previous biological opinions for projects within Mississippi Sound, concluded the actual number of the species utilizing the project area for foraging is likely few based on the small population sizes.

Some data are available to describe what the Gulf sturgeon may feed on in the nearshore zone of the Gulf of Mexico. Studies supporting the critical habitat rule indicate that the Gulf sturgeon's diet includes amphipods, lancelets, polychaetes, gastropods, shrimp, isopods, mollusks, and crustaceans.

The direct placement sandy material into the littoral zone would result in the mortality of some percentage of the existing benthic assemblages. The indirect placement within the littoral zone from localized turbidity increases may also result in benthic mortality; however, the impact from this is expected to be minimal. The non-motile benthic community within the project area would be temporarily, adversely impacted as a result of the dredging and disposal operations. This area within Ship Island would be converted to upland habitat but it would help maintain the integrity of one of Mississippi Sound's primary constituent elements for the Gulf sturgeon (i.e. water quality).

Past monitoring studies associated with placement activities have indicated that the benthic communities showed a high degree of variability through the site. The area exhibited a high degree of resilience and rapid recovery over the study period. Results from the samplings show that there is a general increase in the number of individuals per species as well as an increase in the percentage of prey species out of all species represented. This is particularly true for Branchiostoma (lancelet), which has been identified as primary Gulf sturgeon prey. Based on past benthic studies, it is

concluded that the placement activities associated with barrier island restoration will not cause a significant impact on possible feeding of the Gulf Sturgeon and it is believed the project would not result in an adverse modification to the designated Gulf sturgeon critical habitat.

Migratory passage: The primary migration pattern through the area would be parallel to the shoreline in Mississippi Sound, near the islands and within the island passes. The proposed action is occurring primarily in an open-water environment and will not restrict fish migration. No significant short-term or long-term effects to migratory passage have been identified. The remaining area surrounding the islands would be available for the sturgeon's migration.

Sediment quality: Sediment quality and texture of the material are expected to be similar to the existing conditions at the placement areas. It is expected this constituent element will not be significantly affected by the proposed activity.

Water quality: Impacts from sediment disturbance during construction are expected to be temporary and minimal, with suspended particles settling out within a short time frame, with no measurable effects on water quality. No changes in temperature, salinity, pH, hardness, oxygen content, and other chemical characteristics are expected.

Further consultation with resource agencies will ensure that alteration of Gulf sturgeon critical habitat will not result in adverse modification of the habitat. Evaluation of potential impacts to the four primary constituent elements of critical habitat present in Mississippi Sound follows.

4.3.2.6 Barrier Island Restoration Water Quality Impact

BMPs would be utilized to reduce turbidity associated with placement activities. There are no substantive differences among the water quality impacts of the alternatives evaluated. It is anticipated there would be minimal impacts to water quality in association with activities. This measure would result in less direct impacts to the islands themselves by introduction of sand into the littoral zone where the islands are located. The sand would not be placed on the islands, but in areas between the islands where the currents that make up the littoral drift zone could transport the sand to the islands. It is anticipated there would be minimal impacts to water quality due to the sandy material quickly settling out of the water column.

4.3.2.7 Barrier Island Restoration Land Use Impact

There are no substantive differences among the land use impacts of the alternatives considered. Water bottoms at the littoral site and breach would be filled at shallow depths in association with barrier island restoration. Alteration of land use is expected due to the changes associated with filling in of water bottoms and their conversion to sandy barrier island resulting in expanded acreage. It is anticipated this change in land use would be insignificant as islands would be expanded to historical sizes; thus, benefiting the Mississippi Sound's ecological persistence.

4.3.2.8 Barrier Island Restoration Cumulative Effects

Tables 4-5 and 4-6 provide the Functional Habitat Index (FHI) benefits that would be achieved by implementation of this proposed construction compared to the no action.

Table 4-5
Littoral Zone Placement & Fill of Breach Between West & East Ship Islands

Habitat Units										
Assessment Variables	*Shorebirds*	*Waterfowl*	*Migratory Birds*	*Raptor*	*Beach Fauna*	*Dune Flora and Fauna*	*Oysters*	*Estuarine Fish*	*T&E Species*	*FHI Unit*
Island Persistence	10	8	10	8	10	10	10	10	10	86
Shoreline Stabilization	10	8	8	8	10	10	10	6	10	80
Reproduction Habitat	10	0	0	0	8	10	10	10	10	58
Feeding Habitat	10	6	10	8	8	10	10	10	10	82
Roosting Habitat	10	6	8	6	10	10	10	10	10	80
Wintering Habitat	10	6	8	6	10	10	10	10	10	80
Dune Habitat	10	10	10	10	10	10	10	10	10	90
Beach Habitat	10	10	10	10	10	10	10	10	10	90
Water Column Habitat	8	8	8	8	8	8	10	10	10	78
Water-Land Interface Habitat	10	10	10	10	10	10	10	10	10	90
Fishery Habitat	10	10	10	10	10	10	10	10	10	90
Oyster Habitat	6	6	6	6	6	8	10	8	8	64
									TOTAL FHI	968

Table 4-6
No Action – Barrier Islands

Habitat Units										
Assessment Variables	*Shorebirds*	*Waterfowl*	*Migratory Birds*	*Raptors*	*Beach Fauna*	*Dune Flora and Fauna*	*Oysters*	*Estuarine Fish*	*T&E Species*	*FHI Unit*
Island Persistence	0	0	0	0	0	0	0	0	0	***0***
Shoreline Stabilization	0	0	0	0	0	0	0	0	0	0
Reproduction Habitat	0	0	0	0	0	0	0	0	0	0
Feeding Habitat	0	0	0	0	0	0	0	0	0	0
Roosting Habitat	0	0	0	0	0	0	0	0	0	0
Wintering Habitat	0	0	0	0	0	0	0	0	0	0
Dune Habitat	0	0	0	0	0	0	0	0	0	0
Beach Habitat	0	0	0	0	0	0	0	0	0	0
Water Column Habitat	2	2	2	2	2	2	2	2	2	18
Water-Land Interface Habitat	0	0	0	0	0	0	0	0	0	0
Fishery Habitat	2	2	2	2	2	2	2	2	2	18
Oyster Habitat	2	2	2	2	2	2	2	2	2	18
									TOTAL FHI	**54**

4.4 Comprehensive Plan Components Recommended for Construction

The following components of the Comprehensive Plan are ready for advanced design and implementation. These projects are presented in support of a Record of Decision for construction:

- Coastal Wetland and Forest Restoration:
  - Turkey Creek
  - Bayou Cumbest
  - Dantzler
  - Admiral Island
  - Franklin Creek
- Submerged Aquatic Vegetation Restoration;
- Coast-wide Beach and Dune Restoration;
- Moss Point Municipal Structure Relocation
- Waveland Flood Proofing; and
- Forrest (Forest) Heights Hurricane and Storm Damage Reduction.

The potential project impacts on some parameters are similar and are presented jointly for the projects recommended for construction. Impacts to other parameters are presented separately for each recommended project. The jointly presented impact parameters include:

- Soils
- Sediments
- Geology
- Climate
- Air Quality
- Noise
- Cultural Resources
- Aesthetic Resources
- Hazardous, Toxic, and Radioactive Wastes
- Environmental Justice
- Protection of Children
- Unavoidable Adverse Environmental Effects
- Irreversible and Irretrievable Commitments of Resources

4.4.1 Tentatively Selected Plans - Soils Impacts

Alteration of soils is anticipated within environmental restoration projects – also in conjunction with the HARP; however, in some instances, old fill material would be removed for reestablishment of more native types of soils generally found in the natural system. Alteration of soils could occur as a result of barrier island restoration as sand is introduced onto existing water bottoms. Soils could also be altered at the levees via use of fill material.

4.4.2 Tentatively Selected Plans - Sediments Impacts

Re-suspension of sediments would likely occur within specific project sites. Silt fences and other BMPs would be used to minimize the adverse impacts to the environment during construction activities to the maximum extent practicable. Containment structures, silt curtains, and other BMPs would be used to contain sediment deposition at construction and environmental restoration sites. It

is expected that solids that remain suspended in the water column would migrate by littoral drift. Any impacts that might occur would typically be isolated to each construction site, minor and of short duration. The freshwater diversion project would result in increased nutrients and sediment being released; however, it is anticipated the amount of sediment actually transferred would be relatively limited.

4.4.3 Tentatively Selected Plans - Geology Impacts

There should be no effects to geology. Potential projects have been or would be designed to avoid impacts to current geological formations.

4.4.4 Tentatively Selected Plans - Climate Impacts

There should be no effects to the existing climate.

4.4.5 Tentatively Selected Plans - Air Quality Impacts

Currently, all areas within coastal Mississippi are in attainment with the NAAQS. Air quality in the immediate vicinity of project construction would be slightly affected for a period of time by the fuel combustion and resulting engine exhausts. At those environmental restoration sites requiring burning, such as Turkey Creek, a temporary degradation of air quality is anticipated. Burning the restoration sites would cause emissions of many different chemical compounds, such as small particles, NO, CO, and organic compounds. The compounds and quantity of emissions depends in part on the types of fuel burned, its moisture content, and the temperature of combustions. Visibility conditions are affected by scattering and absorption of light by particles and gases. The fine particles most responsible for visibility impairment are sulfates, nitrates, organic compounds, soot and soil dust. Fine particles are more efficient per unit mass than coarse particles at scattering light. Light scattering efficiencies also go up as humidity rises, due to water adsorption on fine particles, which allow the particles to grow to sizes comparable to the wavelength of light. This is anticipated to be a temporary impact. The standards would not be violated by the implementation of the proposed project.

4.4.6 Tentatively Selected Plans - Noise Impacts

Noise from the construction type equipment is expected to increase during the proposed operations in the project vicinities. Noise levels will resume to existing conditions as construction activities are completed. It is anticipated there would be no significant impacts to noise levels during implementation of these measures.

4.4.7 Tentatively Selected Plans - Water Supply Impacts

There should be no effect on water supply. Potential projects have been or would be designed to avoid impacts to existing public water supply infra-structure and operating facilities.

4.4.8 Tentatively Selected Plans - Socio-Economic Impacts

Refer to the Economic Appendix for more specific details regarding the direct and indirect socio-economic impacts of the recommended projects throughout coastal Mississippi.

Population - It is expected that non-structural projects would benefit the population of the study area. Relocation of homes outside of the high-hazard surge-plain would relocate at risk populations into safer areas that are not vulnerable to storm surges and associated flooding. Flood-proofing of homes would help reduce damages from future flooding events. Environmental restoration would enhance fish and wildlife; thus, potentially benefiting the population of coastal Mississippi.

Employment and Income - Implementation of these tentatively selected plans could result in a positive increase to employment and income of the area and its residents. This effort could also result in the creation of jobs due to project related expenditures.

Housing – Environmental restoration projects would not directly impact housing within coastal Mississippi because no habitable properties would be acquired to implement restoration alternatives. Non-structural and structural projects would benefit current housing stock by reducing damages from future storm and flood events and increasing the quality and value of housing within project implementation areas.

Quality of Life - Implementation of these tentatively selected plans could improve quality of life within coastal Mississippi. Additional wetland restoration would enhance water quality, wildlife habitat, and various natural resource functions as a result of restoration activities. Non-structural and flood damage reduction projects would enhance current living conditions.

Schools - Implementation of this measure would not impact schools within coastal Mississippi.

Public Safety - It is anticipated there could be positive effects to public safety by implementation of the potential measures. Wetland restoration would benefit water quality, wildlife habitat, and various natural resource functions. Non-structural and storm damage reduction projects would improve public safety by the relocation of people outside of the high-hazard areas and reduced damages from flood events.

Recreation - It is anticipated there would be minimal benefits to recreation associated with implementation of the projects.

Transportation and Traffic - It is anticipated there would be no transportation impacts associated with implementation of the projects.

4.4.9 Tentatively Selected Plans - Aesthetics Impacts

During construction aesthetics would be temporarily reduced in the immediate vicinity of the proposed project sites. Many recreational vessels utilize Mississippi Sound within the project vicinities and it is believed some residents and visitors may be disturbed by the presence of required heavy equipment during any construction phases. However, construction activities would be temporary in nature so the disturbance would be anticipated to be minimal at each potential restoration project site. There could be times when numerous projects throughout coastal Mississippi would be under construction simultaneously. The restoration projects should provide residents and visitors with an overall more aesthetically pleasing view as projects are completed.

The environmental restoration projects would provide additional fish and wildlife habitat to numerous shorebirds and various wildlife species, which would enhance coastal Mississippi and its diverse aquatic habitats while providing future sustainability of the natural system.

4.4.10 Tentatively Selected Plans -Cultural Resources Impacts

The vast majority of historic and prehistoric sites are found along the immediate coastal strand and adjacent to estuarine systems. Preference for well-drained, sandy soils adjacent to water sources is apparent. Coast wide survey work performed by both state (Giliberti n.d.) and private researchers (Blitz and Mann 2000) have found a distinctive focus on the immediate coastal and estuarine locations. Unfortunately, the geographic placement of these resources has made them extremely vulnerable to destruction from continued occupation and development, as well as vulnerable to the effects of tropical storms and hurricanes.

Modern development along the Mississippi coast has affected both archaeological sites and standing structures, including individual structures and historic districts in the project area. Key issues are soil disturbance and construction. Soil disturbance affects archaeological sites, and

construction of new buildings and associated infrastructure can affect the view shed and "feel" of a historic building or district or cause demolition or alteration of historic buildings.

From the early 1970s to the present, construction in the project area has greatly increased. In fact, more development and construction has occurred in the three counties that are part of the project area than anywhere else in the state. Land use studies show that between 1972 and 2000 both medium-density and high-density urban land use areas increased by more than 90 percent in the study area; overall, developed land use increased by almost 70 percent during that period (MARIS 1992, 2000; USGS 1972; USGS and USEPA 1992). This sizeable increase in developed land is caused in part by the casinos and related infrastructure, residential, and commercial construction. The development involves large areas of soil disturbance, which destroys archaeological sites.

Previous archaeological and architectural studies along the Mississippi Gulf Coast have documented the destruction caused by natural forces, most notably hurricanes. Standing structures are often the most dramatic and visible witnesses to this destruction. However, prehistoric and historic archaeological sites are also extremely vulnerable. Shell middens, found along the immediate shoreline and within coastal marshes and estuaries, often are flipped and re-deposited by the storm surge and wave action of hurricanes. This effectively destroys much of the value of the sites. Sites such as Indian villages and historic town sites such as those along the bluff on Bay St. Louis can also be destroyed by such wave action. In addition, post storm activities offer many more mechanisms for site destruction. These include clearing of timber by use of skidders and other heavy equipment, debris removal, and reconstruction. The destructiveness of these activities is well documented from the years following hurricane Camille which struck the area in 1969.

Corps, Mobile District Archaeologists, through long standing coordination relationships developed throughout the years, coordinated closely with the Mississippi Department of Archives and History staff in determining effects of the storm event. Hurricane Katrina has been documented to have destroyed a vast majority of the standing historic properties within Hancock County, and a large number of those within Harrison and Jackson Counties. The size and strength of the storm surge has also undoubtedly had as much destruction on archaeological sites. Post hurricane activities have further impacted the remaining historic properties.

Protection from the immediate and post-effects of hurricanes should be considered as beneficial to cultural resources. While some historic properties may be adversely affected by protection plans, long term prevention of damage should be considered a positive measure for historic properties, in particular standing structures.

Mobile District archaeologists are closely coordinating with the State of Mississippi Department of Archives and History regarding potential impacts associated with potential measures being considered in the Comprehensive Plan. Additionally, FEMA and the Mississippi Development Authority are conducting individual cultural resources analyses in conjunction with their identified projects. Mobile District archaeologists will be given access to other agency's findings and reports and will be informed as additional projects are being analyzed regarding cultural resources. Once specific projects become funded, cultural resources analysis would occur on an individual project basis to ensure compliance.

Many of the current analyses that might be needed could actually be in duplication of what is currently being conducted by other agencies. Ongoing coordination with SHPO and other agency representatives will help to prevent duplication of efforts for cultural resources compliance.

4.4.11 Tentatively Selected Plans - HTRW Impacts

Quickly after Hurricane Katrina, the EPA working with the National Strike Team and other national search and rescue teams began identification and cleanup of the Household Hazardous Wastes and other hazardous type debris. The EPA established partnerships with other national and local teams

involved with debris cleanup. The Corps team coordinated with them regularly and provided coordinates/locations of HHW and HTRW that were located during vegetative and construction type debris cleanup. The EPA working with others were charged with the responsibility of final cleanup of this type debris after the storm event.

Site inspections would be conducted at and adjacent to the various components of the proposed projects during development of specific plans and specifications in accordance with the requirements of ER 1165-2-132 entitled, HTRW Guidance for Civil Works Projects, and the American Society of Testing and Materials Standard E 1527.

Inspections would be accomplished to determine the presence or evidence of landfills, surface areas unable to support vegetation, visible sheens of petroleum product, nearby contaminated industrial facilities, or any type of visible indication that HTRW concerns exist that may impact any component of the recommended plans during specific project development. Site inspections of adjacent properties, reviews of historic aerial photographs, on site interviews, and environmental database record searches would be conducted to determine any evidence of HTRW concerns that may impact any component of the recommended plans during specific project development.

Based on the findings of the HTRW site assessments, specific or unusual environmental concerns that are identified that could affect construction of any proposed projects would be addressed appropriately. Additional supplemental environmental impacts statements or environmental analyses may be necessary once specific projects have been identified and development of project plans has begun. HTRW issues and concerns would be addressed during the required NEPA compliance and documentation.

4.4.12 Tentatively Selected Plans - Environmental Justice Impacts

EO 12898, Federal Actions to address Environmental Justice in Minority and Low-Income Populations (February 11, 1994) requires that Federal agencies conduct their programs, policies, and activities that substantially affect human health or the environment in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under such programs, policies, and activities because of their race, color, or national origin. On February 11, 1994, the President also issued a memorandum for heads of all departments and agencies, directing that EPA, whenever reviewing environmental effects of proposed actions pursuant to its authority under Section 309 of the CAA, ensure that the involved agency has fully analyzed environmental laws, regulations, and policies.

The projects being recommended for construction are not designed to create a benefit for any specific group or individual. Any potential measures would not create disproportionately high or adverse human health or environmental impacts on minority or low-income populations within the study area. Since the establishment of the Turkey Creek Community, which includes Forrest (Forest) Heights within its vicinity, by freed slaves and their descendants, federally funded construction programs including the Gulfport Regional Airport, U.S. Highway 49, and Interstate-10 have impacted the Turkey Creek watershed. In addition, numerous other constructions including hotels, shopping centers and housing developments have been federally permitted to fill wetlands and construct within the Turkey Creek watershed. Review and evaluation of the overall comprehensive plan have not disclosed the existence of identifiable minority or low-income communities that would be adversely impacted by proposed measures.

A detailed discussion on the *Historic and Existing Conditions Data from the U.S Department of Commerce, Census of Population and* Housing has been provided in Section 4.2.1.21. This analysis will serve as a beginning point from which further analyses can be built upon during the comprehensive plan components. Ultimately, the plan adopted for the Mississippi coast will not be a

plan forced on them by the Corps or other Federal agencies, but a plan coordinated, discussed, and finally adopted by the numerous entities and individuals that will live with that plan, the residents and local government of coastal Mississippi.

4.4.13 Tentatively Selected Plans - Protection of Children Impacts

The EO 13045, Protection of Children from Environmental Health Risks and Safety Risks (April 21, 1997), recognizes a growing body of scientific knowledge that demonstrates that children may suffer disproportionately from environmental health risks and safety risks. These risks arise because children's bodily systems are not fully developed; because children eat, drink, and breathe more in proportion to their body weight; because their behavior patterns may make them more susceptible to accidents. Based on these factors, the President directed each Federal agency to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children. The President also directed each Federal agency to ensure that its policies, programs activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

It is anticipated that no disproportionate risks to children would occur as a result of the projects being recommended for construction. Further studies during project development phase would determine any activities that might pose any disproportionate environmental health risks or safety risks to children.

4.4.14 Tentatively Selected Plans - Unavoidable Adverse Environmental Effects

It is anticipated that any adverse environmental effects, which could not be avoided should potential projects be implemented, should be temporary and localized and would be minor individually and cumulatively.

4.4.15 Tentatively Selected Plans - Irreversible and Irretrievable Commitments of Resources

Any irreversible or irretrievable commitments of resources involved in any potential proposed projects have been considered and are either unanticipated at this time or will be considered to determine if any would present minor impacts.

The following section provides a thorough detailed analysis of the No Action and Recommended Plans. The detailed analysis for alternatives considered for each restoration project can be found in the Environmental Appendix.

4.5 Beach and Dune Restoration

In addition to the no action alternative, three alternative actions were evaluated. Each proposed action is comprised of a stand alone dune at alternative heights with alternative berm widths as presented below:

- Alternative I: dune elevation 10 ft with 50 ft crest, extended berm to match and sand fence;
- Alternative J: dune elevation 10 ft with 50 ft crest, extended berm to match and sand fence, plus planting dune/fence area; and
- Alternative K: dune elevation 2ft, 60 ft berm, sand fence with planting.

The higher dune elevation alternatives (Alternative I and J) were projected to disrupt highway traffic due to wind blown sand and were therefore not carried forward for full evaluation. The effects of the no action plan and the recommended plan (Alternative K) are discussed below. Only the parameters

which have discernable differences between the no action plan and the recommended plan are presented in the discussion below.

4.5.1 Beach and Dune No Action Plan and Impacts

The No Action alternative involves the continuation of existing conditions and no new solutions for existing problems. This alternative avoids both the monetary investment and potential adverse impacts associated with improvements. Future conditions associated with not restoring the dune feature would result in the continued absence of a valuable ecosystem, including critical habitat for the piping plover, various shorebirds including the least tern, and numerous fish and wildlife species. The immediate area would remain particularly vulnerable to wave and storm activity that continually threaten the mainland shoreline and prevent the re-establishment of the dune system. Maintenance of existing beaches occurs approximately every 12 years by hydraulic placement of sand obtained from within near offshore area. In some instances, particularly in Hancock and Jackson Counties, maintenance of existing beaches occurs annually with sand being obtained from commercial sources and trucked to the site. The No Action Plan would result in continuing current maintenance practices with the potential for increased volumes of sand associated with intensities and frequencies of future storm events.

4.5.1.1 Beach and Dune Restoration No Action Vegetation Impacts

Implementation of the No Action Plan would result in eroded beaches and dunes. The loss of dune vegetation would occur as erosion occurs.

4.5.1.2 Beach and Dune Restoration No Action Fish and Wildlife Impacts

The No Action Plan would allow the beach to become unstable due to erosion and the loss of habitat for nesting and foraging shorebirds and migratory birds would occur.

4.5.1.3 Beach and Dune Restoration No Action Threatened and Endangered Species Impacts

Loss of valuable over-wintering foraging areas for the piping plover would occur.

4.5.1.4 Beach and Dune Restoration No Action Water Quality Impacts

No impact is anticipated to water quality.

4.5.1.5 Beach and Dune Restoration No Action Land Use Impacts

The No Action Plan would not cause a change in land use impacts since these areas are maintained for public benefit.

4.5.1.6 Beach and Dune Proposed Actions and Impacts

Existing beaches, located along approximately one-half of coastal Mississippi mainland shoreline, are situated seaward of existing concrete seawalls. Dune restoration would provide additional protection against erosion during small storm events as well as provide feeding grounds and nesting areas for various birds, crabs, and other fauna.

The Proposed Action would consist of creation of a dune field that would be constructed approximately 50 feet seaward of the existing seawall and about 2 feet above the existing berm with a width of approximately 60 feet running the length of the three coastal counties. The project would include planting of dune vegetation and sand fencing to enhance establishment and survival of the dune vegetation. Sand would be obtained from borrow areas historically used located offshore of the mainland or from upland commercial sources brought in by trucks.

4.5.1.7 Proposed Beach and Dune Restoration Vegetation Impacts

It is anticipated there would be no adverse impacts to vegetation as a result of the proposed action. Actually, the project would provide a benefit to vegetation as native dune plantings occur.

4.5.1.8 Proposed Beach and Dune Restoration Fish and Wildlife Impacts

It is anticipated that implementation of the proposed action would provide significant benefits to fish and wildlife by nourishment of the beaches and reconstruction of damaged or lost dunes. Dunes provide natural habitat and by restoration, the beach dwelling species gain lost habitat. These beaches provide important stopover habitat for species of migratory birds. The beaches are currently designated critical habitat for piping plover. Enhancement of this habitat would benefit piping plover and other shorebirds. The beaches have existed since the mid-fifties and have experienced erosion and nourishment throughout the years. Nourishment activities would not result in significant impacts to the benthic community within the project vicinity.

4.5.1.9 Proposed Beach and Dune Restoration Threatened and Endangered Species Impacts

Overall implementation of the proposed action would benefit piping plover and its critical habitat by an increased amount of over wintering foraging areas. Temporary impacts could occur during construction but could be avoided during the times the piping plover are on the over wintering grounds. Impacts associated with construction activities should be temporary and isolated to actual construction limits. Brown pelicans could utilize the project areas; however, it is anticipated these species would avoid the construction area due to noise and activity. These impacts would be temporary and isolated to actual construction limits. Surveys to determine if nesting brown pelicans are present could be conducted to avoid any impacts. Manatees, Gulf sturgeon and sea turtles could be in the project's borrow area location and there is potential for adverse impacts to occur. It is anticipated these species would primarily avoid the construction areas due to noise and activity resulting in less risk for harm or harassment. Methods of dredging would be utilized to avoid adverse impacts to listed species. Placement activities would be accomplished using appropriate best management practices to reduce turbidity and other potential adverse impacts to species and its critical habitat. Further consultation would be required to determine adverse impacts to critical habitat for the Gulf sturgeon. It is anticipated Whale species would not be present within the project area. Further consultation would determine potential impacts to listed species. Biological Assessments of particular project components would need to be evaluated under future programmatic consultations.

4.5.1.10 Proposed Beach and Dune Restoration Water Quality Impacts

BMPs would be used to minimize impacts to water quality during placement and construction activities. It is anticipated there would be minimal impacts to water quality resulting from the proposed action. Turbidity should be localized to the placement activities and short term in nature.

4.5.1.11 Proposed Beach and Dune Restoration Land Use Impacts

Beach nourishment and construction of the dune feature would help sustain current land use along the existing beach front.

4.6 Admiral Island

Six alternatives plus a no action alternative were considered for ecosystem restoration at Admiral Island. Ecosystem restoration at Admiral Island falls within the Congressional authorization for fish and wildlife preservation on the Mississippi coast.

- No Action
- Plan 1 – Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.
- Plan 2 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.
- Plan 3 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 2 meter spacing.
- Plan 4 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.
- Plan 5 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.
- Plan 6 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

4.6.1 Admiral Island No Action Plan and Impacts

Implementation of the No Action Plan would allow degraded conditions to continue on the existing state-owned property. Tidal marshes in this area were ditched in the 1960s causing changes in the natural hydrology and subsequent changes in the species composition. Hurricane Katrina left extensive debris fields and sedimentation in the area destroying many native trees and vegetation. Due to the loss of native species and the subsequent open spaces, this area has a severe infestation of the invasive Chinese Tallow Tree, which is invading the marshes and adjacent flatwoods.

4.6.1.1 Admiral Island No Action Vegetation Impacts

The invasive species would continue to thrive threatening to take over the site. Persistence of the exotic species would diminish the native food supply to migratory birds and the associated wildlife found in the area. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition.

4.6.1.2 Admiral Island No Action Fish and Wildlife Impacts

The invasive species would continue to thrive threatening to take over the site reducing available native forage for fish and wildlife species to use the area. Lack of available habitat could cause fish and wildlife species to move from the area seeking more suitable habitat.

4.6.1.3 Admiral Island No Action Threatened and Endangered Species Impacts

It is anticipated there will be no impacts to T&E species as the project area does not offer suitable habitat for any of the listed species.

4.6.1.4 Admiral Island No Action Water Quality Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. Continued degradation of the site would further reduce any water quality functions that currently exist.

4.6.1.5 Admiral Island No Action Land Use Impacts

The invasive species would continue to thrive threatening to take over the site; thus, eventually outcompeting the native species and ultimately changing land use. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species

composition; however there should be no change to current land use as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

4.6.2 Admiral Island Proposed Actions and Impacts

The restoration site contains 62 acres of emergent tidal marsh to be restored. The remaining 61 acres of scrub shrub wetland habitat would remain. The tidal marshes in this area were ditched during the 1960s causing changes in the natural hydrology and subsequent changes in the species composition. Hurricane Katrina left extensive debris fields and sedimentation in the area and destroyed many native trees and vegetation. Due to the loss of native species this area has a severe infestation of the invasive Chinese Tallow tree, which is invading the marshes and the adjacent flatwoods. For increased habitat diversity, higher elevations containing shrub/scrub wetland plant species would remain in order to enhance diversity within the restoration site. The following measures were developed:

1. Excavation of old fill material (includes 90-95% removal of existing exotic species in excavated areas) (Mandatory).

This measure, in conjunction with measure 3, affects the hydrologic regime variable, which under existing conditions receives a score 0.25, on the assumption that greater than half the site has been filled above the normal tidal flooding zone. This measure by itself would raise the hydrologic regime variable to a 0.75.

2. 100% removal of exotics from non-excavated areas and maintain removal of exotic plant species in all areas over project lifetime. (Mandatory in all plans).

This measure affects the “percent cover by invasive or exotic species” variable, and would raise the variable score to 1.0 under all plans

3. Filling in 100% of existing artificial ditches/channels.

If this measure is performed in addition to the mandatory measure 1, the hydrologic regime variable score would increase to 1.0 as there would be no more hydrologic alterations to the site.

4. Native Vegetation Planting

Alternatives:

a) 0.5 meter spacing

b) 1 meter spacing

c) 2 meter spacing

This measure affects the “percent cover by woody plant species”, “wildlife habitat diversity”, “vegetation height”, “wetland indicator status” and “mean percent cover emergent plant species” variables. The relevant vegetation variables are assumed to reach their highest potential score at year 5 under 0.5 meter spacing, year 7 with 1.0 meter spacing, and year 10 with 2.0 meter spacing, and then sustained at that level for the project life (50 years). Variable sub index scores are treated as increasing linearly from their value under the no-action plan up to their highest potential value obtained at year 5, 7, or 10, depending on the planting spacing, and then remaining constant thereafter.

A combination of measures resulted in the following plan combinations and a summary of functional unit benefits are shown in the Tables 4-7 and 4-8 below:

Table 4-7
Admiral Island Measures

Plan 1. 1,2,3,4a	Plan 2. 1,2,3,4b	Plan 3. 1,2,3,4c
Plan 4. 1,2,4a	Plan 5. 1,2,4b	Plan 6. 1,2,4c

Table 4-8
Admiral Island Restoration Plans - Summary of AAFU Benefits

Site	Restoration Acres	Plan	AAFU Benefit
Admiral Island	62	No-action plan	0
Admiral Island	62	Plan 1	61
Admiral Island	62	Plan 2	60
Admiral Island	62	Plan 3	59
Admiral Island	62	Plan 4	51
Admiral Island	62	Plan 5	50.5
Admiral Island	62	Plan 6	49

The PDT selected Plan 2 as the best buy plan using the IWR planning suite, based on cost estimates and benefits gained by each alternative. The following analysis is based on Plan 2 being recommended for construction.

4.6.2.1 Admiral Island Restoration Alternative Vegetation Impacts

There will be a benefit to vegetation as the recommended plan will restore hydrology and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species; however, it is the most cost-effective method. This will reduce the percent cover which could allow for exotics to reestablish in the future but with future plantings/management this would be minimized. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Vegetation would support the vital migratory bird population moving through Mississippi.

4.6.2.2 Admiral Island Restoration Alternative Fish and Wildlife Impacts

There will be a benefit to fish and wildlife species, including the migratory bird population, as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species; however, it is the most cost-effective method. This will reduce the percent cover which could allow for exotics to reestablish in the future; however, it is the most cost-effective method but with future plantings/management this would be minimized. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return and to provide necessary habitat for fish and wildlife species.

4.6.2.3 Admiral Island Restoration Alternative Threatened and Endangered Species Impacts

It is anticipated there will be no impacts to T&E species as the project area does not offer suitable habitat for any of the listed species.

4.6.2.4 Admiral Island Restoration Alternative Water Quality Impacts

There will be a benefit to water quality as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for

expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Once complete, the project would mature over a longer period of time; however, the project would provide for improved water quality functions. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

4.6.2.5 Admiral Island Restoration Alternative Land Use Impacts

There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

4.7 Dantzler

Two alternative actions and a no action alternative were considered for ecosystem restoration at Dantzler. Variations on the two alternative action plans were also considered. Ecosystem restoration at Dantzler falls within the Congressional authorization for fish and wildlife preservation on the Mississippi coast.

- No Action
- Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.
- Plan 2 – Maintain Savannah Vegetation by Mowing Annually, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.

4.7.1 Dantzler No Action Plan and Impacts

Implementation of the No Action Plan would allow degraded conditions to continue on the existing state-owned property. The area was planted in plantation pines during the 1960s and ditches and stormwater lines were constructed in the 1970s in anticipation of residential development of the site. Long term exclusion of fire and the invasion of non-native species, cogongrass and Chinese Tallow Trees have severely degraded the site.

4.7.1.1 Dantzler No Action Plan Vegetation Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community.

4.7.1.2 Dantzler No Action Plan Fish and Wildlife Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession, creating a mixed pine/hardwood forest community thus shifting the fish and wildlife species that would normally use the historical pine savannah habitat.

4.7.1.3 Dantzler No Action Plan Threatened and Endangered Species Impacts

The invasive species would continue to thrive threatening to take over the site further degrading available habitat for use by the Mississippi Sandhill Crane.

4.7.1.4 Dantzler No Action Plan Water Quality Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community.

4.7.1.5 Dantzler No Action Plan Land Use Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and creating a mixed pine and hardwood community. There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

4.7.2 Dantzler Proposed Alternatives and Impacts

The restoration site contains 385 acres to be restored to wet pine savanna. This area was planted in plantation pine during the 1960s and ditches and stormwater lines were constructed in the early 1970s in anticipation of residential development of the site. The long-term exclusion of fire and the invasion of non-native species such as Cogongrass and Chinese Tallowtree have severely degraded the site. The following measures were developed:

1. Maintain native savanna vegetation. (Mandatory)

    Alternative:

    a. prescribed burning on a 3-5 year cycle.

    b. mowing annually.

This measure affects the “area of contiguous fire-maintained landscape”, as well as all plant related variables used in the model. It is assumed that these variables will recover to a score of 1.0 under the burn alternative. Under the mowing alternative, the “area of contiguous fire-maintained” landscape variable will score a 0.0 but the plant related variables will still score a 1.0, similar to burning.

2. 100% removal of exotics and plantation pine; maintain removal of exotic plant species in all areas over project lifetime. (Mandatory in all plans).

This measure affects the “percent cover by invasive or exotic species” variable, and would raise the variable score to 1.0 under all plans

3. Filling in 100% of existing artificial ditches. (Mandatory)

If this measure is performed in addition to the mandatory measure 1, the hydrologic regime variable score would increase to 1.0 as there would be no more hydrologic alterations to the site.

A combination of measures resulted in the following plan combinations and a summary of functional unit benefits are shown in Tables 4-9 and 4-10 below:

Table 4-9
Dantzler Restoration Measures

Plans 1-2.	Restoring areas both north and south of road (areas A and B)	
	Plan 1. 1a,2,3	Plan 2. 1b,2,3
Plans 3-4.	Restoring only area north of road (Area A)	
	Plan 3. 1a,2,3	Plan 4. 1b,2,3
Plans 5-6.	Restoring only area south of road (Area B)	
	Plan 5. 1a,2,3	Plan 6. 1b,2,3

Table 4-10
Dantzler Restoration Plans - Summary of AAFU Benefits

Site	Restoration Acres	Plan	AAFU Benefit
Dantzler	385	No-action plan	0
Dantzler	385	Plan 1	1,244
Dantzler	385	Plan 2	943
Dantzler	151	Plan 3	488
Dantzler	151	Plan 4	370
Dantzler	234	Plan 5	756
Dantzler	234	Plan 6	573

The PDT using the IWR planning suite, selected Plan 1 as the best buy plan based on cost estimates and benefits gained by each alternative. The following analysis is based on Plan 1 being recommended for construction.

4.7.2.1 Dantzler Proposed Alternatives Vegetation Impacts

Implementation of this plan will benefit vegetation. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. The only difference in vegetation impacts among the alternatives is the extent of restoration.

4.7.2.2 Dantzler Proposed Alternatives Fish and Wildlife Impacts

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. Many fish and wildlife species depend on these disappearing habitats. Adequate restoration and fire management is necessary to ensure continued existence of species dependent on pine savannah habitats. Mowing may have more of an impact to nesting birds than the fire regime.

4.7.2.3 Dantzler Proposed Alternatives Threatened and Endangered Species Impacts

Implementation of this plan will benefit the Mississippi Sandhill Crane by restoration of the savannah, the main habitat used by the species for nesting and foraging. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal

of exotic species will allow for native species to remain. The Alabama Red-bellied turtle has been documented in using channels within Mary Walker Bayou, adjacent to the project site. It is anticipated the species could use the project site for nesting. The Mississippi Sandhill Crane depends on this type habitat for its continued existence which has experienced declines due to development within coastal Mississippi. There is no substantive difference in threatened and endangered species impact among the two alternatives.

4.7.2.4 Dantzler Proposed Alternatives Water Quality Impacts

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. It is anticipated that burning activities could have short term impacts to water quality due to runoff during rain events. This should be localized and short term in nature. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi. There is no difference between the alternatives concerning water quality impacts.

4.7.2.5 Dantzler Proposed Action Land Use Impacts

There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

4.8 Turkey Creek

Six alternative actions and a no action alternative were considered for ecosystem restoration at Turkey Creek. Ecosystem restoration at Turkey Creek falls within the Congressional authorization for fish and wildlife preservation on the Mississippi coast.

- No Action
- Plan 1 – Acquire lands and maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.
- Plan 2 – Acquire lands and maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.
- Plan 3 – Acquire lands and maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.
- Plan 4 – Acquire lands and maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.
- Plan 5 – Acquire lands and maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.
- Plan 6 – Acquire lands and maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.

4.8.1 Turkey Creek No Action Plan Impacts

Implementation of the No Action Plan could result in two different scenarios occurring on the privately owned property. The site is primarily comprised of a pine savannah wetland. Several miles

of ditches have been excavated throughout the site. Additionally, an elevated railway berm fragments the wetland habitat substantially altering hydrology of the wetlands located to the north. The project site could continue to degrade or the current landowner could obtain a wetland fill permit in order to develop the site into a commercial development resulting in almost the complete site being paved with impervious surfaces.

4.8.1.1 Turkey Creek No Action Vegetation Impacts

The invasive species would continue to thrive threatening to completely colonize the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community. Development of the site into a commercial site would result in a complete loss of existing vegetation. It is anticipated that any bare soils that would not be covered by paving materials would be vegetated with grass or other ornamental landscaping to reduce erosion.

4.8.1.2 Turkey Creek No Action Fish and Wildlife Impacts

The invasive species would continue to thrive threatening to completely colonize the site; thus, eliminating the valuable. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession, creating a mixed pine/hardwood forest community thus shifting the fish and wildlife species that would normally use the historical pine savannah habitat.

4.8.1.3 Turkey Creek No Action Threatened and Endangered Species Impacts

It is anticipated there will be no impacts to T&E species as the project area does not offer suitable habitat for any of the listed species.

4.8.1.4 Turkey Creek No Action Water Quality Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community.

4.8.1.5 Turkey Creek No Action Land Use Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area undergoes succession and creating a mixed pine and hardwood community. The No Action alternative being implemented would not preclude future development from occurring on the site as the site is owned by a private citizen.

4.8.2 Turkey Creek Proposed Alternatives and Impacts

The restoration site is primarily comprised of a degraded pine savannah wetland. Several miles of ditches have been excavated throughout the site. Additionally, an elevated railway berm fragments the wetland habitat substantially altering hydrology of the wetlands located to the north. All alternatives require the acquisition of the undeveloped property. The following restoration and management measures were developed:

1. Filling in ditches (Mandatory to achieve overall restoration project).

This measure affects the “Outflow of Water” variable, which measures the removal of water by ditches or drains. The variable score would increase from 0.0 to 1.0 under this measure.

2. Maintain vegetation (Mandatory to achieve overall restoration project).

Alternatives:

a. Burn (3-year cycle).

b. Mow (annual).

This measure affects the “area of contiguous fire-maintained landscape”, as well as all plant related variables used in the model. It is assumed that these variables will recover to a score of 1.0 under the burn alternative. Under the mowing alternative, the “area of contiguous fire-maintained” landscape variable will score a 0.0 but the plant related variables will still score a 1.0, similar to burning.

3. Excavate and remove existing roadbeds and any additional fill (Mandatory to achieve overall restoration project).

This measure affects the “surface water storage” variable, which measures the presence of excavation or fill at the site. This variable score would increase from 0.0 to 1.0 in areas with existing roadbeds/fill.

A combination of the measures resulted in the following plan combinations and a summary of functional unit benefits are shown in Tables 4-11 and 4-12 below:

Table 4-11
Turkey Creek Restoration Measures

Plans 1-2.	Restoring areas north and south of railroad	
	Plan 1. 1, 2a, 3	Plan 2. 1, 2b, 3
Plans 3-4.	Restoring just areas south of railroad	
	Plan 3. 1, 2a, 3	Plan 4. 1, 2b, 3
Plans 5-6.	Restoring just areas north of railroad	
	Plan 5. 1, 2a, 3	Plan 6. 1, 2b, 3

Table 4-12
Turkey Creek Restoration Plans - Summary of Functional Unit Benefits

Site	Restoration Acres	Plan	Average Annual Functional Unit Benefit
Turkey Creek	879	Existing Condition (plans 1-2)	-
Turkey Creek	689	Existing Condition (plans 3-4)	-
Turkey Creek	190	Existing Condition (plans 5-6)	-
Turkey Creek	879	No-action plan (plans 1-2)	0
Turkey Creek	689	No-action plan (plans 3-4)	0
Turkey Creek	190	No-action plan (plans 5-6)	0
Turkey Creek	879	Plan 1	2,046
Turkey Creek	879	Plan 2	1,352
Turkey Creek	689	Plan 3	1,565
Turkey Creek	689	Plan 4	815
Turkey Creek	190	Plan 5	481
Turkey Creek	190	Plan 6	327

The PDT using the IWR planning suite selected Plan 3 as the best buy plan based on cost estimates and benefits gained by each alternative. The following analysis is based on Plan 3 being recommended for construction.

4.8.2.1 Turkey Creek Proposed Alternatives Vegetation Impact

Implementation of this plan will benefit vegetation. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories more effectively than the mowing alternatives, which will allow native grasses to become established. Removal of exotic species will allow for native species to remain.

4.8.2.2 Turkey Creek Proposed Plan Fish and Wildlife Impact

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Mowing activities could impact ground nesting birds as well as other terrestrial mammals. Mowing creates additional ground litter that could inhibit daily activities of some species although maintenance of early successional habitat will benefit most species. Removal of exotic species will allow for native species to remain. Many fish and wildlife species depend on these disappearing habitats. Adequate restoration and fire management is necessary to ensure continued existence of

species dependent on pine savannah habitats. This plan would only restore the area south of the railroad berm which would provide a contiguous fire maintained landscape. Larger blocks of habitat are more easily managed using fire and less fragmented landscapes provide more benefits to fish and wildlife species.

4.8.2.3 Turkey Creek Proposed Plan Threatened and Endangered Species Impact

It is anticipated there will be no impacts to T&E species as the project area does not offer suitable habitat for any of the listed species.

4.8.2.4 Turkey Creek Proposed Plan Water Quality Impact

Implementation of any of the proposed alternatives will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. It is anticipated that burning activities could have short term impacts to water quality due to runoff during rain events. This should be localized and short term in nature. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

4.8.2.5 Turkey Creek Proposed Plan Land Use Impact

Implementation of this plan would result in slight changes to current land use due to restoration efforts. The site would continue to exist as a wetland with increased functions. The main change in land use would be that the lands would be restricted from future development with the required acquisition and subsequent inclusion in the Mississippi Coastal Preserves Program.

4.9 Bayou Cumbest

Six alternative actions and a no action alternative were considered for ecosystem restoration at Bayou Cumbest. Ecosystem restoration at Bayou Cumbest falls within the Congressional authorization for fish and wildlife preservation on the Mississippi coast.

- No Action
- Plan 1 – Acquisition of lands, Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.
- Plan 2 - Acquisition of lands, Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.
- Plan 3 - Acquisition of lands, Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 2 meter spacing.
- Plan 4 - Acquisition of lands, Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.
- Plan 5 - Acquisition of lands, Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.
- Plan 6 - Acquisition of lands, Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

4.9.1 Bayou Cumbest No Action Plan and Impacts

The project site consists of existing tidal marsh as well as filled and developed residential areas causing changes in the natural hydrology and subsequent losses and fragmentation to marsh. The developed areas were significantly destroyed by Katrina. Jackson County via a FEMA Hazard Mitigation Grant is purchasing repetitively flooded properties within the Bayou Cumbest area. In total Jackson County will purchase approximately 230 acres (126 parcels). Future development of these parcels will be prohibited. Within the project site, 8.6 acres (9 parcels) fall within the County / FEMA program and of these approximately 4 acres fall within the proposed restoration area.

Hurricane Katrina left extensive debris fields and sedimentation in the area destroying many native trees and vegetation. Due to the loss of native species this area has a severe infestation of the invasive Chinese Tallow Tree, cogongrass, and Phragmites, which are invading the marshes and adjacent flatwoods. The endangered Alabama Red-bellied turtle has been documented with using Bayou Cumbest north of the project site. There is potential this species could be found within Bayou Cumbest near or adjacent to the project site. There are no other documented occurrences of any T&E species within the project vicinity. Implementation of the No Action Plan would result in residents rebuilding their damaged homes in an area vulnerable to future hurricanes, smaller storm events, and potential flooding.

4.9.1.1 Bayou Cumbest No Action Plan Vegetation Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition.

4.9.1.2 Bayou Cumbest No Action Plan Fish and Wildlife Impacts

The invasive species would continue to thrive threatening to take over the site reducing available native forage for fish and wildlife species to use the area. Lack of available habitat could cause fish and wildlife species to move from the area seeking more suitable habitat.

4.9.1.3 Bayou Cumbest No Action Plan Threatened and Endangered Species Impacts

It is anticipated there will be no impacts to T&E species as the project area does not offer suitable habitat for any of the listed species, except for the Alabama Red-bellied Turtle as noted above.

4.9.1.4 Bayou Cumbest No Action Plan Water Quality Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition.

4.9.1.5 Bayou Cumbest No Action Plan Land Use Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The site would remain a severely damaged residential community which may experience moderate rebuilding efforts in the future dependent on the need for and availability of insurance by the proposed developers.

4.9.2 Bayou Cumbest Proposed Actions and Impacts

Of the total 148-acre restoration site, approximately 110 acres would be restored to tidal marsh and while the remaining 38 acres would remain scrub/shrub wetland habitat. The area presently consists of previously filled marsh areas that were developed into a residential community. The proposed project requires the acquisition of approximately 144 acres of developed and undeveloped properties

in addition to the use of 4 acres of land being acquired via the County / FEMA process. Portions of approximately 7 parcels of previously developed land fall within the restoration area (20 acres) with the remaining being undeveloped. The recommended project would require the acquisition of the subject properties according the USACE regulations. The majority of the residences were severely damaged or completely destroyed during the hurricanes of 2005. The following management measures were developed:

1. Excavation of old fill material (includes 90-95% removal of existing exotic species in excavated areas) (Mandatory)

This measure, in conjunction with measure 3, affects the hydrologic regime variable, which under existing conditions receives a score 0.50, on the assumption that approximately half the site has been filled above the normal tidal flooding zone. This measure by itself would raise the hydrologic regime variable to a 0.75.

2. 100% removal of exotics from non-excavated areas and maintain removal of exotic species (Chinese Tallow, Phragmites, Cogon Grass) in all areas over project lifetime. (Mandatory in all plans).

This measure affects the "percent cover by invasive or exotic species" variable, and would raise the variable score to 1.0 under all plans

3. Filling in 100% of existing artificial ditches/channels

If this measure is performed in addition to the mandatory measure 1, the hydrologic regime variable score would increase to 1.0 as there would be no more hydrologic alterations to the site.

4. Native Vegetation Planting

Alternatives

a) 0.5 meter spacing

b) 1 meter spacing

c) 2 meter spacing

This measure affects the "percent cover by woody plant species", "wildlife habitat diversity", "vegetation height", "wetland indicator status" and "mean percent cover emergent plant species" variables. The relevant vegetation variables are assumed to reach their highest potential score at year 5 under 0.5 meter spacing, year 7 with 1.0 meter spacing, and year 10 with 2.0 meter spacing, and then sustained at that level for the project life (50 years). Variable sub index scores are treated as increasing linearly from their value under the no-action plan up to their highest potential value obtained at year 5, 7, or 10, depending on the planting spacing, and then remaining constant thereafter.

A combination of measures resulted in the following plan combinations and a summary of functional unit benefits are shown in the Tables 4-13 and 4-14 below:

Table 4-13
Bayou Cumbest Restoration Measures

Plan 1. 1,2,3,4a	Plan 2. 1,2,3,4b	Plan 3. 1,2,3,4c
Plan 4. 1,2,4a	Plan 5. 1,2,4b	Plan 6. 1,2,4c

Table 4-14
Bayou Cumbest Restoration Plans - Summary of AAFU Benefits

Site	Restoration Acres	Plan	AAFU Benefit[1]
Bayou Cumbest	110	No-action plan	0
Bayou Cumbest	110	Plan 1	191
Bayou Cumbest	110	Plan 2	188
Bayou Cumbest	110	Plan 3	184
Bayou Cumbest	110	Plan 4	172
Bayou Cumbest	110	Plan 5	169
Bayou Cumbest	110	Plan 6	164

(1) AAFU's are based on a 50-year period of analysis.

(2) See economic appendix for cost-effective analysis.

The PDT using the IWR planning suite selected Plan 2 as the best buy plan based on cost estimates and benefits gained by each alternative. The following analysis is based on Plan 2 being recommended for construction.

4.9.2.1 Bayou Cumbest Restoration Alternatives Vegetation Impact

There will be a benefit to vegetation as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. The differences in vegetation impacts among the alternatives are based on differing levels of planting density.

4.9.2.2 Bayou Cumbest Restoration Alternatives Fish and Wildlife Impact

There will be a benefit to fish and wildlife species as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return and to provide necessary habitat for fish and wildlife species. There are no substantive differences among the fish and wildlife impacts of the alternatives.

4.9.2.3 Bayou Cumbest Restoration Alternatives Threatened and Endangered Species Impact

It is anticipated the alternatives will have no impact to T&E species as the project area does not offer suitable habitat for any of the listed species.

4.9.2.4 Bayou Cumbest Restoration Alternatives Water Quality Impact

There will be a benefit to water quality as each of the plans would restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Once complete, the project would mature over a longer period of time; however, the project would provide for improved water quality

functions. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

4.9.2.5 Bayou Cumbest Restoration Alternatives Land Use Impact

There would be a significant change in current land use as the existing site consists of a severely damaged residential community. Construction of any of the alternatives would result in the removal of the residences and restoration of the area into a fully functional wetland. In addition the area would be afforded the protections contained within the Mississippi Coastal Preserves Program into the future.

4.10 Franklin Creek

Acquisition of properties and relocation of homeowners within the Franklin Creek Floodway was authorized as a flood damage reduction measure in response to the MsCIP Interim Report dated 30 December 2006 (P.L. 110-28). Fifty nine parcels (29 unimproved, 30 residential) totaling 149 acres of degraded wet pine savannah are currently being purchased. Four alternative management actions and a no action alternative were considered for ecosystem restoration at Franklin Creek. Ecosystem restoration at Franklin Creek falls within the Congressional authorization for fish and wildlife preservation on the Mississippi coast.

- No Action
- Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.
- Plan 2 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.
- Plan 3 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.
- Plan 4 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.

4.10.1 Franklin Creek No Action Plan and Impacts

The site currently consists of degraded pine flatwoods with numerous areas of fill as a result of residential development and the existing railroad which creates a hydrologic barrier between two separate areas. Implementation of the No Action Plan would result in the historical wetland area remaining a partially filled degraded pine savannah wetland.

4.10.1.1 Franklin Creek No Action Plan Vegetation Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community.

4.10.1.2 Franklin Creek No Action Plan Fish and Wildlife Impacts

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession, creating a mixed pine/hardwood forest

community thus shifting the fish and wildlife species that would normally use the historical pine savannah habitat.

4.10.1.3 Franklin Creek No Action Plan Threatened and Endangered Species Impact

It is anticipated there will be no impacts to T&E species as the project area does not offer suitable habitat for any of the listed species.

4.10.1.4 Franklin Creek No Action Plan Water Quality Impact

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community.

4.10.1.5 Franklin Creek No Action Plan Land Use Impact

Implementation of the flood damage reduction project will remove all structures, slabs, utilities, and some of the roadways in the area. This land will then be entered into the Mississippi Coastal Preserves Program. However, the invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition.

4.10.2 Franklin Creek Proposed Actions and Impacts

The restoration site including removal of utilities, building slabs, and roadways is a MsCIP interim buy-out project currently being implemented. The site consists of 149 acres bisected by an elevated railroad atop an earthen berm. The site received severe flood damages during the hurricanes of 2005 and previous storm events. Historically, the site consisted of pine savannah wetlands. It is assumed that removal of utilities, building slabs, and roadways would be completed as part of the ongoing interim project. The following restoration measures were developed:

1. Filling in ditches (Mandatory)

This measure affects the “Outflow of Water” variable, which measures the removal of water by ditches or drains. The variable score would increase from 0.1 to 1.0 under this measure.

2. Maintain vegetation (Mandatory)

Alternatives

a. Burn (3 year cycle)

b. Mow (annual)

This measure affects the “area of contiguous fire-maintained landscape”, as well as all plant related variables used in the model. It is assumed that these variables will recover to a score of 1.0 under the burn alternative. Under the mowing alternative, the “area of contiguous fire-maintained landscape variable will score a 0.05 but the plant related variables will still score a 1.0, similar to burning.

3. Excavate and remove existing roadbeds and any additional fill (Mandatory)

This measure affects the “surface water storage” variable, which measures the presence of excavation or fill at the site. This variable score would increase from 0.1 to 1.0 in areas with existing roadbeds/fill.

4. Add culverts (Mandatory)

This measure increases the hydrologic connection between the two existing wetland areas separated by an elevated railway. The wetlands are primarily precipitation driven resulting in sheet flow drainage. Additional culverts will result in increased sheet flow drainage reducing standing surface water in the northern wetland area.

A combination of measures resulted in the following plan combinations and a summary of functional unit benefits are shown in Tables 4-15 and 4-16 below:

Table 4-15
Franklin Creek Measures

Plan 1. 1,2a,3,4	Plan 2. 1,2b,3,4
Plan 3. 1,2a,3	Plan 4. 1,2b, 3

Table 4-16
Franklin Creek Restoration Plans - Summary of AAFU Benefits

Site	Restoration Acres	Plan	Average Annual Functional Unit Benefit
Franklin Creek	149	No-action plan (plans 1-2)	0
Franklin Creek	56	No-action plan (plans 3-4)	0
Franklin Creek	149	Plan 1	516
Franklin Creek	149	Plan 2	399
Franklin Creek	56	Plan 3	194
Franklin Creek	56	Plan 4	150

The PDT using the IWR planning suite selected Plan 1 as the best buy plan based on cost estimates and benefits gained by each alternative. The following analysis is based on Plan 1 being recommended for construction.

4.10.2.1 Franklin Creek Alternative Plans Vegetation Impact

Implementation of this plan will benefit vegetation. Restoration of hydrology by excavation of old roadbeds and any additional fill will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. . Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will allow for native species to remain. Installation of culverts increases hydrologic connections between the two separate areas which will improve native vegetation.

4.10.2.2 Franklin Creek Alternative Plans Fish and Wildlife Impact

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established.

Removal of exotic species will allow for native species to remain. Many fish and wildlife species depend on these disappearing habitats. The mowing alternatives could impact ground nesting birds as well as other terrestrial mammals. Mowing creates additional ground litter that could inhibit daily activities of some species although maintenance of early successional habitat will benefit most species. Adequate restoration and fire management is necessary to ensure continued existence of species dependent on pine savannah habitats. This plan would restore the entire area north and south of the railroad berm which would provide a contiguous fire maintained landscape. Larger blocks of habitat are more easily managed using fire and less fragmented landscapes provide more benefits to fish and wildlife species. Unfortunately the railroad berm presents a barrier to hydrology, fire, and fish and wildlife species. To accommodate the barrier, additional culverts would be required as well as additional fire breaks for prevention of damages to the railroad berm by fire. Wildlife crossings would aid in dispersal of fish and wildlife species and would reduce train/wildlife collisions.

4.10.2.3 Franklin Creek Alternative Plans Threatened and Endangered Species Impact

It is anticipated there will be no impacts to T&E species as the project area does not offer suitable habitat for any of the listed species.

4.10.2.4 Franklin Creek Alternative Plans Water Quality Impact

Implementation of any of the alternative plans will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. It is anticipated that burning activities could have short term impacts to water quality due to runoff during rain events. This should be localized and short term in nature. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

4.10.2.5 Franklin Creek Alternative Plans Land Use Impact

Implementation of any of the alternative plans would not result in significant changes to current land use as the land will be part of the Mississippi Coastal Preserves. The value of the land use by wildlife however will be significantly improved with the implementation of any of the alternative management measures.

4.11 SAV Pilot Project

4.11.1 SAV No Action Plan and Impacts

The No Action Plan would result in the continued loss of 5 acres of sea grasses that existed prior to Hurricane Katrina. No new techniques could be identified to aid in future larger seagrass restoration projects in brackish and saltwater systems.

4.11.1.1 SAV No Action Plan Vegetation Impacts

The SAVs will not be restored. SAVs are being lost regularly and successful restoration techniques remain unproven and difficult to quantify. Without this project, the lack of much needed research could lead to continued losses of SAVs throughout coastal Mississippi, especially within brackish water systems.

4.11.1.2 SAV No Action Plan Fish and Wildlife Impacts

The SAVs will not be restored. SAVs are being lost regularly and successful restoration techniques remain unproven and difficult to quantify. A high density of juvenile fish utilizes SAV beds and

without its restoration, benefits to fish would be lost. Without this project, the lack of much needed research could lead to continued losses of SAVs throughout coastal Mississippi, especially within brackish water systems.

4.11.1.3 SAV No Action Plan Threatened and Endangered Species Impacts

The SAVs will not be restored. SAVs are being lost regularly and successful restoration techniques remain unproven and difficult to quantify. Without this project, the lack of much needed research could lead to continued losses of SAVs throughout coastal Mississippi, especially within brackish water systems. The endangered Alabama Red-bellied Turtle feeds on SAVs within fresh and brackish water bodies. Destruction of nesting areas along river banks, feeding areas of SAV, and reduced water quality has impacted this species.

4.11.1.4 SAV No Action Plan Water Quality Impact

The SAVs will not be restored. SAVs are being lost regularly and successful restoration techniques remain unproven and difficult to quantify. Without this project, the lack of much needed research could lead to continued losses of SAVs throughout coastal Mississippi, especially within brackish water systems.

4.11.1.5 SAV No Action Plan Land Use Impact

The SAVs will not be restored. SAVs are being lost regularly and successful restoration techniques remain unproven and difficult to quantify. Without this project, the lack of much needed research could lead to continued losses of SAVs throughout coastal Mississippi, especially within brackish water systems and recovery of the once existent land use would not be accomplished.

4.11.2 SAV Proposed Actions and Impacts

The project site is located within Bayou Cumbest and would consist of re-planting approximately 5 acres of destroyed sea grasses as a result of Hurricane Katrina. The pilot project would evaluate three restoration techniques to demonstrate their feasibility for larger restoration projects. Although it is unclear how to quantify benefits associated with restoration of sea grasses, the following information provides additional benefits associated with implementation of this type pilot project:

Value of SAV to Ecosystems

- Primary production (food for other animals)
- Improves water quality
- Storm protection (dampens waves, currents, and storm surge)
- Value to commercial and recreational fisheries by providing
    - Protection to juveniles from predators
    - Nursery habitat
    - Foraging habitat
- Nutrient cycling (estimated to be $7,700/ac/yr in 1996 USD)
- Sediment filtration and trapping (offset sea-level rise)
- Oxygen production
- Organic-matter production and export (provides materials used in other habitats such as adjacent wetlands and marsh, offsets sea-level rise)
- Prevents/reduces erosion
- Increased species diversity (in both the sediments and SAV beds)

Table 4-17
Fish Species Collected at Grand Bay NERR SAV beds

Scientific Name	Common Name
Anchoa mitchilli	Bay anchovy
Bairdiella chrysoura	Silver perch (drum family)
Brevoortia patronus	Gulf menhaden
Citharichthys spilopterus	Bay whiff (flounder)
Ctenogobius boleosoma	Darter goby
Cynoscion nebulosus	Spotted seatrout
Eucinostomus argenteus	Spot-fin mojarra
Lagodon rhomboides	Pinfish
Leiostomus xanthurus	Spot
Lucania parva	Rainwater killifish
Lutjanus grisues	Grey snapper (mangrove snapper)
Menidia beryllina	Inland silverside
Mugil cephalus	Striped mullet
Oligoplites saurus	Leatherjack
Sphoeroides parvus	Least puffer
Sphyraena guachancho	Guaguanche (barracuda family)
Sygnathus louisianae	Chain pipefish
Sygnathus scovelli	Gulf pipefish
Symphurus plagiusa	Black cheeked toungefish (flounder-like)
Synodus foetens	Inshore lizardfish
Archosargus probatacephalus	Sheepshead
Mycteroperca microlepis	Gag grouper
Chasmodes saburrae	Florida blenny
Orthopristis chrysoptera	Pigfish

In addition, the SAV beds support shrimp and blue crabs, both of which have value as commercial and recreational fisheries along with EFH designation status. SAV beds provide critical nursery areas for many species of fish and shellfish. Menhaden and shrimp, the most important commercial species, depend on estuarine wetlands for protection and food when they are juveniles. The relationship between a fishery and wetlands has been very effectively demonstrated for the shrimp fishery. Research has shown that the productivity of shrimp fisheries is directly related to the amount of vegetated area in an estuary. The more wetlands there are in an estuary, the more shrimp the estuary will produce. Shrimp landings account for more than half of the value of Mississippi commercial fisheries, which is why Mississippi shrimp fishermen, facing declining harvests in some areas, have joined other Gulf of Mexico shrimpers in becoming supporters of efforts to conserve and restore coastal wetlands. Another example of a fisheries dependence on wetlands is found in the menhaden fishery, whose total landings (Atlantic and Gulf of Mexico) have decreased by 26% in the last decade. Menhaden are dependent on wetlands for nursery habitat and the detrital food chain. The regional management plan for Gulf menhaden cites the loss of coastal wetlands as one of the principle threats to that fishery.

4.11.2.1 SAV Alternative Plans Vegetation Impact

Implementation of this pilot project would allow experimental techniques to provide much needed research to restore SAVs and determine the effectiveness of subsequent restoration projects. Additionally, the project will replace lost SAVs as a result of Hurricane Katrina. The functions and

resultant values will help sustain productive foraging and refuge habitat for various life stages of numerous aquatic species.

4.11.2.2 SAV Alternative Plans Fish and Wildlife Impact

Experimental techniques associated with this pilot project would provide much needed research and information to restore SAVs and determine the effectiveness of subsequent restoration projects. Additionally, the project will replace loss SAVs as a result of Hurricane Katrina. The functions and resultant values help to sustain productive foraging and refuge habitat for various life stages of numerous aquatic species.

4.11.2.3 SAV Alternative Plans Threatened and Endangered Species Impact

The knowledge gained from implementing this pilot project has direct and indirect benefits to T&E species, such as the Alabama red-bellied turtle. Initially, the project will replace loss SAVs as a result of Hurricane Katrina, which would provide a possible food source to this protected species. Furthermore, the knowledge gained from implementing this proposed small restoration project would allow future projects to incorporate that information to ensure successful restoration projects; thus, provide future benefits to the Alabama red-bellied turtle.

4.11.2.4 SAV Alternative Plans Water Quality Impact

Experimental techniques would provide much needed research and information needed to restore SAVs and determine the effectiveness of subsequent restoration projects. Additionally, the project will replace loss SAVs as a result of Hurricane Katrina. The functions and resultant values help to improve and sustain water quality as the SAVs trap fine silty sediments increasing water clarity, reducing nutrient levels, and providing for overall less turbidity.

4.11.2.5 SAV Alternative Plans Land Use Impact

Implementation of this pilot project, experimental techniques would provide much needed research and information needed to restore SAVs and determine the effectiveness of subsequent restoration projects. Additionally, the project will replace loss SAVs as a result of Hurricane Katrina. The functions and resultant values help to sustain productive foraging and refugia habitat for various life stages of numerous aquatic species. Implementation of the recommended plan would allow for recovery of the once existent resource, thereby establishing the land use as it existed prior to Hurricane Katrina.

4.12 Deer Island Restoration

Deer Island is considered a mainland remnant and is not part of the coastal barrier system of islands along the Mississippi coast. It is unique in that it is one of only a few islands along the Northern Gulf of Mexico that are totally surrounded by an estuarine environment. The storms of 2005 have acerbated an already eroding shoreline and degrading interior marshes and coastal maritime forest areas. The island contains a diverse habitat of beach/dunes, emergent tidal marshes, and coastal maritime forests. Currently, the uninhabited island is part of the MDMR Coastal Preserves Program. Restoration efforts have been funded under the Section 528 of WRDA of 2000 for breaches at the west end and near Grand Bayou, and parts of the southern shoreline. Although a substantial restoration effort in its own right, there are significant opportunities to further restore the island and repair hurricane-caused damage to the islands' ecosystems.

4.12.1 Deer Island No Action Plan and Impacts

As a result of implementing the No Action Plan, Deer Island would continue its degradation and ultimately increased wave action would occur along the mainland at the City of Biloxi. The southern

shorelines would continue to erode; thus, adversely impacting those dependant species, such as birds and crabs. Wave action from daily occurrences and storm events would eventually erode the beach and then begin eroding the emergent tidal marsh and coastal maritime forests. Furthermore, the Section 204 emergent tidal marsh restoration site would continue to degrade. Ultimately, this unique habitat would continue change from a productive beach/dune, emergent tidal marsh, and coastal maritime forest habitat to stressed and non-functioning habitats.

4.12.1.1 Deer Island No Action Plan Vegetation Impact

Vegetation would be lost due to erosion.

4.12.1.2 Deer Island No Action Plan Fish and Wildlife Impact

Lack of available habitat could cause fish and wildlife species to move from the area seeking more suitable habitat.

4.12.1.3 Deer Island No Action Plan Threatened and Endangered Species Impact

It is anticipated there will be no impacts to T&E species as the project area does not offer suitable habitat for any of the listed species.

4.12.1.4 Deer Island No Action Plan Water Quality Impact

The area would continue to experience changes in hydrology due to erosion of the island and changes in native species composition.

4.12.1.5 Deer Island No Action Plan Land Use Impact

Upon implementation of the No Action Plan, the island could possibly eventually erode away.

4.12.2 Deer Island Proposed Actions and Impacts

Comprehensive Deer Island restoration consists of a combination of the following alternatives to form the recommended plan:

- Repair/Replace the Section 204 containment dike;
- Add/Replace material in the Section 204 containment dike;
- Analyze new stone training dikes on the northern and southern ends of the islands as a result of Section 204;
- Lengthen stone containment dikes on northern and southern ends as a result of Section 204; and
- Create additional marsh habitat area adjacent to the existing created marsh area.

The following table provides an overview of benefits associated with implementation of the proposed project.

Table 4-18
Functional Habitat Index Restoration of Grand Bayou, the West End Breach and Entire Southern Shoreline

Functions	Shoreline Birds	Migratory Birds	Native Fish	Sport Fish	Macro Invertebrates & Primary Producers	Bivalves	Proposed Alternative		Future Without	
							Functional Habitat Index (FHI)	FHI 525 acres	Future w/o FHI	FHI 0 acres
Restoration of Emergent Beach and Dune System	0.10	0.10	0.05	0.05	0.05	-	0.35	183.75	-	0.0
Restoration of Maritime Forest Habitat	0.10	0.10	-	-	0.05	-	0.25	131.25	-	0.0
Soft Substrate	0.05	0.05	0.10	0.10	0.05	0.05	0.40	210	-	0.0
Reestablishment of pre-disturbance shoreline	0.05	0.05	-	-	-	-	0.10	52.5	-	0.0
Reduced Wave Energy along Grand Bayou and the Southern Shoreline	0.10	0.10	0.05	0.05	0.05	0.05	0.40	210	-	0.0
Shoreline Stabilization	0.05	0.05	0.05	0.05	-	-	0.20	105	-	0.0
Roosting Habitat	0.10	0.10	-	-	-	-	0.20	105	-	0.0
Nesting Habitat	0.10	0.10	-	-	-	-	0.20	105	-	0.0
Native Vegetation Propagation	0.10	0.10	0.05	0.05	0.10	-	0.40	210	0.10	0.0
Shoreline Foraging Habitat	0.10	0.10	0.10	0.10	0.05	0.05	0.50	262.5	0.10	0.0
Erosion Control	0.05	0.05	0.05	0.05	0.05	0.10	0.35	183.75	-	0.0
Sediment Stabilization	0.05	0.05	0.05	0.05	0.05	0.10	0.35	183.75	-	0.0
Water Quality	-	-	0.05	0.05	0.05	0.05	0.20	105	-	0.0
Hard Substrate-ocean bottom or submerged rip-rap	-	-	0.05	0.05	-	0.10	0.20	105	-	0.0
Direct Benefit = 0.10					Total FHI =		4.1	2152.5	0.20	0.0
Indirect Benefit = 0.05										

4.12.2.1 Deer Island Alternative Plans Vegetation Impact

It is anticipated there would be no adverse impacts to vegetation. The alternative actions would provide a benefit to vegetation as the project would help stabilize the island ensuring its future sustainability. The marsh creation would help offset losses that have occurred during the past. In some cases, native wetland vegetation would be replanted in place of invasive exotic species.

4.12.2.2 Deer Island Alternative Plans Fish and Wildlife Impact

It is expected that restoration of Deer Island would result in positive impacts to fish and wildlife and their habitat. Overall, the environmental restoration would reduce and assist in the restoration of past losses to habitats.

Construction might cause temporary adverse impacts to fish and wildlife during construction phases; however, lost functions would be returned. Restoration of natural habitats allows for displaced fish and wildlife to re-inhabit these areas. Restoration would result in creation of contiguous blocks of habitat and would result in reduction of fragmentation. Additionally, restoration of these lost habitats would result in an increase to essential lifecycle requirements to numerous species. Hydrology would be restored in areas resulting in increased flushing activities which would help sustain and

increase resources of national importance. Valuable habitat for breeding amphibians would be restored. These habitats are currently experiencing a worldwide decline.

4.12.2.3 Deer Island Alternative Plans Threatened and Endangered Species Impact

Environmental restoration would benefit T&E species; however, there is potential for temporary impacts during construction activities. It is expected the species would avoid project areas during construction due to noise and activity. Further study and consultation would be required to determine the full extent of impacts to listed species associated with implementation of this measure.

4.12.2.4 Deer Island Alternative Plans Water Quality Impact

BMPs would be utilized during construction activities to ensure stabilization of bare soils in order to reduce run off. Environmental restoration activities would improve overall water quality within coastal Mississippi. It is anticipated that implementation of this measure would result in benefits to overall water quality within the study area.

4.12.2.5 Deer Island Alternative Plans Land Use Impact

It is expected that no significant changes in land use would occur as a result of the proposed project as the island is currently owned by the State of Mississippi and is being preserved as a natural wildlife area.

4.13 Moss Point Relocation

The municipal facilities for the City of Moss Point are located adjacent to the shoreline of the Escatawpa River in a low lying flood prone area. The facilities suffered extensive damage during Hurricane Katrina and municipal services were interrupted for an inordinate length of time.

4.13.1 Moss Point No Action Plan and Impacts

The City's municipal services would not be relocated and the badly damaged or uninhabitable structures would have to be reconstructed in the same area as funding becomes available.

4.13.1.1 Moss Point No Action Plan Vegetation Impact

The City's municipal services would not be relocated and the badly damaged or uninhabitable structures would have to be reconstructed in the same area as funding becomes available. There would be no impacts to vegetation as the relocation project would not occur.

4.13.1.2 Moss Point No Action Plan Fish and Wildlife Impact

The City's municipal services would not be relocated and the badly damaged or uninhabitable structures would have to be reconstructed in the same area as funding becomes available. There would be no impacts to fish and wildlife resources as the relocation project would not occur.

4.13.1.3 Moss Point No Action Plan Threatened and Endangered Species Impact

The City's municipal services would not be relocated and the badly damaged or uninhabitable structures would have to be reconstructed in the same area as funding becomes available. There would be no impacts to T&E species as the relocation project would not occur.

4.13.1.4 Moss Point No Action Plan Water Quality Impact

The City's municipal services would not be relocated and the badly damaged or uninhabitable structures would have to be reconstructed in the same area as funding becomes available. It is anticipated there would be only minor, temporary, and insignificant impacts to water quality as a

result of the rebuilding efforts and potential runoff. The use of BMPs should be required to be used on construction sites to reduce runoff during construction activities.

4.13.1.5 Moss Point No Action Plan Land Use Impact

The City's municipal services would not be relocated and the badly damaged or uninhabitable structures would have to be reconstructed in the same area as funding becomes available. There would be no changes to current land use as result of the No Action Plan.

4.13.2 Moss Point Proposed Actions and Impacts

This component consists of relocating the City of Moss Point's municipal buildings to a lower risk site with regards to flooding within the incorporated limits. This will aid the city in providing basic community services in a more timely fashion after future storm events, and further demonstrate the effectiveness of relocations projects as a hurricane and storm damage reduction measure along the Mississippi coast. These buildings include the city hall, police station, fire station and community services building and will be replaced to current standards and based upon the existing community needs. Implementation of this project would allow a demonstration of a relocation project in order to determine the effectiveness of the hurricane and storm damage reduction measure by relocation of the city's municipal services at a lower risk area.

4.13.2.1 Moss Point Alternative Plans Vegetation Impact

Implementation of this project would allow a demonstration of a relocation project in order to determine the effectiveness of the hurricane and storm damage reduction measure by relocation of the city's municipal services at a lower risk area. It is anticipated there could be impacts to vegetation as a result of implementation of this measure as the relocations would require earthwork in the new sites; however, due to the potential sites being located within largely developed areas within the City of Moss Point, it is believed the impacts would be minor in significance.

4.13.2.2 Moss Point Alternative Plans Fish and Wildlife Impact

Implementation of this project would allow a demonstration of a relocation project in order to determine the effectiveness of the hurricane and storm damage reduction measure by relocation of the city's municipal services at a lower risk area. It is anticipated there could be impacts to fish and wildlife resources as a result of implementation of this measure as the relocations would require disturbances at new sites; however, due to the potential sites being located within largely developed areas within the City of Moss Point, it is believed the impacts would be minor in significance.

4.13.2.3 Moss Point Alternative Plans Threatened and Endangered Species Impact

Implementation of this project would allow a demonstration of a relocation project in order to determine the effectiveness of the hurricane and storm damage reduction measure by relocation of the city's municipal services at a lower risk area. It is anticipated there would be no impacts to T&E species as a result of implementation of this measure as the relocations are in areas that do not support the listed species, due to the potential sites being located within largely developed areas within the City of Moss Point.

4.13.2.4 Moss Point Alternative Plans Water Quality Impact

Implementation of this project would allow a demonstration of a relocation project in order to determine the effectiveness of the hurricane and storm damage reduction measure by relocation of the city's municipal services at a lower risk area. It is anticipated there would be only minor, temporary, and insignificants impacts to water quality as a result of this alternative as BMPs would be utilized to reduce runoff during construction activities.

4.13.2.5 Moss Point Alternative Plans Land Use Impact

Implementation of this project would allow a demonstration of a relocation project in order to determine the effectiveness of the hurricane and storm damage reduction measure by relocation of the city's municipal services at a lower risk area. There would be changes in current land use at the relocation sites as well as the current site. The current site would be converted to recreational green space for the citizens of Moss Point.

4.14 Waveland Floodproofing

4.14.1 Waveland No Action Plan and impacts

The city of Waveland is located in Hancock County, Mississippi and was directly in the path of Hurricane Katrina. Because of the low lying area in which the city is located, the only flood damage reduction measures available to a portion of Waveland are either acquisition or floodproofing the individual structures. Implementation of the No Action Plan would not alleviate the damages which may be suffered by these structures in the future from flooding, and would not afford the opportunity to educate the community on appropriate floodproofing techniques for the coastal area.

4.14.1.1 Waveland No Action Plan Vegetation Impact

There would be no impacts to vegetation as the project would not be constructed. This area of Waveland would be reconstructed without any protection afforded by structural measures.

4.14.1.2 Waveland No Action Plan Fish and Wildlife Impact

There would be no impacts to fish and wildlife resources as the project would not be constructed. This area of Waveland would be reconstructed without any protection afforded by structural measures.

4.14.1.3 Waveland No Action Plan Threatened and Endangered Species Impact

There would be no impacts to T&E species as the project would not be constructed. This area of Waveland would be reconstructed without any protection afforded by structural measures.

4.14.1.4 Waveland No Action Plan Water Quality Impact

It is anticipated there would be only minor, temporary, and insignificant impacts to water quality as a result of the rebuilding efforts and potential runoff. The use of BMPs should be required to be used on construction sites to reduce runoff during construction activities.

4.14.1.5 Waveland No Action Plan Land Use Impact

There should be no change to current land use by implementation of the No Action Plan as the area currently exists as a residential neighborhood.

4.14.2 Waveland Proposed Actions and Impacts

In order to evaluate the different foundation and building types, 25 existing structures would be selected in the Waveland area that could be safely elevated out of the 1% chance storm event, and which could not be protected by any other structural measures evaluated as part of this study.

4.14.2.1 Waveland Alternative Plans Vegetation Impact

There should be only minor insignificant and temporary impacts to vegetation by implementation of the recommended plan as structural components of this plan would only apply to existing houses within a developed area.

4.14.2.2 Waveland Alternative Plans Fish and Wildlife Impact

There should be only minor insignificant and temporary impacts to fish and wildlife resources by implementation of the recommended plan as structural components of this plan would only apply to existing houses within a developed area.

4.14.2.3 Waveland Alternative Plans Threatened and Endangered Species Impact

There should be no impacts to T&E species by implementation of the recommended plan as structural components of this plan would only apply to existing houses within a developed area.

4.14.2.4 Waveland Alternative Plans Water Quality Impact

It is anticipated there would be only minor, temporary, and insignificant impacts to water quality as a result of the floodproofing efforts and potential runoff. The use of BMPs would be required to be used on construction sites to reduce runoff during construction activities.

4.14.2.5 Waveland Alternative Plans Land Use Impact

There should be no change to current land use by implementation of the No Action Plan as the area currently exists as a residential neighborhood.

4.15 Forrest (Forest) Heights Levee

The community of Forrest (Forest) Heights lies on the bank of Turkey Creek about 2.6 miles from the mouth at Bernard Bayou. Ground elevations over most of the residential area are between elevations 10-14 ft NAVD88. Drainage is mostly along streets and through natural drainage ways to Turkey Creek. Impacts from flooding and hurricanes have been devastating. Hurricane Katrina in August, 2005 resulted in significant flood damages to residences in the Forrest (Forest) Heights community. A levee with top width of 6 ft was constructed around the community to elevation 16.5 ft NGVD with side slopes of 1 vertical to 1.5 horizontal in 1969, prior to Hurricane Camille. It has not been adequately maintained and is a state of disrepair. There were two alternative actions and a no action alternative evaluated for the Forrest (Forest) Heights Levee Project. This storm damage reduction project falls within the Congressional authorization for storm damage reduction along the Mississippi coast.

- No Action
- Levee Elevation 17 feet
- Levee Elevation 21 feet

4.15.1 Forrest (Forest) Heights No Action Plan and Impacts

The Natural Resources Conservation Service will restore the existing levee to as-built condition by January of 2009. However, the restored levee will not be sufficient to meet the present day standard for certification according to the existing FEMA flood profiles in the vicinity. The existing condition assumes that the NRCS has reconstructed the levee around the Forest Heights community to a crest elevation of 16.5 feet.

4.15.1.1 Forrest (Forest) Heights No Action Plan Vegetation Impact

It is anticipated there would be not be any impacts to vegetation from implementation of this alternative as the project would not be constructed.

4.15.1.2 Forrest (Forest) Heights No Action Plan Fish and Wildlife Impact

It is anticipated there would be no impacts to fish and wildlife species from implementation of this alternative as the project would not be constructed.

4.15.1.3 Forrest (Forest) Heights No Action Plan Threatened and Endangered Species Impact

It is anticipated there would be no impacts to T&E species from implementation of this alternative as the project would not be constructed.

4.15.1.4 Forrest (Forest) Heights No Action Plan Water Quality Impact

It is anticipated there would be no impacts to water quality from implementation of the No Action Plan as construction of the project would not occur.

4.15.1.5 Forrest (Forest) Heights No Action Plan Land Use Impact

It is anticipated there would be no impacts to current land use as a result of this alternative since the existing site consists of an existing residential community. Under the no action plan, however, the residences within the Forrest Heights community will not be able to meet the criteria under the revised Flood Insurance Rate Maps and any future rebuilding following disaster will be severely limited.

4.15.2 Forrest (Forest) Heights Proposed Actions and Impacts

The existing with-project condition assumes clearing and snagging of debris in Turkey Creek will counteract any local water surface profile impact due to flow obstruction by the levee. The selective clearing and snagging would extend for approximately 4.5 miles from the mouth of Turkey Creek at Bernard Bayou to the upstream limits. Selective clearing and snagging would remove obstructions such as debris dams and excessive sedimentation that hinders the flow through the Turkey Creek channel. While the selective clearing and snagging component of the plan does not eliminate flooding along Turkey Creek, the plan does reduce flood damages along the creek and at the upper end of the canals at 28th Street. The main purpose of the selective clearing and snagging is to make sure that induced damages do not occur due to the construction of the levee.

During some hurricane events or high water in Turkey Creek, when the culvert gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. A detention basin was added to help reduce the size of required pumps. The detention basin would have an area of approximately 3 acres but would not be excavated. The area is the lowest site in the subdivision and is presently is used for recreation facilities such as baseball and tennis. Detailed modeling of the area was not possible for this report, therefore the exact extent of the detention basin is not precisely defined. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further design during construction will refine the requirement for the appropriate detention area and pump sizes to provide protection from 100-yr rainfall.

This option consists of an earthen levee around northern, western, and southern sides of the Forrest (Forest) Heights community. Because of the height of the levee, the eastern side will be constructed with a concrete “T”-wall structure. The “T” wall will take less space than an earthen levee and encroach less into property along the alignment. The alignment of the levee is generally the same as Option A. Closure gates across the two access roads to the subdivision will be required. The lengths of the levee culverts will be slightly longer than those used in Option A. Other features and methods of analysis are the same.

Through modeling results, a levee height of 21 feet above sea level was determined to be consistent with the levee certification guidelines with the basis measurement being a storm surge elevation that has a 0.2% probability (500-year event) of occurrence in any given year. The levee is estimated to be 6,500 linear feet and require 93,000 cubic yards of fill. An existing park of 12 to 14 feet in elevation would serve as a water detention area for temporary containment of rainfall during storm events.

4.15.2.1 Forrest (Forest) Heights Alternative Plans Vegetation Impact

Under the 17-foot alternative, there is an expected loss of 19.85 acres of non-tidal wetland vegetation impacted by construction of the levee. Additionally, construction of the levee to 21 feet would cause the loss of 3.15 acres of other vegetation, which consists of mainly mixed pine hardwood forests. Although native vegetation under the levee footprint would be lost, the levee itself would be vegetated with non-native species for stabilization of the structure. Any required mitigation for wetland losses would be accomplished within the same watershed.

4.15.2.2 Forrest (Forest) Heights Alternative Plans Fish and Wildlife Impact

Due to a pre-existing disturbed condition created by the presence of the residential development and partial levee system currently in place, the alternatives would result in increased impacts to fish and wildlife species from the additional height of the levee expansion. Continued maintenance of the levee reduces natural habitats that are currently available for numerous wildlife species. Unnatural crossings of water bodies by culverting, etc, could reduce in-stream habitat for various life stages of fish. Impacts to wetland crossings remove essential lifecycle requirements for numerous fish and wildlife species.

4.15.2.3 Forrest (Forest) Heights Alternative Plans Threatened and Endangered Species Impact

It is anticipated there will be no impacts to T&E species as the project area does not offer suitable habitat for any of the listed species.

4.15.2.4 Forrest (Forest) Heights Alternative Plans Water Quality Impact

BMPs would be utilized during construction to ensure stabilization of bare soils in order to reduce run-off of materials. Interior drainage would be accomplished by the removal of stored water through culverted crossings of small water bodies and by the use of pump stations where necessary. Limited clearing and snagging of Turkey Creek would assist in improving overall water quality through the improvement of tidal flows.

4.15.2.5 Forrest (Forest) Heights Alternative Plans Land Use

Under the preferred alternative, there is an expected loss of 19.85 acres of non-tidal wetland vegetation impacted by construction of the levee and the required buffer zone for maintenance access. Although construction of the levee to this elevation would require additional land for the expanded footprint, impacts to current land use should be minimal as the area currently exists as an established residential community.

5 DESCRIPTION OF TENTATIVELY SELECTED COMPREHENSIVE PLAN COMPONENTS

5.16 Comprehensive Plan Description

The comprehensive plan provides integrated systems-based solutions and tentatively selected plans that address: ***hurricane and storm damage reduction, ecosystem and restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion.*** The tentatively selected plans also provide measures that aid in: regional economic redevelopment, positive societal effects, and long-term measures to reduce risk to the public and property.

This report supports the recommendation of the following tentatively selected features to Congress for authority to implement the Mississippi Coastal Improvements Comprehensive Plan:

- Construct the list of projects seeking a construction ROD
    - Barrier Island Restoration
    - Turkey Creek Ecosystem Restoration
    - Bayou Cumbest Ecosystem Restoration
    - Dantzler Ecosystem Restoration
    - Admiral Island Ecosystem Restoration
    - Franklin Creek Ecosystem Restoration
    - Submerged Aquatic Vegetation Restoration;
    - Coast-wide Beach and Dune Restoration;
    - Moss Point Municipal Structures Relocation
    - Waveland Residential Structure Flood Proofing; and
    - Forrest (Forest) Heights Levee Elevation
- Implement the High Hazard Area Risk Reduction Plan (HARP Phase 1); in most critical areas
- Conduct feasibility level investigations for
    - Escatawpa River Diversion – Grand Bay Marsh Ecosystem Restoration
    - Additional Damage Reduction Alternatives, and
    - Additional Coastal Mississippi Ecosystem Restoration Alternatives.

Additionally, this report supports the recommendation for Congressional authority to study the Long-term HARP.

The Congressional authorization for this study mandated a comprehensive approach to solutions for water resource problems in coastal Mississippi. The comprehensive nature of the study team's approach included identifying solutions regardless of implementation authority or agency. Hence a number of tentatively selected plan features also include education and hurricane preparedness. These features include:

- Hurricane Risk Reduction Education
- Hurricane and Storm Warning Systems
- Hurricane Evacuation Planning
- Floodplain Management
- Building Codes
- Zoning Codes, and
- Relocation of Critical Infrastructure and Services (Line of Defense 5).

Feasibility level investigations concerning freshwater diversion at Violet, LA are authorized by Congress under WRDA 2007. Section 3083 authorized the design and implementation of a project for diversion of freshwater at or near Violet, Louisiana, for the purposes of reducing salinity in the western Mississippi Sound, enhancing oyster production, and promoting the sustainability of coastal wetlands. The MsCIP supports this action and is a critical element to sustain the ecosystems of coastal Mississippi. This report supports a recommendation to Congress for a freshwater diversion project that is fully coordinated between the States of Mississippi and Louisiana, the appropriate entities within the Corps of Engineers, and other interested stakeholders.

The following table identifies how the recommended components of the Comprehensive Plan address the Congressional concerns identified in the authorization. These comprehensive plan components are 'keystone' pieces of the comprehensive plan on which later recommendations would build. These plan elements have been determined to be engineeringly feasible, environmentally acceptable and beneficial, and cost effective. Each of these recommended comprehensive plan components are designed to be implemented and function as stand alone units should additional time be required to design all plan components or additional plan components be determined to not be cost effective.

Table 5-1
Components of the Comprehensive Plan

	Areas of Concern			
Recommendation	**Storm Damage Reduction**	**Erosion Reduction**	**Salt Water Intrusion**	**Fish and Wildlife**
High Hazard Area Risk Reduction Plan	√			√
Additional Damage Reduction Alternatives	√			
Additional Ecosystem Restoration Alternatives	√	√		√
Barrier Island Restoration	√	√	√	√
Violet, LA Fresh Water Diversion	√	√	√	√
Escatawpa Fresh Water Diversion			√	√
Beach and Dune Restoration	√	√		√
SAV Restoration				√
Moss Point Municipal Structure Relocation	√			√
Waveland Floodproofing	√			
Forrest (Forest) Heights Levee	√			
Deer Island Restoration	√	√		√
Turkey Creek Restoration	√			√
Bayou Cumbest Restoration				√
Dantzler Restoration				√
Admiral Island Restoration	√			√
Franklin Creek Restoration	√			√

All tentatively selected ecosystem restoration plans incorporate monitoring and adaptive management capabilities, where needed. The role of monitoring and adaptive management in the Comprehensive Plan is presented in section 5.5 Monitoring and Adaptive Management.

5.17 Education and Hurricane Preparedness Plan Features

The Mississippi Coast is a complex geographic system which is governed and managed by multiple agencies and entities. No single agency or entity could reasonably be expected to implement the all of the diverse components of a Comprehensive Plan. Implementation of these recommendations will enhance the effectiveness of the comprehensive plan developed by the MsCIP team.

5.17.1 Hurricane Risk Reduction Education

Over 300 persons were confirmed as having perished or were identified as missing in the State of Mississippi as a result of Hurricane Katrina. Any loss of life is tragic, and any number of those deaths may have been prevented. Even one death prevented is sufficient reason to improve our methods of educating the public on hurricane and storm threats, and to ensure that all is done to warn all those in coastal Mississippi as to the extreme hazard to all that reside in the area, from the dual hazards of wind and surge/waves. It is particularly vital to inform the public as to the zones of highest hazard in regards to surge and wave impact, as these can also have extremely destructive impacts to property, in addition to that of its effects on the lives of those that might remain behind during an event. Education needs to include articulation of effects related to the potential magnitude of the threat, the urgency to heed the call to evacuate, and providing the means by which to make wise choices on evacuation methods and route (see recommendations given below under "Hurricane Evacuation Planning"). The following are suggested guidelines in the interests of good education on hurricane storm threats:

- Provide good science and information to the residents of coastal Mississippi, so they can understand the nature of the threat, and its possibility of happening at any time, even repeatedly within a single year. This information should be provided in both written form, and as maps, in a variety of venues, including:
    - Posting in supermarkets, libraries, public buildings, and schools;
    - Education in schools and at public workshops, at regular intervals (minimum 1 yr.);
    - Providing information on hurricane threat by zone, evacuation routes, and procedures, on publicly-accessible websites, updated regularly (minimum 1 yr.).
- Provide information on hurricane threats within the course of continued study and after the study effort is concluded. The study team held numerous public workshops during the course of the Interim and Comprehensive Plan studies. More workshops on risk will be held in the future, to educate residents to their current and future risks, and to allow them to make better choices in selecting plans for potential implementation.
- Educate members of Congress and other public representation as to the need to continue support for upgrading and maintenance of systems supporting the goals of providing early warning of hurricanes and tropical storms, and support for efforts to provide media dissemination of early warning and evacuation data.

There is nothing humanly possible that can be done to protect the lives and safety of Mississippi residents, if they do not have sufficient warning, and if they then do not use that knowledge to evacuate in a timely manner.

5.17.2 Hurricane and Storm Warning

Residents and visitors to the coast of Mississippi need to recognize that they live in, or are visiting, a high-hazard area. Although certain times of the year pose less risk than others, each year's hurricane season provides a strong possibility of hurricane impact. All residents and visitors need to be made aware of the current hurricane threat, but that threat must be assessed and information passed along, by a system of instruments that pass on information on the location and nature of

weather conditions, and for that information to be evaluated and passed on to national and local media, for dissemination. Continued support of the following activities is critical to an adequate warning system:

- On-going efforts to upgrade the existing system of buoys and advanced warning measures that provide date on the location and nature of weather conditions.
- Efforts directed at the interpretation of that data and its dissemination to the media and public, through the National Weather Service.
- Public appreciation for the need to be aware at all times of, and the need to listen to weather reports and advice given on various media. Television weather reports, radio, and the internet all provide excellent up-to-date information on weather conditions, and the development of threatening situations. Simply living in or visiting the Gulf Coast should provide the need to be exceptionally aware of the weather, and its consequences.
- The vital importance of heeding the advice of experts. One should know what needs to be done in the event of an approaching storm. Family members should conduct evacuation drills, keep needed phone numbers and travel supplies on hand, and be prepared to leave on short notice. One should be aware of evacuation routes, keeping a full tank of gas during the hurricane season, and having a plan for where one should go, how to maintain contact with other family members, and where one will re-locate temporarily, particularly if this turns out to be longer than expected.

5.17.3 Hurricane Evacuation Planning

The critical need for adequate evacuation planning was borne out by Hurricane Katrina. An evacuation plan is an essential component of a comprehensive plan for ensuring the safety of residents of and visitors to the coast of Mississippi. The preservation of life is the single most important goal and objective of the tentatively selected plans. The joint Federal Emergency Management Agency (FEMA)/ NOAA/Corps/Mississippi Emergency Management Agency (MEMA) task force's Mississippi Hurricane Evacuation Study of April 2002 has provided a tremendous amount of value to-date in aiding local government, individual and family readiness, in the face of approaching events. Support for this program is a critical element of the tentatively selected plans for coastal Mississippi. The following are important recommendations in support of efforts to support Hurricane Evacuation Planning:

- There is still much that can be done to update this on-going effort, and to provide new, and more widely-disseminated data and tools for evacuation planning by local county and city governments, and also for use by individuals and families in their preparation for an impending event.
- Evacuation route signage is an important part of a successful evacuation campaign. Replacement of missing or destroyed signage is viewed as a vital link in ensuring the safety of residents and visitors alike. Given recent experience with how many signs were destroyed during Katrina, placing replacements on heavier posts driven a greater distance into the ground, and possessing concrete footings, would be essential in ensuring that signage survives inundation or wind damage, particularly given the possibility that another event might occur in short order.
- The provision of additional signage illustrating surge height achieved during Katrina would be an added and continual link to on-going education efforts. This could take the form of signs placed in locations in which there is significant traffic, such as major thoroughfares, where pedestrians walk, and particularly in those highest hazard zones based on elevation/depth data.

5.17.4 Floodplain Management

Management of the floodplain is a non-Federal responsibility, yet is considered a key component of the Comprehensive Plan. Much of the information needed to make on-going and future decisions about appropriate measures to take in the interest of public safety has only been recently developed as part of this on-going MsCIP study effort. These decisions also dependent on review and finalization of FEMA's Flood Insurance Rate Maps (FIRMs) for the area (released for public review 11 – 13 December 2008). Therefore, it may be some time before a complete revision of local floodplain management plans can be undertaken.

It is hoped that communities within the study area will make use of a number of the products of this study, particularly the RISK ZONE maps developed for the public and government education campaign that are shown below in Figure 5-1.

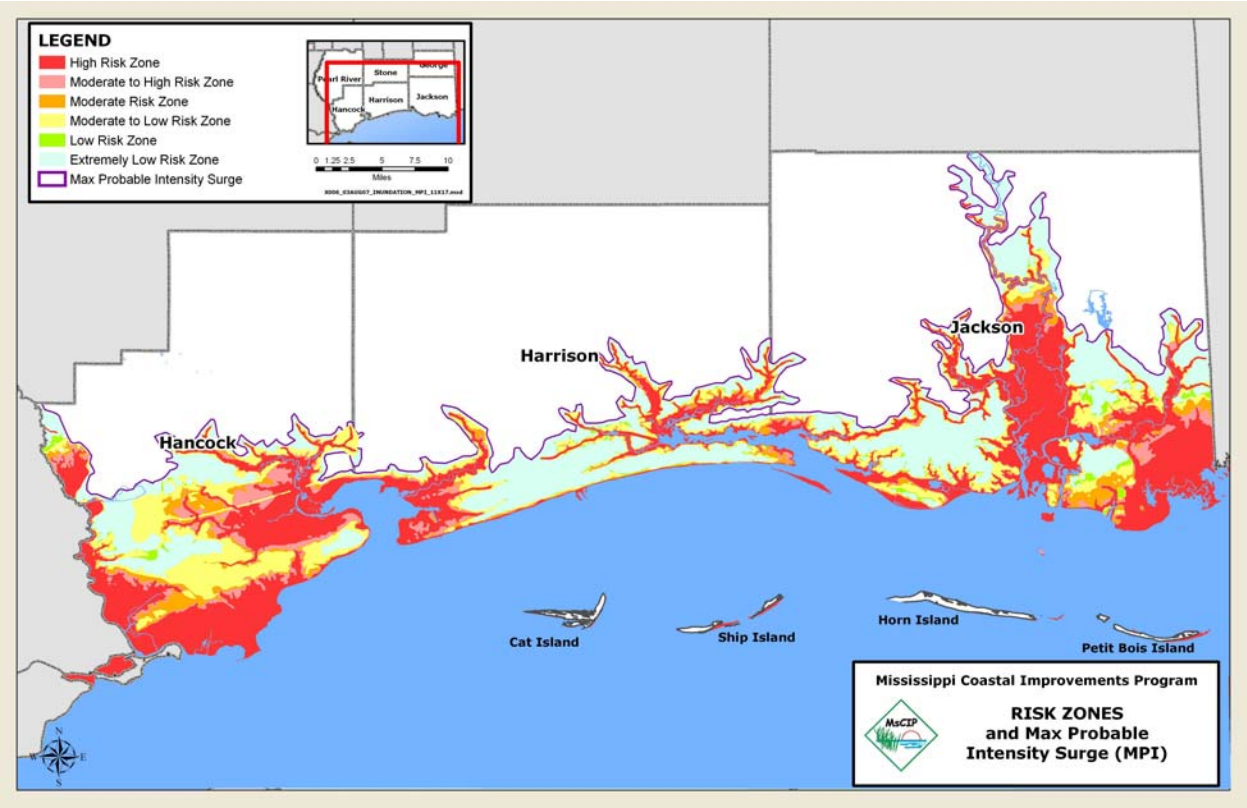


Figure 5-1
Coastal Mississippi Risk Zones

This map, along with the new FEMA Flood Insurance Rate Maps (FIRMs) and accompanying data, provide local government tools to be used in the determination of how to manage development or location of inhabited development, infrastructure, businesses, hazardous waste facilities, sites that contain large, un-anchored structural components such as fuel tanks, lumber and other potentially damaging flood-borne materials, and other sites that require careful consideration of potential surge effects, when developing Master Plans for their communities. The map above provides an assessment of risk based on a frequency framework, in which each area is color-coded according to its potential frequency for surge inundation, as well as its potential for shallow to very deep inundation. The red zone is the highest hazard zone within coastal Mississippi, subject to the most frequent inundation, and during large events, to the greatest depth of surge and waves. Each

successive zone is at generally lower risk. It should be noted that virtually all of coastal Mississippi has the equal potential for wind damage due to hurricanes.

Key components of the effort to revise floodplain management guidelines will also be to evaluate and adopt new zoning code-related information for the purposes of re-construction and new construction. This may also take time to develop, but is also considered a critical component of a Comprehensive Plan for the coast.

5.17.5 Building Code Update

The majority of the municipalities and counties have adopted the International Building Code (IBC) to guide the design and construction of residential and commercial structures in the project area. In most cases, these local jurisdictions are using the 2003 version of the IBC. In order to assure that the latest design and construction techniques are being used that apply to hurricane-resistant construction, each of the local jurisdictions should adopt the latest version of the IBC (2007) and ensure enforcement of the codes through diligent building permit processing and on-site inspections of construction. Annual training classes on the use and enforcement of the new IBC should be implemented by the local jurisdictions. In addition, all local jurisdictions should consider appending the published document "FEMA 550 Guidelines for Elevating Residential Structures on the Gulf Coast" as a part of their updated building codes for construction in areas where surge inundation may be present.

5.17.6 Zoning Code Update

Zoning Code updates are similar to the suggestions made under the section on Floodplain Management. This recommendation focuses on continued support of efforts being made by the three counties and their cities in the updating of current zoning codes. These entities are expected to make strong use of the Corps' RISK ZONE maps, shown above, and new FEMA Flood Insurance Rate Maps (FIRMs), as the basis for modification of existing zoning codes to reflect higher to lower hazard zones, and appropriate land uses within those zones. Updated zoning codes are expected to limit development in highest hazard areas to those uses that will incur lesser damage and risks to life and safety, given the relative frequency and magnitude of event occurrence. While a local responsibility, the counties and cities may make full use of the resources provided under this study.

5.17.7 Long-term Critical Infrastructure and Services Relocation (LOD 5)

The Comprehensive Plan recommends relocation of critical infrastructure and services outside the Maximum Probable Intensity (MPI) boundary, which is identified as Line of Defense 5. Infrastructure and services recommended for relocation include the following:

- evacuation centers,
- long-term care facilities,
- school and municipal bus and transportation facilities,
- power plants,
- water treatment plants,
- City and County records,
- hospitals that do not contain emergency care components, and
- other resources critical to rapid response or recovery.

The methodical relocation of these facilities north of this boundary will save untold lives and funds. This program may be instituted under a Capital Improvement Program, where structures reaching

the end of their economic life are successively replaced outside the MPI boundary, as funds become available.

Facilities necessary for the conduct of emergency and every day services needed within individual cities should be re-sited, according to funds availability, at the highest elevation possible within that individual community.

Realistically, Police and Fire facilities, which have a need to be located "forward" to adequately address emergency response, may not have the luxury of relocating north of the MPI boundary, but could be re-constructed under this same program, to locate critical components of each facility above the MPI inundation depth, and to re-construct these facilities to withstand the effects of surge, waves, and wind, perhaps at a safer distance from the shoreline than they currently reside. So-called "wet" flood-proofing (in which doors and windows are temporarily sealed from water infiltration) may be one component of that required to create a structure adequate for survival within the surge zone; however, it is critical that these facilities and structures are capable of surviving the event, so that they can quickly respond after recession of the surge, to protect lives and property in their charge.

5.18 Recommendations for Proposed Corps of Engineers Implementation

5.18.1 High Hazard Area Risk Reduction Plan (HARP)

This report supports the recommendation for authorization and immediate implementation of the Phase I HARP, and for planning of a Long-term HARP, as described below.

5.18.1.1 Phase I HARP

The most effective alternative for reducing the risk from future hurricane surge events is to remove all structures and relocate population centers from the high risk zones. Formulation of alternatives included those which would provide for minimum level of risk reduction (approximate base flood elevation) up to those that would provide for risk reduction from increasing levels of inundation.

Hurricane Katrina destroyed an estimated 32,446 structures (i.e., damages of 51% to 100% of structure value), and caused significant damage to another 15,000 to 25,000 structures located within the inundation footprint of the three coastal counties in Mississippi. The vast majority of all destroyed homes within the inundation footprint have not yet been rebuilt, nearly three years after the event. The rebuilding rate within the inundated area is much slower than might typically be expected following a hurricane. This is due in part to a significant increase in construction costs since Katrina, higher flood insurance rates and uncertainty resulting from the fact that FEMA has recently released draft Flood Insurance Rate Maps (FIRM) and requirements outlining at what elevation future first-floor construction must adhere to in order to qualify for flood insurance through the NFIP.

Limited rebuilding is occurring within the surge-plain, at a variety of elevations. Those that are rebuilding at former elevations are largely self-insured (or un-insured), while those rebuilt prior to approval of the revised FIRMs at higher elevations are doing so with an assumption as to what the Base Flood Elevations (BFE) may be for their area. Regardless, most of those that would need flood insurance have not rebuilt at the time of this report, due to changes in National Flood Insurance Program (NFIP) requirements relative to BFE or lack of available and affordable hazard insurance. Other reasons include a desire to move from the hazardous areas following flooding as a result of Hurricanes Gustav and Ike in 2007.

The sheer magnitude of the devastation, together with the number of persons still displaced more than two years after Hurricane Katrina presents unprecedented challenges and opportunities. The HARP alternative appears to be the most cost-effective option that provides a non-structural alternative for reducing property damage resulting from hurricanes, storm surge and flooding, and by extension, reducing threats to lives in those areas, in the most hazardous areas along the Mississippi Coast. In the Phase I HARP, acquisition of those properties where the residential owners have not yet rebuilt presents a unique window of opportunity to minimize project costs. This report recommends that the Phase I HARP is specifically structured to capitalize on the current opportunity and encourage relocation outside the high-hazard surge-plain.

The advantages of such a program are numerous including:

- Reduces future property loss and potential loss of life;
- Eliminates costly structural alternatives and associated long term operation and maintenance costs;
- Provides a buffer and aids in reducing storm surge to adjoining properties; and
- Provides a potential opportunity to initiate alternative uses of the acquired land for fish and wildlife, ecosystem restoration and public recreation.

Prompt initiation of acquisition is more cost effective to the Government than commencing acquisition at a later date. Sensitivity analysis indicates that for every 1,000 previously-occupied parcels acquired prior to rebuilding, approximately $100 - $150 million could be saved by prompt acquisition, as compared to acquiring these same parcels after they are rebuilt. Acquisition prior to rebuilding avoids displacement impacts which increase significantly after residents have rebuilt. Near-term acquisition would reduce requirements for other Government-assisted temporary housing programs for those owners that might be still displaced, and would be continuing to receive financial assistance from the Federal Government.

Phase I HARP Benefits

The tentatively recommended plan for immediate application for hurricane and storm damage reduction is a limited acquisition and relocation program, directed at approximately 2,000 of the most high-risk properties along the coastline. Benefits of the program include reduction of future damages and risks to lives within those areas, and incidental recreation and social effects benefits. Select areas within certain acquired areas would be available for ecosystem restoration, and could also produce additional restoration benefits. The average annual average damages avoided for the 2,000 structures were determined to be between $22,000,000 and $33,000,000. Regional economic benefits include an increase in sales volume of $1,171,260,000, a $246,056,800 increase in local income, and a net increase of 7,213 jobs.

Phase I HARP Costs

The estimated costs for implementation of Phase I range between $187,500,000 and $397,000,000 depending on the ultimate number of parcels acquired and range of benefits provided under P.L. 91-646.

5.18.1.2 Long-term High Hazard Area Risk Reduction Plan Evaluation

Evaluation of long term HARP is warranted to address the relocation of structures from the high to moderately high risk areas of the Mississippi coast. This program which could cover risk reduction opportunities over the next 20 to 40 years could target those properties which have been rebuilt but are still susceptible to significant future damage. A long-term HARP could involve the acquisition of large contiguous properties immediately following any large future hurricane events and be a joint effort between the USACE, FEMA, and the State of Mississippi.

Long Term HARP Benefits

The benefits of an ongoing acquisition and relocation program for coastal Mississippi could be tremendous taken into account the implications of sea level rise, continued development along the coast, and the frequency and magnitude of storms known to affect this area of the northern Gulf of Mexico. The additional study effort aimed at developing the framework and guidelines, detailed benefits, and costs would involve local and State interests as well as FEMA.

Long Term HARP Study Cost

Estimated study cost for development of a long-term HARP program is $5,000,000.

5.18.2 Moss Point Municipal Services Relocation

This report supports the recommendation for authorization to immediately implement the Moss Point Municipal Services Relocation component of the Comprehensive plan. The City of Moss Point is located north of the City of Pascagoula in Jackson County. All of the City's municipal services were disrupted by Hurricane Katrina, and their structures were either severely damaged or deemed uninhabitable. The MsCIP has formulated alternatives that would aid the city in providing basic community services in a more timely fashion after future storm events, and further demonstrate the effectiveness of relocations projects as a hurricane and storm damage reduction measure along the Mississippi coast. The best means of achieving these goals consists of relocating the city's municipal buildings to a lower risk site with regards to flooding within the incorporated limits. These buildings include the city hall, police station, fire station and community services building. Future use of the existing site of these buildings would be as open space that would provide a buffer between City and the Escatawpa River further reducing the damages from hurricane surge and flooding events.

Based upon the best available FIRM data, the four relocation sites shown on the Moss Point Relocations Pilot Map are all at elevation 12.0. The elevation of the 1% annual chance flood at those locations is elevation 11.0 based again upon the FIRM data. The risks of surge inundation (at varying levels) at the four sites would be addressed during the site and building design phase of development. Both the site(s) and building(s) can be designed such that the first floors of the structures can be set at an elevation that reduces any damages by surge inundation. Given the confined urban context of the sites, it is likely that required parking would be accommodated on the ground level beneath the structure and the first and upper stories set well above surge heights. ADA access requirements would be addressed during the design phase to accommodate the differences in elevation.

Moss Point Benefits

The relocation of these facilities would greatly reduce future damages to the local infrastructure and provide a higher confidence in uninterrupted public service in future events. Regional economic benefits include an increase in sales volume of $20,250,000, a $4,286,426 increase in local income, and a net increase of 129 jobs.

Moss Point Costs

First Costs: $10,800,000
Annual O&M: $0

5.18.3 Waveland Floodproofing

This report supports the recommendation for authorization to immediately implement the flood proofing at Waveland, MS. The city of Waveland is located in Hancock County and was directly in the path of Hurricane Katrina. Because of the low lying nature of the city, the only flood damage reduction measures available to a portion of Waveland are either acquisition or floodproofing of

individual structures. FEMA has released a manual for "Recommended Residential Construction for the Gulf Coast" which is meant to aid residents in rebuilding on strong and safe foundations. The design manual (FEMA 550) provides recommended foundation design and guidance for rebuilding homes destroyed by hurricanes in the Gulf Coast. The Waveland floodproofing alternatives are designed to evaluate the FEMA 550 guidelines with regards to current Corps' floodproofing practices. In addition to showing the application of existing elevation techniques and construction practices to reduce flood damages, this alternative would evaluate the use of possible innovative contracting techniques. These techniques would be designed to improve the Corps – contractor – homeowner relationship, focusing on using more timely and customer focused approaches. The 25 structures selected for floodproofing represent an adjacent group of structures that were not destroyed by Hurricane Katrina.

Waveland Benefits

In order to evaluate the different foundation and building types, 25 structures would be selected in the Waveland area that could be safely elevated out of the 1% chance storm event, and which could not be protected by any other structural measures evaluated as part of this study. Damages to these structures would be significantly reduced and the area would serve as an example of smart growth. Regional economic benefits include an increase in sales volume of $20,250,000, a $4,286,426 increase in local income, and a net increase of 129 jobs.

Waveland Costs

First Costs: $4,425,000
Annual O&M: $0

5.18.4 Forrest (Forest) Heights Hurricane and Storm Damage Reduction Component

This report supports the recommendation for authorization to immediately implement levee construction at Forrest (Forest) Heights in Harrison County Mississippi. The Forrest (Forest) Heights community is located within the city of Gulfport at the lower end of the Turkey Creek floodplain and in a part of the larger historic Turkey creek community. The Harrison County area was over topped and heavily damaged by the hurricanes of 2005. Particularly, the storm surge and winds generated by Hurricane Katrina on August 29, 2005, caused structural damage to the existing levee that provides inland flood protection to this low lying residential community.

Storm surge inundation reached a depth of 2-8 ft over the entire community during Hurricane Katrina. In addition, prior to Hurricane Katrina, Forrest (Forest) Heights was frequently inundated by flood waters due to inland flooding along the lower reach of Turkey Creek that overtopped the existing levee. An economically justified improvement to the existing earthen levee for inland flooding protection was evaluated in July 2005, prior to landfall of Hurricane Katrina. These evaluations included 100-year, 250-year and 500-year protection and elevations up to 19.5 feet above sea level. This plan was put on hold following Katrina in order to evaluate suitable defense of Forrest (Forest) Heights from hurricane storm surge flooding. The proposed levee was evaluated at elevations 17 ft and 21 ft above sea level.

All evaluated alternatives were also gauged against the intent of Executive Order 12898, "Federal actions to address environmental justice in minority and low-income populations". Since the establishment of the Turkey Creek Community by freed slaves and their descendants, federally funded construction programs including the Gulfport Regional Airport, US Highway 49 and Interstate Highway - 10 have impacted the Turkey Creek Watershed. In addition, numerous other constructions including hotels, shopping centers and housing developments have been federally permitted to fill wetlands and construct within the Turkey Creek watershed.

Through modeling results, a levee height of 21 feet above sea level was determined to be consistent with the levee certification guidelines with the basis measure being a storm surge elevation that has a 0.2% probability (500-year event) of occurrence in any given year. The levee is estimated to be 6,500 linear feet and require 93,000 cubic yards of fill. An existing park of 12 to 14 feet in elevation would serve as a water detention area for temporary containment of rainfall during storm events.

Forrest (Forest) Heights Benefits

Equivalent annual damages reduced by the 21-foot levee are estimated to be $331,508. Regional economic benefits include an increase in sales volume of $20,250,000, a $4,286,426 increase in local income, and a net increase of 129 jobs. In addition to these damages reduced, the levee would provide a significant boost to the cohesiveness of the historically significant community, preserve the culture and heritage of it's predominantly minority residential population, and greatly improve their overall quality of life.

Forrest (Forest) Heights Costs

First Costs: $14,000,000
Annual O&M: $114,000

5.18.5 Potential Local Flood Risk Management Projects

This report supports a recommendation for future feasibility level analyses of local flood risk management components of the Comprehensive Plan. While large structural solutions such as surge gate barriers did not garner much local support, there were smaller scale structural solutions, such as smaller ring levees, local surge barriers, and and levee alignments that have the potential to provide cost effective solutions. Possible ring levee alternatives identified as part of this study including ring levees at: Belle Fontaine, Gulf Park Estates, Pascagoula/Moss Point, Pearlington, Gautier, Ocean Springs, and Bay St. Louis. Potential local surge barriers have been identified for St. Louis Bay and Biloxi Bay. Other levees with alternative alignments may also potentially be feasible. The development of cost effective, acceptable structural alternatives however will require additional study and coordination.

Potential Local Flood Risk Management Project Benefits

A very preliminary estimate of annual without-project damages for these potential structural solutions totals well over $60 million. The implementation of ring levees and / or other structural components in these areas would reduce a significant portion of those damages and warrants further feasibility level consideration.

Potential Local Flood Risk Management Project Costs

To complete feasibility level analyses for these potential structural solutions will require a significant amount of additional design. Due to time constraints, the current cost estimates are based significantly less than feasibility level investigations. Also, none of the options requiring further study and additional design have the benefit of geotechnical investigations or preliminary assessments for hazardous, toxic or radiological waste (HTRW) and much of the levee alignment would be in highly developed areas. For this study, most of the structural components such as traffic gates through levees, pumping stations, boat access gates, surge gates and other hard structural components were assigned to groups with a range of capacities.

Table 5-2 shows the cost of studies and additional design for individual projects associated with options that may be grouped into a structural alternative. The cost used as a basis for the design is the higher contract cost (without contingencies) of the group of options that may be included. Cost to complete feasibility level designs was estimated as seven percent of the estimated contract cost for each option. The value of 7% was selected by the PDT based on having completed some preliminary investigations (as included in this report), but not having geotechnical data or HTRW information to provide detailed feasibility level cost estimates.

Table 5-2
Local Flood Risk Management Study and Project Costs

Project	Feasibility Study Cost	Preliminary Construction Cost Estmate w/o Contingency
Pearlington Ring Levee	$5,343,000	$76,319,000
Bay St. Louis Ring Levee	$9,812,000	$140,171,000
Ocean Springs Ring Levee	$8,861,000	$126,584,000
Gulf Park Estates Ring Levee	$8,414,000	$120,191,000
Belle Fontaine Ring Levee	$6,786,000	$96,936,000
Gautier Ring Levee	$17,164,000	$245,194,000
Pascagoula/Moss Point Ring Levee	$29,082,000	$415,449,000
Hancock County LOD-4 Levee	$31,269,000	$446,697,000
St. Louis Bay Surge Barrier	$115,276,000	$1,646,792,000
Harrison County LOD-4 Levee	$29,201,000	$417,147,000
Harrison County Menge Ave. Levee Alignment	$7,000,000	$100,000,000
Biloxi Bay Surge Barrier	$88,351,000	$1,262,154,000
Jackson County LOD-4 Levee	$8,532,000	$121,882,000
TOTAL COSTS	**$365,091,000**	**$5,215,514,000**

5.18.6 Site Specific Ecosystem Restoration Plan Components

This report recommends Congressional authorization to construct a number of site-specific ecosystem restoration components of the Comprehensive Plan. Attainment of three of the objectives of the MsCIP study effort: fish and wildlife preservation, reduction of coastal erosion, and amelioration of the effects of saltwater intrusion, would significantly restore the ecosystem of coastal Mississippi to pre-hurricane conditions. The proposed restoration efforts would not only enhance the natural habitats of the area but would make the coastal area more resilient to the adverse impacts of future storms. Team members, including staff from the States of Mississippi and Louisiana, U.S. Fish and Wildlife Service, National Park Service, and non-governmental environmental organizations developed a number of options including coastal forest and wetland ecosystem restoration, barrier island / Mississippi Sound ecosystem restoration, and beach and dune ecosystem restoration to achieve these missions. From these options, nine comprehensive plan elements are recommended

for construction, one is recommended for continued engineering and design, and several are recommended for additional feasibility level studies.

5.18.6.1 Turkey Creek Ecosystem Restoration

This project site is located in north Gulfport, Mississippi, adjacent to U.S. Highway 49, a major north-west thoroughfare, and within the impaired Turkey Creek watershed. The area is becoming increasingly urbanized and development pressures are resulting in increased wetland degradation and loss by direct filling with the incumbent decrease in flood storage capability. The Turkey Creek site is approximately 880 acres of predominately undeveloped land. The site is divided by an east-west running railroad berm and contains a number of dirt road/paths and several miles of drainage ditches. These drainage ditches were constructed in the past in an effort to drain the site and control the drainage across the site into specified areas in order to make the site more attractive for development. Approximately 689 acres are south, and 190 acres are north, of the existing railway. The railway berm effectively separates the two portions of the site and therefore these areas function separately. The site is primarily comprised of degraded pine savannah wetland habitat. The elevated railway berm, miles of drainage ditches, and undeveloped roads fragment the wetland habitat and substantially alters the hydrology of the wetlands located to the south. Hurricane Katrina damaged and/or destroyed much of the remaining habitat (wind and salt damage to vegetation as well as salinity increases in the soils from the surge) such that the area has been determined to be incapable of unassisted recovery.

Wet (hydric) flats, which comprise as much as 20 – 30 percent of the coastal plain landscape from southeastern Virginia to south-eastern Texas, include wetlands on both organic and mineral soils and in the southeastern U.S. occur on the interfluvial marine terraces of the coastal plain. The hydric conditions contributing to the development of this habitat type include abundant rainfall and slow drainage associated with a landscape of low relief. Historically these habitats have been maintained in their open understory character by periodic fire. Pine savannah wetlands found in coastal Mississippi provide for diverse habitat for a number of plants and animals including many T&E species found only in these unique habitats. Pine savannah wetlands are commonly referred to as sponges that provide floodwater retention, groundwater recharge, and water purification. These habitats have been identified by the U.S. Fish and Wildlife Service as habitats of high value for evaluation species and relatively scarce or becoming scarce on a national basis or in the ecoregion section (Category 2) (Service Mitigation Policy, FR 46(15):7656-7663; dated 23 Jan 1981).

Current national trends show the continued movement of a large portion of the population to the nation's coastal communities and this evident in Mississippi as well. Numerous development plans for this property have been presented and so far have been unsuccessful; however, it is reasonable to assume future action will occur. This would result in loss of valuable habitat within an impaired watershed and subsequent increase in flooding. In addition, development of this property would contribute to the ongoing water quality degradation of this area.

Several plans were evaluated in order to determine the most cost-effective plan for restoration. The Turkey Creek site had an HGM assessment performed in 2000, using the *Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains* (Rheinhardt et al 2002). Results from this earlier assessment are used to establish baseline (current) conditions at the site. The site has been divided into 8 separate assessment areas (Figure 8.1.2.1.4-1), as there were different baseline conditions for each area. The same HGM model is also being used to measure functional unit benefits at the site resulting from different restoration plans.

The recommended plan requires the acquisition of 689 acres of predominately undeveloped land, filling the previously constructed draining ditches, excavating and removing existing roadbeds and any additional fill, and maintaining vegetation growth by burning the project area in the initial year of

construction as well as maintaining it by mowing and burning every three years over the life of the project as needed (Plan 3).

An essential component necessary when selecting the recommended plan at Turkey Creek was the need for burning. Burning allows the wet pine savannah environment to continue naturally as a functioning system without future intensive maintenance to maintain the required vegetation species. Although mowing does effectively keep understory plants from over colonizing the area, it does not simulate the natural conditions (i.e. seed germination, heating the pine bark, etc.) Dominant flora species in wet pine savannah habitats are dependent upon burning; thus, the following plan was selected knowing that most of these plant species would colonize the area upon establishment of routine burning and hydrology.

In addition, selection of the most cost effective plan was aided by the fact that the site is effectively divided into two functional units by the railroad berm. To make the entire site a functional unit would have required significant modification to this berm to restore the hydrology of the northern area. The additional cost was not supported by the additional benefits that would be gained.

Turkey Creek Ecosystem Restoration Benefits

Higher areas within the site will be designated as wet pine savannah. These areas have depressional areas within them which will enable water to flow down into the depression thus, holding water. Following the initial burning there would be a natural re-growth of wet pine savannah habitat, including species such as *Pinus elliotti*, *Morella cerifera, Ilex glabra, Spartina patens, and Panicum virgatum*.

Many species of wildlife are indigenous to the wet pine savannah habitat and are expected to thrive in the restored area. Understory plant communities including wiregrass, sedges, orchids, American Chaffseed and rough-leaved loosestrife as well as the insectivorous plants (pitcher plants, bladderworts, venus flytrap, and sundews) would be expected. Rare and threatened and endangered birds that are expected to utilize the areas following burning and regrowth include Henslow's sparrow, Bachman's sparrow, red-cockaded woodpecker, and Mississippi Sandhill Crane. This ecosystem may also benefit the Mississippi Gopher frog and in drier areas along ridges, the black pine snake and the gopher tortoise.

The HGM approach was used to assess wetland function. Benefits are measured in terms of average annual functional units (AAFU). Results from this assessment were used to establish baseline (current) conditions and, ultimately, to measure the functional unit benefits resulting from different restoration plans. Table 5-3 shows the total functional units under the recommended plan and the AAFU net benefit. It is assumed that functional units will remain the same under existing conditions and the no action plan even though it is likely that under the no action plan the functional value of the habitat would degrade over time. For this reason the calculation of the environmental benefits of the proposed restoration are considered conservative in nature.

The AAFU net benefit was calculated as the difference between the total functional units for the ecosystem restoration plan and the total functional units for the no action plan. The selection of Plan 3 would result in a net benefit of over 1500 average annual functional habit units at a minimum of high value scarce habitat on an ecoregional or national basis.

Table 5-3
Turkey Creek Ecosystem Summary of Benefits

Plan	Plan Description	Total Functional Units	AAFU Net Benefit
Existing Condition	Existing Condition	-	-
No Action	No Action	1,012	0
Recommended Plan – Plan 3	689 Acre Restoration Maintain by Burning	2,577	1,565

Turkey Creek Ecosystem Restoration Costs

First Costs: $6,800,000
Annual O&M: $47,000.

5.18.6.2 Dantzler Restoration Area

The 385-acre State-owned site is located in central Jackson County near the Pascagoula River. The site was planted in plantation pine during the 1960s and drainage ditches and stormwater lines were constructed in the early 1970s in anticipation of residential development of the site. The restorable area is split by a road, 151 of the acres are north of the road and the remaining 234 acres are south of the road. The long-term exclusion of fire and the invasion of non-native species, such as Cogon grass and Chinese tallow tree, have also severely degraded the site. These exotic species out compete the native vegetation, which provides food sources to the many fish and wildlife important species, including T&E species. Without any native competing species, these exotic species eventually become the only species in the area and result in a continuing degradation of the functional value of the wetlands. The importance of the wet pine savannah has been previously been discussed in the Turkey Creek ecosystem restoration project above.

Winds from Hurricane Katrina destroyed most if not all of the plantation pine leaving massive amounts of tree litter on the ground. In addition, debris and sedimentation resulting from the storm surge added even more litter. The exotics that were present in the site prior to the storm thrive in this type environment and it is likely that without restoration of the site they will become the dominant species inhabiting the site. Six alternative plans were developed to address the ecosystem restoration of the area.

The recommended plan requires filling ditches, excavating and removing existing roadbeds and any additional fill, and maintaining vegetation growth by mowing and burning the project area in the initial year of construction as well as maintaining it by burning every three years over the life of the project as needed (Plan 1). As with the Turkey Creek ecosystem restoration, periodic burning of the site is a critical element to the success of the restoration.

Dantzler Restoration Benefits

Benefits are measured in terms of AAFU. The HGM approach was used to assess wetland function similar to Turkey Creek. Table 5-4 shows the AAFU net benefit under the recommended plan. The AAFU net benefit was calculated as the difference between the total functional units for the ecosystem restoration plan and the total functional units for the no action plan. For the analysis, it is assumed that functional units would remain the same under existing conditions and the no action plan even though it is likely that under the no action plan the functional value of the habitat would degrade significantly as exotic species became the dominant vegetation. For this reason the calculation of the environmental benefits of the proposed restoration are underestimated.

Table 5-4
Dantzler Ecosystem Summary of Benefits

Plan	Plan Description	Total Functional Units	AAFU Net Benefit
Existing Condition	Existing Condition	-	-
No Action	No Action	116	0
Plan 1	385 Acre Restoration Maintain by Burning	604	1,244

Dantzler Restoration Costs

First Costs: $2,200,000
Annual O&M: $26,000

5.18.6.3 Franklin Creek Ecosystem Restoration

The Franklin Creek ecosystem restoration area is located near the communities of Orange Grove and Pecan, Mississippi in eastern Jackson County, near the Mississippi - Alabama state line. This area has already been funded for acquisition and demolition of 30 structures as part of the MsCIP Interim Report (P.L. 110-28). The restoration area consists of 149 acres located north and south of U.S. Highway 90, a major thoroughfare through the community and the CSX railway alignment. This area routinely floods with only a slight rainfall; thus, this would also provide additional flood storage capacity by restoring the natural habitat. Pine savannah wetlands are commonly referred to as sponges that provide floodwater retention, groundwater recharge, and water purification. This wetland habitat is under increased developmental pressures due to the extreme and urgent housing need faced by Mississippians as they are trying to rebuild. This habitat is becoming fragmented and with the increased development, fire maintenance is increasingly harder to perform.

The recommended plan requires filling ditches, excavating and removing existing roadbeds and any additional fill, installing culverts under the highway, and maintaining vegetation growth by burning and mowing the project area in the initial year of construction as well as maintaining it by burning every three years over the life of the project as needed (Plan 1).

Franklin Creek Restoration Benefits

Benefits are measured in terms of AAFU. The HGM approach was used to assess wetland function similar to Turkey Creek discussed above. Table 5-5 shows the AAFU net benefit under the recommended plan. The AAFU net benefit was calculated as the difference between the total functional units for the ecosystem restoration plan and the total functional units for the no action plan. For the analysis, it is assumed that functional units would remain the same under existing conditions and the no action plan even though it is likely that under the no action plan the functional value of the habitat would degrade significantly as exotic species became the dominant vegetation. For this reason the calculation of the environmental benefits of the proposed restoration are underestimated.

Table 5-5
Franklin Creek Ecosystem Summary of Benefits

Plan	Plan Description	Total Functional Units	AAFU Net Benefit
Existing	Existing	-	-
No Action	No Action (149 acres)	80	0
Recommended Plan – Plan 1	149 Acre Restoration Maintain by Burning & Restore Hydrology	596	516

Franklin Creek Restoration Costs

First Costs: $1,850,000
Annual O&M: $11,000

5.18.6.4 Bayou Cumbest Ecosystem Restoration

This area is located in the extreme southeastern portion of Jackson County adjacent to Bayou Cumbest and the Mississippi Sound. The Bayou Cumbest restoration area contains approximately 148 acres to be restored to emergent tidal marsh and scrub shrub habitat. The area currently consists of a degraded tidal marsh, as well as filled and developed areas (Figure 8.1.2.4.4-1). Due to the severity of Hurricane Katrina, most of the residential development was severely damaged or destroyed. The area contains low elevations and since most residential structures have been destroyed, the opportunity exists reduce the risk of future hurricane and storm damage and to restore the once existent tidal marsh. Of the total 148-acre restoration site, approximately 110 acres would be restored to tidal marsh and while the remaining 38 acres would remain scrub/shrub wetland habitat. The area presently consists of previously filled marsh areas that were developed into a residential community. The proposed project requires the acquisition of approximately 144 acres of developed and undeveloped properties in addition to the use of 4 acres of land being acquired via the County / FEMA process. Portions of approximately 7 parcels of previously developed land fall within the restoration area (20 acres) with the remaining being undeveloped. The recommended project would require the acquisition of the subject properties according the USACE regulations. In addition, this would also provide additional future storm surge protection to the overall coastal area by increasing the natural protection that marsh provides.

Wetlands, marshes, and nearshore marine and estuarine habitat are the nursery grounds for the entire marine food chain in the Gulf of Mexico. These habitats have been identified by the U.S. Fish and Wildlife Service as habitats of high value for evaluation species and is unique and irreplaceable on a national basis or in the ecoregion section (Category 1) (Service Mitigation Policy, FR 46(15):7656-7663; dated 23 Jan 1981).Pollution, development, and other factors are destroying such habitat throughout the Gulf region. As this habitat is destroyed, it further depletes the species that form the base of the food chain throughout the Gulf of Mexico. Numerous species of marine flora and fauna begin their life cycles in marshes and wetlands. Ultimately, the entire Gulf of Mexico ecosystem is threatened by the accelerated destruction of this habitat. Failure to address the loss of this habitat in the Gulf of Mexico region threatens the long-term health of the entire ecosystem and human culture, with the attendant loss of billions of dollars of marine-related resources.

The recommended plan will restore 148 acres. The recommended plan consists of acquiring lands and restoring the natural ecosystem by excavating old fill material, removing exotic plant species from non-excavated areas, filling existing artificial ditches, and planting native vegetation, such as *Spartina alterniflora* (Smooth Cordgrass) at the seaward edge of marsh; *Juncus roemerianus* (Black Needle Rush) at a slightly higher elevation; and *Spartina patens* (Saltmeadow Cordgrass) at even higher elevations at a density of 1 meter (Plan 2).

Bayou Cumbest Restoration Benefits

Benefits are measured in terms of AAFU. The HGM approach was used to assess wetland function. A HGM assessment was performed in 2000 using the *Regional Guidebook for Applying the HGM Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains*. Results from this assessment were used to establish baseline (current) conditions and, ultimately, to measure the functional unit benefits resulting from different restoration plans. Table 5-6 shows the total functional units under each implemented plan and the AAFU net benefit. To calculate the AAFU net benefit, it is assumed that benefits will be maximized at year 5 with 0.5 meter spacing of vegetation, at year 7 with 1.0 meter spacing of vegetation, and at year 10 with 2.0 meter spacing of vegetation. These benefits are estimated to be sustainable over the life of the project. Net AAFU benefits are calculated as the difference between the total functional units for the ecosystem restoration plan and the total functional units for the no action plan. As with the other ecosystem restoration area, the benefits are likely to be underestimated since it is assumed that the existing functional value of the site will continue into the future with no diminishment. This is highly unlikely due to the aggressive nature of the exotic species that are currently in the area.

Table 5-6
Bayou Cumbest Ecosystem Summary of Benefits

Plan	Plan Description	Total Functional Units	Net AAFU Units
Existing Condition	Existing Condition	-	-
No Action	No Action	1,052	0
Recommended Plan 2	Excavate Fill Remove Exotics Fill Ditches Plant at Density 1.0m	1,719	637

Bayou Cumbest Restoration Costs

First Costs: $25,400,000
Annual O&M: $114,000.

5.18.6.5 Admiral Island Ecosystem Restoration

The 123 acre restoration area is located in Hancock County adjacent to Bayou La Croix and near Bay of St. Louis. The site contains of 62 acres of emergent tidal marsh and 61 acres of scrub shrub habitats. The property is owned by the State of Mississippi and consists of degraded wetland habitat as a result of debris and sediment deposited during the storm surge event of Hurricane Katrina.

The tidal marshes in this area were ditched during the 1960s causing changes in the natural hydrology and subsequent changes in the species composition. Hurricane Katrina left extensive debris fields and sedimentation throughout the area and destroyed many native trees and vegetation. Due to the loss of native species, this area is experiencing a severe infestation of the invasive Chinese tallow tree, which is invading the marshes and the adjacent flatwoods. These exotic species out-compete the native vegetation, which provides food sources to the many fish and wildlife important species, including T&E species. Without any native competing species, these exotic species eventually become the only species in the area and result in a much degraded function of the wetlands.

The recommended plan consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas, planting native vegetation at a density of 1.0 meter,

and filling existing artificial ditches. T he planting of native vegetation consist of *S. alterniflora, J. roemerianus, and S. patens* (Plan 2).

Admiral Island Restoration Benefits

Benefits are measured in terms of AAFU. The HGM approach was used to assess wetland function similar to Bayou Cumbest. Table 5-7 shows the total functional units under each implemented plan and the AAFU net benefit. To calculate the AAFU net benefit, it is assumed that benefits will be maximized at year 5 with 0.5 meter spacing of vegetation, at year 7 with 1.0 meter spacing of vegetation, and at year 10 with 2.0 meter spacing of vegetation. These benefits are estimated to be sustainable over the life of the project. Net AAFU benefits are calculated as the difference between the total functional units for the ecosystem restoration plan and the total functional units for the no action plan. The recommended plan was selected based on the criteria used for Bayou Cumbest.

Table 5-7
Admiral Island Ecosystem Summary of Benefits

Plan	Plan Description	Total Functional Units	Net AAFU Net Benefits
Existing		-	-
No Action	No Action	358	0
Recommended Plan – Plan 2	Excavate Fill Remove Exotics Plant at Density 1.0m Fill Ditches	471	108

Admiral island Restoration Costs

First Cost: $21,700,000
Annual O&M: $58,000

Deer Island Ecosystem Restoration

Deer Island, located within the boundaries of Harrison County, Mississippi near the mouth of Biloxi Bay and the City of Biloxi, has a history of tropical storm damage. Damages from these storms has varied based on varying degrees of storm surge, wave action and wind depending on the speed, intensity, direction of travel, and proximity of the given storm. Figure 3-6 displays a recent aerial photograph of Deer Island, showing the damage exacerbated during Hurricane Katrina. The breach on the west end was significantly widened, coastal marshes were impacted by debris and sedimentation, and the maritime forest was killed by wind and salt spray. With all this damage, it is amazing that the wetland created via Section 204, Beneficial Use of Dredged Material, on the eastern end of the island survived and is currently thriving.

The island is considered a mainland remnant and is not part of the coastal barrier system of islands along the Mississippi Coast. The island contains a diversity of habitat areas including beach/dune areas, marsh area, and maritime forest areas. It's proximity to the City of Biloxi provides a certain amount of protection to the city from waves generated by approaching hurricanes. This protection comes at a cost to the island as that energy affects the seaward shoreline and the interior marshes. It has been estimated that the island has lost approximately 300 acres or about 34 percent of its area since 1850, due to eroding shoreline.

A second restoration effort is currently underway which will fill the western breach and provided selective restoration to critical areas on the southern shoreline. This project is authorized under Section 528 WRDA 2000 and will be complete in 2009. Funding for this effort, however, is inadequate to completely restore the island and to remediate for the additional damage to the island caused by Hurricane Katrina.

Due to the interrelated nature of some of the features, i.e. a+b, c+d, the team evaluated a total of 7 combination plans. Of these 7 the plan which best meets the planning objectives is the most cost effective is Combination Plan 7 which includes implementation of each of the alternatives.

Deer Island Benefits

Implementation of the combination plan would significantly improve the sustainability of Deer Island and result in the creation of approximately 20 acres of tidal emergent fringe marshes, restore beach and dune habitat, create hard bottom habitat through the use of stone containment, provide protection from coastal erosion, remove sedimentation and debris, and restore the coastal maritime forest an ecosystem of regional importance and concern.

Deer Island Costs

First Costs: $21,400,000
Annual O&M: $0

5.18.6.6 Submerged Aquatic Vegetation Pilot Project

Additional study is required to assess the complex environmental make-up impacting submerged aquatic vegetation (SAV) in Mississippi Sound due to the fact that previous planting efforts utilizing vegetation alone have not been entirely successful. Many questions must be answered (i.e. water quality, circulation, etc.) prior to SAV restoration implementation. SAV restoration efforts across the nation have proven to be rather challenging and many examples can be identified close to Mississippi over in Florida. Therefore, the MsCIP environmental team is recommending additional study via an in situ pilot project. Opportunities exist to partner with Federal, state, and local resource agencies as well as NGOs. Involvement of local colleges and universities with ongoing research programs would also help to identify and pinpoint specific problems for development of potential solutions.

Bayou Cumbest Pilot Restoration

The first goal of the proposed community-based restoration project in the Grand Bay National Estuarine Research Reserve (NERR) will result in restoration of up to 5 acres of *Ruppia maritima* resulting in the recovery of an equal amount of SAV habitat to that lost during the 2005 hurricane season. The second goal is to evaluate 3 restoration techniques to demonstrate their feasibility for larger restoration projects. The third and final goal to be achieved is educational – to increase awareness of the importance of SAV habitat in Mississippi Sound and provide coastal managers and restoration practitioners with the knowledge of techniques to maximize their return on dollars spent.

Three transplanting methods for restoring *R*. *maritima* will be evaluated as follows:1) direct planting from the donor site, 2) harvesting plant sprigs with one or more meristems (growth regions) from the donor site with subsequent growth in a greenhouse setting prior to planting, and 3) spreading seeds or mature flowering shoots over the restoration site. All plants and seeds would be acquired from a common donor site within the same system (Figure 8.1.2.6.1-1). After transplanting, quarterly monitoring for two years would be conducted to determine plant establishment, photosynthesis, growth, and expansion.

Educational outreach materials will be disseminated through Grand Bay NERR's Coastal Training Program to inform coastal decision-makers and resource managers of successful restoration techniques.

SAV Restoration Benefits

Submerged aquatic vegetation is an essential primary producer forming the basis of the food web for many estuarine species. These grasses provide important habitat for many Aquatic Resources of National Importance. In addition, SAVs are sensitive indicators of estuarine condition because of their high light requirements (Dennison et al 1993) and susceptibility to eutrophication-induced algal blooms and hypoxia (Hauxwell et al 2001). Furthermore, loss of SAV promotes the alteration of the

sediment characteristics and nutrient cycling, causing long-term changes in habitat suitability for natural plant recolonization. These changes include loss of fine sediments through resuspension and transport, promoting a feedback loop that further inhibits natural recovery. Therefore, it is vitally important that restorative replanting be undertaken soon after damage or loss of plants to inhibit a negative change in system dynamics (Fonseca et al 2004).

SAV Restoration Costs

First Costs: $900,000 for monitoring and producing a final restoration report.

5.18.6.7 Additional Ecosystem Restoration Studies

This report supports the recommendation for further investigations of additional ecosystem restoration components of the Comprehensive Plan in anticipation of potentially recommending the features for future authorization as part of the MsCIP Comprehensive Plan.

Introduction

Development of the GIS based SDSS tool allowed the MsCIP environmental team, working in cooperation with the USFWS and MDMR, to identify and prioritize potential wetland restoration areas throughout coastal Mississippi (Lin 2007). A detailed explanation of this GIS based SDSS tool is provided in the Environmental Appendix to this report. The recommendation for further investigations would allow ecosystem restoration to be implemented on a holistic, watershed, and regional approach. Establishment of this program would ensure commitment to restoration of the hurricane damaged and destroyed ecosystems in coastal Mississippi; thus, allowing attainment of the overall Comprehensive Plan objectives.

Unique habitats exist in coastal Mississippi that are critical to the continued health of a number of fish and wildlife species of the Gulf of Mexico. Most of these proposed restoration habitats have been impacted and/or destroyed nationally, regionally, and locally by development and/or natural events. These sites require man-intervention in order to restore to their historical environmental setting. Failure to restore these sites could impact all coastal Mississippi.

Program Development

Using the GIS based SDSS model allows effectively analysis of needs in coastal Mississippi and the broader northern Gulf region. A subset of potential restoration sites were identified by the SDSS tool and then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS. Based on this work, which allowed both confirmation of the accuracy of the SDSS results and collection of additional on-site information pertinent to restoration efforts, the projects discussed above have been developed as cost effective means of initiating ecosystem recovery. In addition to these specific projects, other potential environmental restoration projects are identified for further study. Implementation of any of these projects would be dependent upon the preparation of a decision document, such as Project Information Report, which would range from $100,000 to $350,000 depending upon the specific project complexness. This cost has been incorporated into the cost estimates that follow.

Partnerships

Development of partnerships with Federal resource agencies, state agencies, and NGOs is crucial to the success of this program. These partnerships would provide opportunities to access local knowledge of the existing environment. Specialists in specific restoration techniques would be available as well as opportunities to build on existing programs.

Planning and Evaluation Teams

Development of teams would be necessary to organize the program, establish prioritization of projects, development and evaluation of project plans, and future monitoring. Development of assessment models as well as monitoring plans would be accomplished by various inter-disciplinary planning and evaluation teams.

Projects

The SDSS model identified hundreds of potential restoration areas. The list was verified in the field and through existing partnerships with Federal and state agencies. Verification was based on personal knowledge of the overall comprehensive natural system and the level of success to be gained via these restorations as part of the overall system-wide comprehensive approach. These sites were screened further and a list of 38 additional restoration sites is proposed, as identified in Table 5-8.

Table 5-8
Additional High Priority Ecosystem Restoration Sites

Site	Restoration Acres	Environmental Setting	Project Cost with Contingency
(1) Pearlington, Hancock	76 acres (State owns 2,200 acres in the Pearlington area)	Emergent aquatic vegetation Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$15,300,000 ER $14,900,000 RE
(2) Pearlington South, Hancock	11 acres	Emergent aquatic vegetation Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$2,300,000 ER $21,100,000 RE
(3) Port /West, Hancock	49 acres	Emergent aquatic vegetation	$10,000,000 ER $9,800,000 RE
(4) Ansley, Hancock	2,023 acres (State owns 6,000 acres west of Lakeshore Road)	Emergent aquatic vegetation Wet pine savannah	$399,100,000 ER $83,000,000 RE
(5) Heron Bay, Hancock	594 acres	Emergent aquatic vegetation	$83,200,000 ER $80,000,000 RE
(6) Lower Bay, Hancock	226 acres	Emergent aquatic vegetation	$31,700,000 ER $8,400,000 RE
(7) Lakeshore, Hancock	275 acres	Emergent aquatic vegetation	$54,500,000 ER $14,700,000 RE
(8) Bayou Caddy/Lakeshore, Hancock	362 acres	Emergent aquatic vegetation	$71,700,000 ER $41,700,000 RE
(9) Clermont Harbor, Hancock	209 acres	Emergent aquatic vegetation	$41,600,000 ER $166,700,000 RE
(10) Bayou La Croix, Hancock	259 acres	Emergent aquatic vegetation	$51,400,000 ER $155,700,000 RE
(11) Shoreline Park, Hancock	889 acres	Emergent aquatic vegetation	$175,600,000 ER $1,083,600,000 RE
(12) Chapman Road, Hancock	146 acres	Emergent aquatic vegetation	$29,200,000 ER $144,900,000 RE
(13) Jourdan River – Interstate 10 Development, Hancock	638 acres	Emergent aquatic vegetation	$126,200,000 ER $29,700,000 RE

Site	Restoration Acres	Environmental Setting	Project Cost with Contingency
(14) Diamondhead, Hancock	433 acres	Emergent aquatic vegetation	$85,800,000 ER $182,200,000 RE
(15) Delisle, Harrison	120 acres (State owns 1,000 acres)	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs	$24,100,000 ER $17,800,000 RE
(16) Ellis Property, Harrison	443 acres	Emergent aquatic vegetation Pine savannah - wet pine flatwoods.	$46,900,000 ER $13,400,000 RE
(17) Pine Point East, Harrison	103 acres (State owns 40-50 tax forfeited lots)	Emergent aquatic vegetation Wet pine savannah habitat	$20,600,000 ER $26,900,000 RE
(18) Pine Point West, Harrison	83 acres (State owns 40-50 tax forfeited lots)	Emergent aquatic vegetation Wet pine savannah habitat	$16,800,000 ER $19,900,000 RE
(19) Pass Christian Beach Front, Harrison	21 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs	$4,300,000 ER $6,400,000 RE
(20) Pass Christian Site – Bayou Portage, Harrison	43 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs	$8,700,000 ER $19,100,000 RE
(21) Brickyard Bayou, Harrison	14 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs	$2,900,000 ER $4,100,000 RE
(22) Biloxi River – Shorecrest, Harrison	15 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs Riverine/levee forests	$3,000,000 ER $9,500,000 RE
(23) Biloxi River – Eagle Point, Harrison	17 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs Riverine/levee forests	$3,200,000 ER $14,200,000 RE
(24) Biloxi Front Beach - South of Highway 90, Harrison	40 acres	Dune System	$7,000,000 ER $53,500,000 RE
(25) Keegan Bayou, Harrison	54 acres	Emergent aquatic vegetation Wet Pine Savannah habitat	$10,900,000 ER $20,600,000 RE
(26) St. Martin, Jackson	467 acres	Emergent aquatic vegetation	$92,400,000 ER $55,100,000 RE
(27) Fort Point, Jackson	83 acres	Emergent aquatic vegetation	$16,700,000 ER $12,700,000 RE
(28) Pine Island, Jackson	237 acres	Emergent aquatic vegetation	$497,900,000 ER $20,700,000 RE
(29) Belle Fontaine, Jackson	1,516 acres	Dune System	$297,900,000 ER $75,800,000 RE

Site	Restoration Acres	Environmental Setting	Project Cost with Contingency
(30) Griffin Point, Jackson	182 acres	Emergent aquatic vegetation	$36,000,000 ER $34,900,000 RE
(31) Bayou Chico, Jackson	258 acres	Emergent aquatic vegetation	$51,200,000 ER $31,700,000 RE
(32) Grand Bay/Bayou Cumbest, Jackson	2,666 acres	Emergent aquatic vegetation	$525,700,000 ER $95,700,000 RE
(33) Wachovia, Hancock	1,200 acres total – 800 marsh, 200 forested, 200 savannah	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$2,830,000 ER $ 0 RE
(34) Ansley, Hancock	900 acres – 800 marsh, 100 forested	Emergent aquatic vegetation, Wet pine savannah	$2,420,000 ER $ 0 RE
(35) LaFrancis Camp Trenaisse, Hancock	45 acres total – all open water	Open water	$8,770,000 ER $ 0 RE
(36) DuPont, Harrison	650 acres – 170 marsh, 480 forested	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$TBD ER $ 0 RE
(37) Dantzler Part 2, Jackson	900 acres – 500 marsh, 385 forested	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$6,597,000 ER $ 0 RE
(38) Pascagoula River Marsh, Jackson	11,150 acres	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$2,230,000 ER $ 0 RE
ER = Construction Costs, RE = Acquisition Cost, TBD = Costs for these ecosystem restoration are being developed			**Sum of Project Costs With Contingency: $5,481,047,000**

Sequencing Plan

Once the restoration sites have been prioritized, a sequencing plan would be developed identifying the events necessary to accomplish restoration. This would ensure prioritized sites received immediate attention and further details developed for the required analysis.

Project Information Reports

As projects are being developed, specific details would be developed to ensure compliance with regulations, policies, and acts. This information would be complied in a PIR and would consist of certain NEPA documents, EA, Finding of No Significant Impact, and others as necessary, project designs and details, economic analysis including incremental cost analysis for use in selection of a best buy plan, and other necessary documentation for approvals. The level of detail contained in a

PIR would be commensurate with the complexity and cost of the project while including the information necessary to meet requirements.

Costs

A rough order of magnitude cost estimate has been prepared for each project based on existing conditions and restoration measures. This could serve as an upward limit of funding for the comprehensive environmental restoration program. Costs cover site acquisitions including associated relocation costs, removal and site demolition activities, and ecosystem restoration activities. A breakdown of the costs at each site is presented in the table above.

Monitoring and Adaptive Management

Monitoring and adaptive management is an integral part of the ecosystem restoration program. Post-construction monitoring would provide a systematic assessment of key indicators throughout coastal Mississippi ecosystems. Monitoring would inform the implementation of any adaptive measures which might be required to achieve project benefits. The role of monitoring and adaptive management in the Comprehensive Plan is presented in section 5.5 Monitoring and Adaptive Management.

Program Status Reports

Program Status Reports would accomplish a system-wide reevaluation that would consider program and project-level considerations, and the level of success of overall met program goals and objectives. Project level formulation activities would address optimization of the overall program's contribution to the system-wide goals and objectives in general, and project goals and objectives would be more specific. The individual project monitoring reports may result in project modifications that impact or modify system output, however, these modifications would not address system-wide issues within the comprehensive plan. Status reports would provide updates on the overall success of environmental restoration throughout coastal Mississippi.

5.18.7 Violet Freshwater Diversion Project Engineering and Design

This report supports a recommendation for initiating studies required to accomplish the intent of Section 3083 of the Water Resources Development Act of 2007 to design a freshwater diversion project to be located in the vicinity of Violet, LA. The project would provide sufficient inflows to the western Mississippi Sound area to support oyster reef health and productivity.

Background

Mississippi Department of Marine Resources (MDMR) has been working with the Mississippi congressional delegation in order to address impacts from saltwater intrusion and degradation of the oyster resources found within Mississippi Sound, specifically in the western portion of the state in Hancock County. Joint efforts between Mississippi and Louisiana congressional delegates resulted in the identification of potential freshwater diversion projects from the Mississippi River as a mechanism for reversing the historic increase in salinity in the Mississippi Sound/Biloxi marshes area in order to support fresher marshes and oyster reef health and productivity thus enhancing both their economic value and the ecological services they provide (WRDA 2007, Section 3083).

Modeling Efforts

During 2002, MDMR began serious efforts into developing a freshwater diversion project and through collaboration with state academia, began running modeling scenarios. Additionally, in 2006, the MsCIP environmental team began refinement of water quality modeling utilizing existing data collected during the Gulfport Harbor widening study. The results from a simulated diversion of 7,500 cfs of Mississippi River water near Violet, Louisiana, suggest that 180 days after initiation of the diversion, salinities were lowered in western Mississippi Sound, (Dortch et al 2007) sufficiently to warrant additional examination. However, at present, absolute salinity values predicted by the model poorly match calibration data. Further refinement of the models should correct this limitation

to allow the usefulness of the model results for estimating potential beneficial or deleterious effects on oysters and other coastal resources.

Collaboration

During further collaboration between the states' congressional delegations, a project has been agreed upon and consists of a freshwater diversion of Mississippi River that should prove beneficial in reaching each state's goals of establishing and maintaining salinity regimes for oysters and introducing sediment into the eroding Biloxi marshes of Louisiana. Additionally, the State of Louisiana, through CIAP funding is currently designing a much smaller diversion project into the Central wetlands that could be incorporated as a small component of the much larger overall freshwater diversion project being developed by the Corps, Mobile and New Orleans Districts.

The MsCIP environmental team has participated in initial project development meetings between the states of Mississippi and Louisiana, Corps New Orleans District, and Lake Pontchartrain Foundation. The freshwater diversion project at Violet is being incorporated into the MsCIP Comprehensive Plan as a recommendation for engineering and design.

In an effort to apply this water quality data to ecological issues, MsCIP and ERDC convened a panel of representatives from TNC, MDMR, and USM at GCRL. The aim of the panel is to suggest simplistic ecological models that can be incorporated with projections from the combined hydrodynamic and water quality models to identify simulations which might result in an improvement in oyster habitat quality. The panel has identified several key attributes that need to be incorporated into the evaluation of freshwater diversion options. The first is that salinities average as closely as possible to the optimal range for oyster health and productivity. This is clearly of critical importance since the primary purpose for contemplating freshwater diversions is to improve habitat conditions for oysters. Second, a diversion should not result in extended periods of low salinity resulting in mortality or poor growth and reproduction. This consideration is particularly critical during times of high river flow or other extreme conditions. Third, a diversion should not unduly influence habitat conditions for other critical resources.

Diversions that result in favorable conditions for oyster health may not be conductive to other equally important resources. For instance, most sea grasses do poorly at salinities less than 20 ppt. A diversion that results in excellent conditions over the prime commercial beds but drives salinities below 20 ppt in the seagrass elsewhere would not be acceptable. Other important habitat requirements that should also be considered for seagrass health include light availability and nutrient concentrations. These environmental concerns associated with water diversions, in addition to potential impacts on important fisheries species of those areas, require monitoring and adaptive operations of the diversion structure to enhance the long-term sustainability of nearshore and estuarine resources.

Project Development

The Violet diversion project will take a monitoring and adaptive operations approach in order to fully understand the impacts associated with the freshwater diversion. The project will likely consist of a gravity diversion structures constructed on the east bank of the Mississippi River at Violet, Louisiana. The structure would be designed and operated to provide for an estimated target freshwater diversion of approximately 10-12,000 cfs released into Lake Borgne. The structure would be operated in such a matter as to allow for releases in the quantities and frequencies necessary to reach the target salinity rate. Early modeling suggests timing of the release as well as frequency is crucial to ensure success at reaching the target salinity rate for oysters, an indicator species as to the overall health of the ecosystem. Further modeling would refine target frequencies and timing of releases of the freshwater to meet oyster habitat goals.

Future Development

The diversion project would be closely coordinated between the Corps, New Orleans and Mobile Districts, States of Louisiana and Mississippi, and the Lake Pontchartrain Foundation. This collaborative partnership would provide opportunities to build on information gathered during previous studies and modeling and to ensure that overall objectives and specific goals are established by the groups involved.

Violet Freshwater Diversion Study Costs

An estimated $ 12,000,000 is required for completion of engineering and design to include the preparation of supplemental NEPA documentation.

5.18.8 Escatawpa River Diversion – Grand Bay Marsh Ecosystem Restoration

This report supports the recommendation for authorization to conduct feasibility level analyses of fresh water diversion at the Escatawpa River in anticipation of potentially recommending this comprehensive plan element for future authorization as part of the MsCIP Comprehensive Plan. Historically, the estuarine marsh within the Grand Bay NERR represented the former deltaic environments of the Pascagoula and Escatawpa Rivers in eastern Jackson County. The outlets of these rivers have shifted westward over time, severely limiting the inflow of freshwater, nutrients, and sediments into the Bayou Cumbest area of the reserve.

Currently, it is speculated that much of the freshwater entering the Grand Bay NERR estuary is from surface runoff through Bayou Heron and Bayou Heron, within the Bangs Lake Hydraulic Unit, measuring approximately 21,374 acres. Human disturbances to the area have also altered historic sheet flow and surface water flows into the area, as well as the natural migration of the Pascagoula and Escatawpa Rivers.

Additional Study Efforts

Due to the time constraints, the team was only able to qualitatively determine that freshwater input into the systems does change the overall environment. It is known that these systems have been altered and/or starved by lack of freshwater inflow. An integrated environmental web exists in these rivers and also in Mississippi Sound, which needs to be fully identified, in order, to completely understand various effects that could possibly occur.

Further studies would allow for development of a refined hydrodynamic model for the area, inputting biological, water quality, and physical data into the model to evaluate a variety of freshwater diversion scenarios. This work represents a critical first step in the final assessment of potential water diversion projects for this area. Additionally, community information needs to be solicited obtained through interviews and public workshops will be solicited and a public workshop will be held to share the results.

Escatawpa River Diversion Benefits

A freshwater diversion project in the area, if feasible, may serve to enhance the wildlife resources of the area. The need for freshwater diversion at the Grand Bay savannahs and marshes would help restore the predominant wet pine savannah habitat. Shoreline erosion along the Grand Bay area (i.e. loss of the Grand Batture Islands) has also contributed to the increased salinity in the area.

Escatawpa River Diversion Costs

An estimated $ 3,000,000 is required for the additional environmental and engineering study and design.

5.18.9 Coast-wide Beach and Dune Ecosystem Restoration

This report supports the recommendation for authorization to construct beach and dune restoration improvements along the Mississippi coast. Essentially all the beaches along Coastal Mississippi are man-made. Harrison County has the most beachfront with a 26-mile stretch extending from Biloxi Bay to St. Louis Bay. This beach is the longest man-made beach in the U.S. Hancock County has several miles of beach while Jackson County only has a small beach located in the Cities of Pascagoula and Ocean Springs. In total, the beaches extend along less than half of the Mississippi coastline.

Most of the dunes that previously existed along these beaches were destroyed by Hurricane Katrina and much of the beach was damaged. Many Federal, state, and local entities raised environmental concerns regarding the various Mississippi beaches during initial discussions held to receive local citizenry input. In some areas, such as in the City of Pascagoula, the beach was completely gone. Reconstruction of the dunes, where beaches exist, will provide a reduction of damaging wave action from smaller storms (i.e. normal summer storms, tropical storms, and/or lower energy hurricanes).

A project to restore the beaches in Harrison County has been funded and is underway as part of the Flood Control and Coastal Emergencies (FCCE). Other projects to construct dunes to a height of 5-foot in Harrison County and to 2-foot in Hancock and Jackson County were proposed as part of the MsCIP Interim Report. That dune restoration project has since been funded and the Corps, Mobile District is underway preparing the plans and specifications.

The beaches, situated immediately seaward of developed areas, provide an excellent location where elevated dunes could be constructed to provide some additional protection against smaller hurricanes. Furthermore, the seaward side of the dunes also provides excellent feeding grounds at the nearshore and intertidal shore areas for various birds, crabs, and other fauna.

Beach and Dune Ecosystem Restoration Alternatives

Original concepts were to look at crest elevations of +10.0 feet and +15.0 feet as options for all dunes. Further discussions made it clear that the top elevation of the dunes needed to be below the elevation of the adjoining roadway. This was to help mitigate the migration of the sand onto the roadway as aeolian (wind blown) deposits. Alternatives evaluated included dune heights of 2 and 6 feet with planting of appropriate dune vegetation.

Beach and Dune Ecosystem Restoration Benefits

The storms of 2005 destroyed a large percentage of critical habitat for the Piping Plover, various shorebirds including the Least Tern, and numerous fish and wildlife species. Beach nourishment and dune restoration would benefit piping plover as well as providing lost habitats for other shorebirds, additional eco-tourism opportunities, and enhancement to the overall quality of life in Coastal Mississippi. Placement of the dunes directly against a raised seawall or roadway would also serve aesthetically to mask the appearance of a structural barrier. Thus, adding to the public acceptance and/or appeal of this proposal.

Dunes are consistent with public preference for a more natural appearing defense mechanism rather than a hardened structure. Construction of dunes will include planting vegetation, such as sea oats (*Uniola paniculata*), and sand fencing to help stabilize the dunes. Sand dunes are naturally occurring dynamic coastal features, which are formed by the accumulation of wind blown sand. Sand is naturally carried along the beach by the wind. Sand fences help facilitate the building of sand dunes by trapping and collecting this wind driven sand. Sand fences are usually made of wood or biodegradable material. Dune plants tolerate harsh beach conditions including wind, salt spray, storms, scarce nutrients, limited freshwater, and intense sunlight and heat. The plants and/or seedlings provide feeding sources to a variety of animals while also providing nesting and roosting habitat.

The tentatively recommended plan for this element of the Comprehensive Plan was determined by a combination of cost-effectiveness analysis and achievement of key restoration objectives. The most cost-effective and functionally complete alternative was determined to consist of creation of a dune field that would be constructed approximately 50 ft seaward of the existing seawall and about 2 feet above the existing berm with a width of approximately 60 ft. The most functionally-effective alternative included dune vegetation and sand fencing to enhance establishment and survival of the dune vegetation.

Table 5-9
Coastwide Beach/Dune Ecosystem Restoration Summary of Benefits

Plan	Plan Description	Functional Habitat Index
Existing Condition	Existing Condition	-
No Action	No Action	96
Recommended Plan	2-foot High x 60-foot Wide Dune With Planting & Sand Fencing	248

Beach and Dune Ecosystem Restoration Costs

First Costs: $23,200,000.
Annual O&M: $0

5.18.10 Barrier Island Ecosystem Restoration Alternatives

This report supports the recommendation for authorization to construct ecosystem restoration improvements at Mississippi's barrier islands. The barrier islands have historically constituted a barrier to saltwater, maintaining a careful balance of saltwater and freshwater flows, which sustain the valuable marine resources of Mississippi Sound. The barrier islands also provide a barrier to onshore movement of waves, and to a lesser extent storm surge, by attenuation. Over recent decades, the level of wave and surge reduction they provide has been steadily reduced, but much more so during the hurricane events of Camille, and Katrina, in which Ship Island was first severed, then dramatically separated, and badly eroded.

The contribution of surge reduction provided by the barrier islands, in their historic, existing, and altered states, has been subject to sensitivity analyses that indicate that some surge reduction is realized on the western Mississippi coast by the islands being in a pre-Camille footprint. Additional benefits were also predicted by creating longer and higher islands that were not subject to erosion on storms. It has also been roughly estimated that as much as ten feet of wave height reduction is provided by the barrier islands in their present condition as compared to the islands being removed from the system. It can only be speculated as to how much actual damage reduction the barrier islands provide, but one thing is known for sure, and that is that the disappearance of the barrier islands would provide the means for a dramatically increased wave climate, along the coast of Mississippi. and unlike in previous periods, the barrier islands are incapable of rebuilding on their own due to frequent, intense storms, relative sea level rise, and anthropogenic activities that may have resulted in a reduction in sand supply to the Mississippi barrier islands.

Similarly, the degree of decline in shellfish and other marine resources within Mississippi Sound attributable to the degradation of the barrier islands is currently impossible to precisely quantify; however, it is known that declining oyster populations are directly attributable to the increasing salinity within Mississippi Sound. Oysters are sensitive to specific ranges of salinity. Under current conditions, the islands provide a natural boundary between the water's salinity [~33 parts per thousand (ppt)] of the open Gulf of Mexico and the brackish water found in Mississippi Sound. Salinity in the Sound during low flow periods range from 10 to 30 ppt. Additional study would be required to determine impacts to salinity from the loss of the barrier islands.

The alternatives for barrier island renourishment and protection of Mississippi Sound are being formulated and evaluated by a multi-agency regional study team consisting of staff from the National Park Service, U.S. Geologic Survey, and Corps of Engineers. In addition, barrier island restoration has been suggested and is supported, by numerous members of the public, other agencies, and the State of Mississippi.

Alternatives being evaluated include very limited restoration of Ship Island, only in the vicinity of the endangered cultural sites of Fort Massachusetts and French Warehouse, on (the post-Katrina condition) "West" and "East" Ship Islands, respectively up to 'massive' restoration of the historic island dimensions. Although the protection of the cultural resource sites appears to be a justified option, this alternative would neither represent a complete solution, nor a completely effective means of addressing the larger problem faced on that island and the others. On the other hand, a more massive plan for barrier island restoration, or more direct application of sand, was rejected by many on the team, as unmanageable and potentially damaging, due to the unknown effects that might be introduced by placing sand into an area that could not be maintain by littoral drift over the long-term. More massive measures did not appear to provide a significantly greater volume of functional increase, for a much larger outlay of funds.

As part of the evaluation increasing the volumes of sand to the system is determined to be increasingly effective in achieving additional functional value, particularly when sand was provided directly into the littoral drift that created and nourishes the islands, so that "Mother Nature" can finish the job of distributing the sand in a natural way, to those areas of the island most suited to the current drift climate.

Table 5-10
Barrier Island Ecosystem Restoration Alternatives

Management Measure	Description
Option A	Restore Island to pre-Camille Footprint with Massive Restoration of Dune
Option B	Replenish Sand in Littoral Zone, Inland Sand Source
Option C	Replenish Sand in Littoral Zone, Offshore Sand Source
Option D	Dune Restoration with 2-foot Dune, No Additional Sand
Option E	Dune Restoration with 6-foot Dune, Minimal Additional Sand
Option F	Seagrass Restoration North of Existing Islands
Option G	Direct Sand Placement in Camille Cut
Comprehensive Plan	Direct Sand Placement in Camille Cut with Dune Vegetation Planting Littoral Zone Placement East Ends of Ship, Horn, & Petit Bois Islands Coastal Processes Analysis of Cat Island

Plan Selection

Several alternatives have been evaluated regarding the restoration of the Mississippi barrier islands. The most promising alternative for barrier island renourishment and protection of Mississippi Sound would produce the greatest functional benefit per dollar expended, would be a complete solution, would represent an efficient use of Federal and local funds, would be effective in its treatment of the problem (particularly in comparison to less effective structural wave reduction measures), and would be acceptable in terms of existing laws, policies and priorities. In addition, the public is highly supportive of measures meant to address the degradation of the barrier islands, as an element of a

natural barrier to storms, and in the restoration of marine resources associated with Mississippi Sound.

This alternative includes the direct placement of sandy sediments to fill the breach in Ship Island and thereby reconnect West and East Ship Islands to their historic condition and to place sandy sediments within the littoral zones of Ship, Horn and Petit Bois Islands to ensure that the sediment budget of the islands is sufficient to maintain the islands in the future. This littoral zone placement would also benefit from the modification of dredging and disposal practices of the federally maintained Gulfport and Pascagoula Harbor navigation projects. These coupled efforts would begin the long-term process of barrier island repair and sustainability. Another consideration that still must be addressed is the best alternative for dealing with the erosion of Cat Island. This island is geomorphically different from the other 3 barrier islands and our understanding of the processes controlling Cat Island is not well developed. Additional effort would be required to add this island into an overall comprehensive barrier island restoration plan.

Barrier Island Ecosystem Restoration Benefits

Restoration of the Mississippi barrier island system would provide significant system-wide ecosystem benefits as well as economic benefits associated with damages and economic losses avoided and regional economic benefits.

Most notably the restoration of the islands would help maintain and sustain the fragile Mississippi Sound ecosystem with its economic, recreational, environmental, and aesthetic benefit and provide for additional nesting habitat for threatened and endangered sea turtles and over wintering critical habitat for the piping plover. A functional habitat index evaluation of just the direct placement of sand in Camille Cut with the associated dune habit restoration would increase that habitat value of Ship Island to approximately 500 habitat units vs. the 96 units provided currently by Ship Island. With the continued erosion of this island, the habitat value will only decline in the future without intervention. No environmental benefits have been calculated relative to the maintenance of the Mississippi Sound but a rough estimate of the fishery losses avoided by restoration of the island is over $43 million in average annual benefits. Additional economic benefits are provided in Table 5-11 and detailed in the Economic Appendix to this report.

Table 5-11
Summary Benefits for Barrier Island Comprehensive Plan

	Damages Avoided (Annual $)	Recreation Losses Avoided (Annual $)	Fishery Losses Avoided (Annual$)	Change in Sales Volume	Change in Income	Change in Employment
Barrier Island Comprehensive Plan (G)	$17,699,600	$466,341	$43,618,143	$843,210,000	$177,140,450	5,192

Barrier Island Ecosystem Restoration Costs

First Costs: $477,200,000
Annual O&M: $0

5.19 Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R)

It is anticipated that the entities of the State of Mississippi or other appropriate coastal municipalities (e.g. City of Gulfport for the Forrest Heights Levee) will assume complete responsibility for the

operation of, maintenance of, repair of, and rehabilitation of, programs and projects recommended for implementation in this Interim Report.

5.20 Monitoring and Adaptive Management

Monitoring project performance, followed by adaptive changes to the project if necessary, is a responsible means of ensuring project performance. Monitoring determines if the projected outputs are being achieved and provides feed back for future projects. Post-implementation monitoring of ecosystem restoration components of the Comprehensive Plan is projected to be conducted for no more than five years at a cost of less than 1% of the total first cost of the project's ecosystem restoration features.

Adaptive management of proposed comprehensive ecosystem restoration programs and projects is an important aspect of project success. It is generally anticipated that some post-implementation project modifications will be required based on the feed back provided by project monitoring. Because the nature of the tentatively selected plans made in this Comprehensive Report is not extremely risky in terms of projected outputs, it is anticipated that adaptive management would not be a major project expense. Adaptive management of ecosystem restoration features is expected to cost no more than 3% of ecosystem restoration feature first costs, and may in some cases be less than that figure. Monitoring and adaptive management costs have been accommodated in the cost estimates for each potential ecosystem restoration component as part of the contingency estimate.

Information gained from post-implementation monitoring and adaptive management of tentatively selected ecosystem restoration plans will be used to provide "lessons learned" for the design and implementation of future ecosystem restoration projects. These "lessons learned" will provide important information, which will be used to improve the effectiveness and reduce the costs of future ecosystem restoration components of the Comprehensive Plan.

5.21 Environmental Considerations

A detailed discussion of the potential environmental impacts associated with near-term tentatively selected plans is included in Chapter 4 and the Environmental Appendix accompanying this report.

5.22 Cultural and Archaeological Resource Considerations

A detailed discussion of the potential cultural and archaeological resource considerations associated with near-term tentatively selected plans is included in Chapter 4 and the Environmental Appendix accompanying this report.

5.23 Compliance with Environmental Laws and Regulations

The comprehensive tentatively selected plans have been determined to be in compliance with all applicable State and Federal laws and regulations. Based on the conclusions of this integrated Draft Report and Environmental Impact Statement, a Record of Decision will be prepared pending the public review of the integrated draft report. A determination of consistency with the Mississippi Coastal Program has been made and will be provided to the Mississippi Department of Marine Resources for concurrence. Impacts to waters of the US have been evaluated in a Section 404(b)(1) Evaluation. Requests for State Water Quality Certification from the Mississippi Department of Environmental Quality will be made for those actions which may involve the placement of dredged or fill materials in waters of the US following public review of the integrated draft report and EIS and 404(b)(1) Evaluation. A draft Section 404(b)(1) Evaluation can be found in the Environmental Appendix. An Environmental Laws compliance table can be found in Section 3 of the Environmental Appendix.

5.24 Summary of Plan Accomplishments

The tentatively selected plans presented in this Comprehensive Report are limited in nature, given the requirements of rapid technical, economic, and environmental analysis and implementation. They do, however, provide a firm basis for cost-effective comprehensive tentatively selected plans that will greatly aid the communities of coastal Mississippi in their road to recovery.

Many of the most critical elements of recovery are being dealt with by other agencies, through FEMA's Public Assistance and other programs, by HUD's grants for recovery of water supply and treatment, and many more. However, the issues of recovery of advanced warning systems, adoption of a more comprehensive education and evacuation campaign and plans, and recovery of pre-Katrina protection measures, drainage, infrastructure, and environmental resources, has not been thoroughly covered.

The tentatively selected plans made herein, the benefits of which are presented in Chapter 5, should provide some measure of recovery beyond that which has currently occurred. All potential programs presented here are of a need that has been clearly demonstrated by the effects of Hurricane Katrina. Analysis of an array of alternatives at each final problem area resulted in selection of a well-balanced, cost-effective recommendation for implementation, as demonstrated in each of the System of Accounts comparison.

All potential projects presented here have been shown to be cost-effective, technically sound, and environmentally feasible, by virtue of a System of Accounts analysis, and by evaluation of each recommendation by the rigorous use of criteria presented in the report.

The tentatively selected plans made will provide vital assistance in the recovery, and insurance of provision of added safety for the residents of, visitors to, environmental resources within, and property residing on the coast of Mississippi.

Justification of the cost-effectiveness, technical feasibility, environmental feasibility, and other plan accomplishments for each recommendation, are presented in detail, in the individual appendices attached to the main report.

6 IMPLEMENTATION REQUIREMENTS

A Letter of Intent from the State of Mississippi indicating the intent to be the non-Federal sponsor of the Comprehensive Plan was received by the Mobile District on 28 August 2008. A copy of the letter is provided as an attachment to this report.

6.25 Cost-Sharing

The tentatively selected plans contained herein are subject to cost sharing, financing, and other applicable requirements of Federal and State laws and policies, including WRDA 1986, as amended, and with the non-Federal sponsor agreeing to comply with applicable Federal law and policies, and with the following requirements:

a. Provide a minimum of 35 percent, but not to exceed 50 percent of total project costs allocated to structural flood damage reduction, as further specified below:

(1) Provide 25 percent of design costs allocated to structural flood damage reduction in accordance with the terms of a design agreement entered into prior to commencement of design work for a project element for structural flood damage reduction;

(2) Provide, during the first year of construction of a project element for structural flood damage reduction, any additional funds necessary to pay the full non-Federal share of design costs allocated to structural flood damage reduction;

(3) Provide, during construction of a project element for structural flood damage reduction, a contribution of funds equal to five percent of total project costs allocated to structural flood damage reduction;

(4) Provide all lands, easements, and rights-of-way, including those required for

relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of a project element for structural flood damage reduction;

(5) Provide, during construction of a project element for structural flood damage reduction, any additional funds necessary to make its total contribution for structural flood damage reduction equal to at least 35 percent of total costs allocated to structural flood damage reduction;

b. Provide 35 percent of total project costs allocated to hurricane and storm damage reduction, as further specified below:

(1) Provide 25 percent of design costs allocated to hurricane and storm damage reduction in accordance with the terms of a design agreement entered into prior to commencement of design work for a project element for hurricane and storm damage reduction;

(2) Provide, during the first year of construction of a project element for hurricane and storm damage reduction, any additional funds necessary to pay the full non-Federal share of design costs allocated to hurricane and storm damage reduction;

(3) Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the

Government to be required or to be necessary for the construction, operation, and maintenance of a project element for hurricane and storm damage reduction;

(4) Provide, during construction of a project element for hurricane and storm damage reduction, any additional amounts as are necessary to make its total contribution for hurricane and storm damage reduction equal to 35 percent of total project costs allocated to hurricane and storm damage reduction;

c. Provide 35 percent of total project costs allocated to ecosystem restoration, as further specified below:

(1) Provide 25 percent of design costs allocated to ecosystem restoration in accordance with the terms of a design agreement entered into prior to commencement of design work for a project element for ecosystem restoration;

(2) Provide, during the first year of construction of a project element for ecosystem restoration, any additional funds necessary to pay the full non-Federal share of design costs allocated to ecosystem restoration;

(3) Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of a project element for ecosystem restoration;

(4) Provide, during construction of a project element, any additional funds necessary to make its total contribution for ecosystem restoration equal to 35 percent of total project costs allocated to ecosystem restoration;

d. Provide 35 percent of total project costs allocated to nonstructural flood damage reduction, as further specified below:

(1) Provide 25 percent of design costs allocated to nonstructural flood damage reduction in accordance with the terms of a design agreement entered into prior to commencement of design work for a project element for nonstructural flood damage reduction;

(2) Provide, during the first year of construction of a project element for nonstructural flood damage reduction, any additional funds necessary to pay the full non-Federal share of design costs allocated to nonstructural flood damage reduction;

(3) Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of a project element for nonstructural flood damage reduction;

(4) Provide, during construction of a project element for nonstructural flood damage reduction, any additional funds necessary to make its total contribution for nonstructural flood damage reduction equal to 35 percent of total project costs allocated to nonstructural flood damage reduction;

e. Not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefor, to meet any of the non-Federal obligations for a project element unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;

f. Not use a project element for ecosystem restoration or lands, easements, and rights-of-way required for a project element for ecosystem restoration as a wetlands bank or mitigation credit for any other project or project element;

g. Not less than once each year, inform affected interests of the extent of protection afforded by the project elements for structural flood damage reduction, nonstructural flood damage reduction, or hurricane and storm damage reduction;

h. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs for project elements for structural flood damage reduction, nonstructural flood damage reduction, or hurricane and storm damage reduction;

i. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of a project element for structural flood damage reduction, nonstructural flood damage reduction, or hurricane and storm damage reduction;

j. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by a project element for structural flood damage reduction, nonstructural flood damage reduction, or hurricane and storm damage reduction;

k. For so long as a project element for hurricane and storm damage reduction remains authorized, ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based;

l. For so long as a project element for hurricane and storm damage reduction remains authorized, provide and maintain access roads, parking areas, and other public use facilities, open and available to all on equal terms;

m. Prevent obstructions or encroachments on a project element (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project element lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection a project element affords, reduce the outputs produced by a project element, hinder operation and maintenance of a project element, or interfere with a project element's proper function;

n. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 46014655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of a project element, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act ;

o. For so long as a project element remains authorized, operate, maintain, repair, rehabilitate, and replace the project element, or functional portions of the project element, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project element's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

p. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to a project element for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project element;

q. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of a project element and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

r. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to a project element, for a minimum of three years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

s. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701- 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.);

t. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of a project element. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

u. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of a project element;

v. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of a project element for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project element in a manner that will not cause liability to arise under CERCLA; and

w. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 1030) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 22130)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element. Table 6-1 provides a summary of all tentatively selected comprehensive plan elements including total cost and cost share requirements.

Table 6-1
Mississippi Coastal Improvements Program
Sharing (August 2008 Price Level)

Tentative Selected Plan Feature (AUTHORIZATION 65/35 percent)	Total Project Cost	Federal Cost *	Non Federal Cost *
Hurricane Risk Reduction Education	**	**	**
Hurricane and Storm Warning	**	**	**
Hurricane Evacuation Planning	**	**	**
Floodplain Management	**	**	**
Building Code Update	**	**	**
Zoning Code Update	**	**	**
Long-term Critical Infrastructure and Services Relocation (LOD 5)	**	**	**
Phase I High Hazard Area Risk Reduction Plan	$187,500,000	$121,875,000	$65,625,000
Moss Point Municipal Services Relocation	$11,424,000	$7,425,600	$3,998,400
Waveland Floodproofing	$4,611,000	$2,997,150	$1,613,850
Forrest Heights Levee	$14,500,000	$9,425,000	$5,075,000
Turkey Creek Ecosystem Restoration	$7,200,000	$4,680,000	$2,520,000
Dantzler Ecosystem Restoration	$2,300,000	$1,495,000	$805,000
Franklin Creek Ecosystem Restoration	$2,000,000	$1,300,000	$700,000
Bayou Cumbest Ecosystem Restoration & Hurricane Storm Damage Reduction	$26,900,000	$17,485,000	$9,415,000
Admiral Island Ecosystem Restoration	$23,200,000	$15,080,000	$8,120,000
Deer Island Ecosystem Restoration	$22,900,000	$14,885,000	$8,015,000
Submerged Aquatic Vegetation Pilot Program	$1,000,000	$650,000	$350,000
Coast-wide Beach and Dune Ecosystem Restoration	$24,900,000	$16,185,000	$8,715,000
Comprehensive Barrier Island Restoration (100% Federal; NPS Property)	$516,000,000	$516,000,000	$0
Subtotal of Authorization Request	**$844,435,000**	**$729,782,750**	**$114,952,250**
Freshwater Diversion, Violet Louisiana*** (WRDA 2007, Sec 3083)	$12,000,000		
Subtotal of AE&D Request	**$12,000,000**		

Tentative Selected Plan Feature (CONTINGENT AUTHORIZATION 65/35 percent)	Total Project Cost	Federal Cost *	Non Federal Cost *
LaFrancis Camp, Trenaisse Canal, Hancock County	$8,770,000	$5,700,500	$3,069,500
Wachovia Coastal Preserve, Hancock County	$2,830,000	$1,839,500	$990,500
Dantzler Coastal Preserve Part 2, Jackson County	$6,597,000	$4,288,050	$2,308,950
Pascagoula River Marsh, Jackson County	$2,230,000	$1,449,500	$780,500
Ansley Coastal Preserve, Hancock County			

	$2,420,000	$1,573,000	$847,000
Subtotal of Contingent Authorization	**$22,847,000**	**$14,850,550**	**$7,996,450**

Tentative Selected Plan Feature (INVESTIGATIONS 50/50 percent)	**Total Project Cost**	**Federal Cost ***	**Non Federal Cost ***
Long-term High Hazard Risk Reduction Plan	$5,000,000	$2,500,000	$2,500,000
Escatawpa River Freshwater Diversion	$3,000,000	$1,500,000	$1,500,000
Long-term Ecosystem Restoration and Hurricane Storm Damage Reduction	$12,867,000	$6,433,500	$6,433,500
Structural Hurricane Storm Damage Reduction	$84,019,000	$42,009,500	$42,009,500
Subtotal of Related Investigations	**$104,886,000**	**$52,443,000**	**$52,443,000**
Total MsCIP Comprehensive Plan	**$984,168,000**	**$796,776,300**	**$175,391,700**

* Indicated cost sharing is consistent with law and Corps policy.
** Additional coordination is required to determine total cost and cost sharing as necessary
*** Cost sharing for the Violet Diversion is established in WRDA 2007, Section 3038

6.26 Independent Technical Review (ITR) and External Peer Review (EPR)

The Comprehensive Plan and Integrated Programmatic Environmental Impact Statement report has undergone an Independent Technical Review (ITR) conducted by the Corps" National Center of Expertise for Hurricane and Storm Damage Reduction in North Atlantic Division (NAD). The ITR has been coordinated by the Philadelphia District and utilized resources of NAD, other Corps Divisions, and the Engineering Resource and Development Center (ERDC). Comments made by the ITR team and responses to those comments are documented in the ITR package, which is provided as an appendix. Certification of completion of ITR is also provided as part of that appendix.

The final report products will also undergo ITR by NAD, coordinated by the Philadelphia District and utilize resources of NAD, other Corps Divisions, and ERDC.

External Peer Review of the final report will also be coordinated by Baltimore District of the Corps via a contract with Battelle, Inc, and conducted by appropriate outside resources familiar with the study area and its resources. Comments made by the EPR team and responses to those comments, are documented in the EPR package, and also provided in the ITR/EPR appendix. Certification of completion of EPR is also provided as part of that appendix.

Consideration of information generated by the Interagency Performance Evaluation Task Force was done at all times during the conduct of this study, and was included in the development of Comprehensive Plan alternatives.

6.27 Schedule for Implementation of Comprehensive Tentatively Selected Plans

Key milestones for the completion of the Comprehensive Plan and Integrated Programmatic Environmental Impact Statement Report are displayed below.

Comprehensive Plan Report Schedule

February – March 2009	Draft Comprehensive Report/EIS for Public Review
21 May 2009	Civil Works Review Board
June – July 2009	State and Agency Review
July 2009	Record of Decision
July 2009	Report of the Chief of Engineers
July – August 2009	Report to Assistant Secretary of Army for Civil Works

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8 GLOSSARY OF TERMS

AAHU	Average Annual Habitat Units
ABFE	Advisory Base Flood Elevation
ASA(CW)	Assistant Secretary of the Army for Civil Works
BEA	U.S. Bureau of Economic Analysis
BFE	Base Flood Elevation
BGEPA	Bald and Golden Eagle Protection Act
BMP	Best Management Practices
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CBRA	Coastal Barrier Resources Act
CDBG	Community Development Block Grant
CEFIT	Corps of Engineers Flood Inventory Tool
CIAP	Coastal Impact Assistance Program
Corps	U.S. Army Corps of Engineers
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DEIS	Draft Environmental Impact Statement
DHS	Department of Home Land Security
DOE	U.S. Department of Energy
DOI	Department of Interior
DOL	U.S. Department of Labor
DOT	Department of Transportation
EA	Environmental Assessment
EAD	Equivalanet Annual Damages
EC	Engineering Circular
EFH	Essential Fish Habitat
EIFS	Economic Impact Forecasting System
EIS	Environmental Impact Statement
EM	Engineering Manual
EPR	External Peer Review
EO	Executive Order
EQ	Environmental Quality

ER	Engineering Regulation
ERDC	Engineering Research and Design Center
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FHI	Functional Habitat Index
FMCs	Fishery Management Councils
FPPA	Farmland Protection Policy Act
FWCA	Fish and Wildlife Coordination Act
GMEI	Gulf of Mexico Estuarine Inventory and Study, Mississippi
HCD	Habitat Conservation Office
HCWSWMD	Harrison County Wastewater and Solid Waste Management District
HEC-FDA	Hydrologic Engineering Center-Flood Damage Analysis
HGM	Hydrogeomorphic Model
HMGP	Hazard Mitigation Grant Program
HQ	Headquarters
HTRW	Hazardous, Toxic, and Radioactive Wastes
IPCC	Intergovernmental Panel of Climate Change
IPR	In-Progress Review
ITR	Independent Technical Review
IWR	Institute for Water Resources
IWR-PLAN	Institute for Water Resources-PLAN Decision Support Software
LaPR	Louisiana Coastal Protection and Restoration
LERRD	Land Costs to include Easements, Rights-of-way, Relocations and Disposal or Borrow Areas
LOD	Lines of Defense
m^2	Square Miles
MCACES	Micro-Computer Aided Cost Estimating System
MCP	Mississippi Coastal Program
MDEQ	Mississippi Department of Environmental Quality
MDMR	Mississippi Department of Marine Resources
MDWFP	Mississippi Department of Wildlife, Fisheries, and Parks
MEMA	Mississippi Emergency Management Agency
MGCRWA	Mississippi Gulf Coast Regional Wastewater Authority
MGD	Million Gallons Per Day
MMPA	Marine Mammal Protection Act

MMS	Minerals Management Services
mph	miles per hour
MPRSA	Marine Protection, Research, and Sanctuaries Act
MsCIP	Mississippi Coastal Improvement Program
NAAQS	National Ambient Air Quality Standards
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NERR	National Estuarine Research Reserve
NGOs	Non-Governmental Organizations
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
O&M	Operation and Maintenance
OCRM	Office of Ocean and Coastal Resource Management
OMB	Office of Management and Budget
OSE	Other Social Effects
PCX-CSDR	Planning Center of Expertise for Coastal Storm Damage Reduction
P.L.	Public Law
PDT	Project Delivery Team
PED	Preconstruction Engineering and Design
PMP	Project Management Plan
PRD	Protected Resources Division
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RED	Regional Economic Development
RES	Real Estate Supplement
RIDF	Risk-Informed Decision Framework
RSL	Relative Sea Level

RSM	Regional Sediment Management
SAD	South Atlantic Division
SAV	Submerged Aquatic Vegetation
SDSS	Spatial Decision Support System
SHPO	State Historic Preservation Officer
SIPs	State Implementation Plans
SOA	System of Accounts
SRWMD	South Regional Wastewater Management District
SWPPP	Storm Water Pollution Prevention Plan
T&E	Threatened and Endangered
TANF	Temporary Assistance for Needy Families
TNC	The Nature Conservancy
TSCA	Toxic Substances Control Act
U.S.	United States
USEPA	U.S. Environmental Protection Agency
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WRDA	Water Resources Development Act

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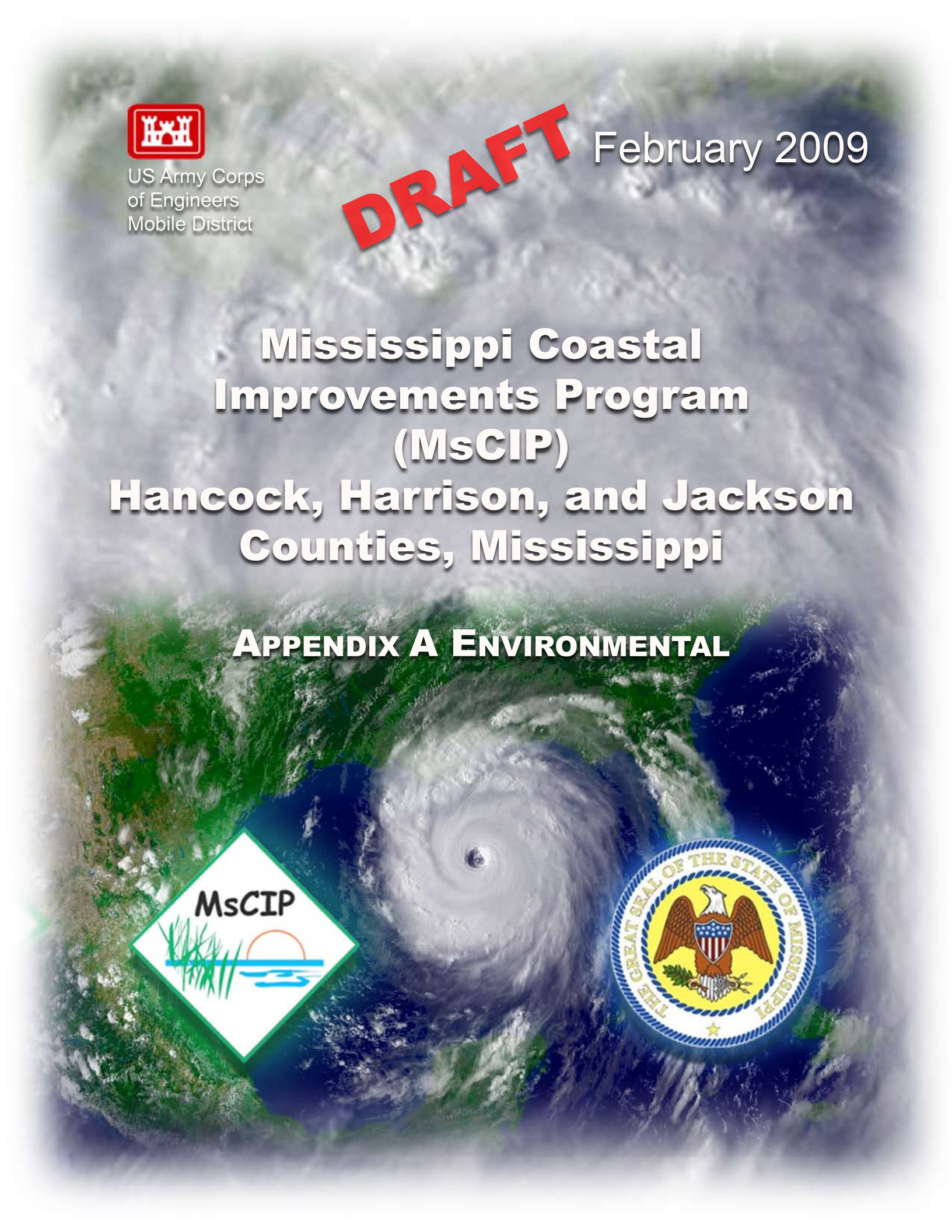
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Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

Appendix A Environmental



ENVIRONMENTAL APPENDIX



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SECTION 1
ENVIRONMENTAL BASELINE AND RECOVERY

1.1 COASTAL MISSISSIPPI – THE ECOSYSTEM PRE- AND POST-HURRICANES & RECOVERY ANALYSES

FOREWORD

This document is one of a number of technical appendices to the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Feasibility Report and Programmatic Environmental Impact Statement.

The Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Integrated Feasibility Report and Programmatic Environmental Impact Statement provides systems-based solutions and recommendations that address: hurricane and storm damage reduction, ecosystem restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion. The recommendations contained in the Integrated Main Report/Programmatic Environmental Impact Statement (EIS) also provide measures that aid in: greater coastal environmental and societal resiliency, regional economic re-development, and measures to reduce long-term risk to the public and property, as a consequence of hurricanes and coastal storms. The recommendations cover a comprehensive package of projects and activities, that treat the environment, wildlife, and people, as an integrated system that requires a multi-tiered and phased approach to recovery and risk reduction, irrespective of implementation authority or agency.



Source: Corps

Figure 1. The MsCIP Study Area

The purpose of the Comprehensive Plan Report is to present, to the Congress of the United States, the second of two packages of recommendations (i.e., the first being the "interim" recommendations funded in May 2007, and this "final" response, as directed by the Congress), directed at recovery of vital water and related land resources damaged by the hurricanes of 2005, and development of recommendations for long-term risk reduction and community and environmental resiliency, within

the three-county, approximately 70 mile-long coastal zone, including Mississippi Sound and its barrier islands, of the State of Mississippi.

This appendix, the Integrated Main Report/Programmatic EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and an External Peer Review (EPR). Both review processes will have been conducted in accordance with the Corps "Peer Review of Decision Documents" process, has been reviewed by Corps staff outside the originating office, conducted by a Regional and national team of experts in the field, and coordinated by the National Center of Expertise in Hurricane and Storm Damage Protection, North Atlantic Division, U.S. Army Corps of Engineers.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing tentatively selected features directed at assisting the people of the State of Mississippi in recovery, tentatively selected actions and projects that would assist in the recovery of the physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

This appendix contains detailed technical information used in the analysis of existing and future without-project conditions, in the development of problem-solving measures, and in the analysis, evaluation, comparison, screening, and selection of alternative plans, currently presented as tentatively-selected recommendations contained in the Integrated Main Report/Programmatic EIS.

Each appendix functions as a complete technical document, but is meant to support one particular aspect of the feasibility study process. However, because of the complexity of the plan formulation process used in this planning study, the information contained herein should not be used without parallel consideration and integration of all other appendices, and the Integrated Main Report/Programmatic EIS that summarizes all findings and recommendations.

An Environmental Appendix has been prepared to evaluate the environmental recovery of Coastal Mississippi as a result of the hurricane damage. Environmental effort focuses on the preservation of fish and wildlife [i.e. prior to the 1950s development period (Corps 1984)], prevention of saltwater intrusion, and prevention of erosion. Environmental efforts tentatively selected in this Environmental Appendix have been included in the Integrated MsCIP Comprehensive Report/Programmatic Environmental Impact Statement (EIS).

ES – 1 Executive Summary

An Environmental Appendix has been prepared to evaluate the ecological recovery of Coastal Mississippi. Environmental effort focuses on the preservation of fish and wildlife [i.e. prior to the 1950s development period (Corps 1984)], prevention of saltwater intrusion, and prevention of erosion. In order for Coastal Mississippi to environmentally recover, the MsCIP Environmental project delivery team (PDT) identified ecological issues throughout the three coastal counties – Jackson, Harrison, and Hancock – of Mississippi and the offshore ecosystem. During this effort, both a non-structural PDT and a structural PDT developed measures to benefit Coastal Mississippi from a flood-proofing stand-point (i.e. non-structural) and an engineered (i.e. hardened structures) stand-point, respectively. The environmental effort also involved close coordination with both the structural and non-structural PDTs of the MsCIP study effort to ensure environmental consistency. Environmental efforts tentatively selected in this Environmental Appendix have been included in the Integrated MsCIP Comprehensive Report/Programmatic EIS. The Integrated Programmatic EIS – Effected Environment section contained within this Environmental Appendix provides the impact analysis for those projects screened out early during the plan formulation process.

ES – 1.1 Description of Natural System

The primary study area consists of the three coastal counties in the State of Mississippi: Hancock, Harrison, and Jackson counties; and the coastal (offshore) ecosystem, including its barrier islands. This area ranges in elevation from sea level to about 30 feet above mean sea level. The essentially flat to gently undulating, locally swampy Coastal Lowlands are underlain by alluvial, deltaic, estuarine, and coastal deposits and merge with the fluvial-deltaic plains of the streams and rivers of the area. This portion of Coastal Mississippi has been classified as an alluvial coast, a terraced, and deltaic plain. According to the Cowardin et al (1979), *Classification of Wetlands and Deepwater Habitat of the United States*, there are five major wetland and deepwater systems, four of which are found within Coastal Mississippi. They include marine, estuarine, riverine, and palustrine wetland systems.

ES – 2.1 Problems and Opportunities

In response to major damages on the coast of Mississippi as a result of Hurricane Katrina, Congress directed the U.S. Army Corps of Engineers (Corps) to conduct an analysis and design for comprehensive modifications and improvements in the Mississippi coastal area for the purposes of hurricane damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resources purposes. Coastal Mississippi was the point of impact of the greatest tidal surge that has hit the mainland of the United States (U.S.) in its recorded history. Hurricane Katrina affected over 90,000 square miles (m^2) of the Gulf Coast region and caused almost complete destruction of several large coastal communities while seriously damaging numerous others. The destruction was on a scale unmatched by any natural disaster in U.S. history. The loss to Coastal Mississippi is unprecedented and has presented a high cost to the nation with a complete fisheries failure being declared by the Commerce Secretary, marine debris covering valuable productive water bottoms and coastal wetlands, exacerbated coastal erosion, loss to maritime forests, degraded water quality, increased pollution, widespread debris fields throughout coastal wetlands, degraded coastal preserve lands owned and maintained by the State of Mississippi, Department of Marine Resources (MDMR), increased risks to infrastructure and human life, danger to fish and wildlife including threatened and endangered (T&E) species and their critical habitats, and the loss of an entire way of life. Losses to many commercially important fisheries stock,

foraging areas, nurseries, and etc. have been felt economically in the overall region. Spawning, breeding, and foraging grounds of fish and shellfish were severely impacted resulting in rising prices and once readily available resources are now becoming limited. The ability of wetlands to enhance protection from future storm surges, coastal erosion, and flooding has been greatly reduced. Human activities add another layer of complexity to the natural processes of coastal lands and materials. People's activities are often conducted without an adequate understanding of coastal geology and processes. As a result, they can lead to unforeseen degradation of coasts. Even human actions intended to save or improve the coast may inadvertently increase erosion. Cooperative scientific investigations are starting to provide the crucial information needed to minimize the unintended effects of human disturbances along coasts.

The Governor of the State of Mississippi has developed a *Seven-Point Strategy* for rebuilding coastal resources of the State. It is anticipated to be an on-going effort over the next 10 to 15 years. The strategy is summarized as follows:

- Implementation of breakwater structures for surge protection (natural surge diffusers, breakwaters, jetties seawalls, etc.);
- Deer Island restoration to pre-1900 footprint with fortification of the south side;
- Barrier Island restoration to pre-Camille conditions;
- Restoration of 10,000 acres of coastal marshes, beaches, and forests;
- Restoration of historical water flow to Coastal Mississippi watersheds to provide water quality and quantity critical to estuarine and marine habitats, including efforts to divert freshwater from Louisiana into the Biloxi marshes;
- Restoration of submerged aquatic vegetation (SAV) in Mississippi Sound; and the
- Restoration and enhancement of reef systems in Mississippi waters and adjacent Federal waters (i.e. oysters, nearshore low-profile reefs, and offshore artificial reefs).

The Governor of the State of Mississippi has also provided extensive guidance in the rebuilding of communities, infrastructure, the economy, and human services which were devastated by the hurricanes of 2005. Much of this guidance has been incorporated into the formulation of the environmental approach detailed in the Environmental Appendix and also in the Integrated MsCIP Comprehensive Report/Programmatic EIS. The Integrated MsCIP Comprehensive Plan/Programmatic EIS will address and consider a wide array of environmental restoration techniques to include vegetative plantings, river diversions, hydrologic restoration, marsh creation, shoreline protection, and sediment trapping and stabilization of the barrier islands.

ES – 3.1 Development of Environmental Measures and Alternatives

The formulation of measures was based on coastal resources assessments of hurricane and stormwater damage, saltwater intrusion, preservation of fish and wildlife, coastal erosion, flooding, navigation, and other problems and opportunities, in a collaborative approach involving Federal, state and local agencies, stakeholders, and citizen groups. The strategy for analyzing post-storm conditions, both for past and potential future events, was developed by the interagency PDT, and reviewed by an ITR team and an ETR team, with approval by the U.S. Army Corps of Engineers, Headquarters (Corps-HQ). This analyzing strategy was required to formulate measures and alternatives.

The interagency PDT is comprised of representatives from the following:

- U.S. Environmental Protection Agency (USEPA)
- Federal Emergency Management Agency (FEMA)
- U.S. Fish and Wildlife Service (USFWS)
- National Park Service (NPS)
- National Oceanic and Atmospheric Administration (NOAA) Fisheries, Protective Resource Division (PRD) and Habitat Conservation Division (HCD)
- National Weather Service (NWS)
- Natural Resources and Conservation Service (NRCS)
- U.S. Geological Survey (USGS)
- MDMR
- Mississippi Department of Environmental Quality (MDEQ)
- Mississippi Department of Transportation (MDOT)
- Mississippi State Historic Preservation Officer (SHPO)
- Hancock, Harrison and Jackson Counties
- Communities of Bay St. Louis, Biloxi, D'Iberville, Gautier, Gulfport, Long Beach, Moss Point, Ocean Springs, Pascagoula, Pass Christian, and Waveland
- Engineering Research and Development Center (ERDC)
- Mississippi State University (MSU)
- University of Southern Mississippi (USM) – Including the Gulf Coast Research Lab
- Coastal Restoration Network
- Audubon Society
- Sierra Club
- The Nature Conservancy (TNC)

In analyzing potential measures, the Environmental PDT has considered, in all cases in which it would be appropriate, integration of environmental measures within structural and non-structural potential solutions.

The following environmental measures were evaluated and screened by the Environmental PDT based on applicability to the specific problem area.

ES – 3.1.1 Freshwater Diversions

Consists of evaluation of current conditions of expansive marsh systems located in western and eastern portions of Coastal Mississippi. Diversions of freshwater from existing river systems would be evaluated based on ecosystems needs.

ES – 3.1.2 Ecosystem Restoration of Historical Wetlands Previously Developed

Development of a Geographical Information System (GIS) based – Spatial Decision Support System (SDSS) – by which to prioritize potential areas based on historical conditions, damages from storm surge and coastal flooding, and location to existing natural undisturbed lands (i.e. potentially State of Mississippi or Federal lands).

ES – 3.1.3 Barrier Island Restoration

Partnering with NPS to develop a vision for the barrier islands that would restore lost and damaged ecosystems including beach and dune restoration, restoration of salt and freshwater marshes, and revegetation of maritime forests. Supplemental information can be found in the Barrier Island Appendix.

ES – 3.1.4 SAV Restoration

Development of a program to determine conditions of SAVs and to determine causes of resource degradation. Identify opportunity to partner with other Federal and state agencies, as well as universities, to establish research necessary to establish potential solutions and projects.

ES – 3.1.5 Incorporation of State of Mississippi Initiative

Continue partnership with MDMR to develop and compliment the State of Mississippi projects as opportunities arise.

ES – 3.1.6 Restoration of Coastal Forests

Continue partnership with NPS to further evaluate restoration of coastal forests destroyed by the hurricanes along the barrier islands. Continue partnership with MDMR to develop and compliment the State of Mississippi projects as opportunities arise concerning the mainland of Coastal Mississippi.

ES – 3.1.7 Clean-up of Impaired Waterbodies

Determine which waterbodies in Coastal Mississippi were not cleared of deposited sediment and debris as part of the FEMA mission. Establish partnering opportunities with local and state governments to determine increased risks of flooding and develop potential projects that would lessen that risk.

ES – 3.1.8 Restoration of Degraded Coastal Wetlands

Continue to assess the degradation of coastal wetlands (i.e. wet pine savannah, etc.) using the GIS analysis tool – SDSS – in conjunction with the resource agencies to identify additional potential restoration opportunities.

ES – 3.1.9 Reduction of Coastal Flooding

Work with the Corps, non-structural PDT to assess coastal flooding impacts to developed commercial and residential areas in order to reduce adverse impacts while also restoring historical ecosystems.

ES – 3.1.10 Restoration of Oyster Resources

Continue developing and coordinating with MDMR to implement their restoration of oyster resources wherever feasible. Also incorporate oyster restoration in any applicable proposed projects.

ES – 3.1.11 Restoration of Fishing Reefs

Develop a partnership with MDMR to assist in their existing fishing reef program in order to identify any additional potential locations while also addressing any potential improvements in Mississippi Sound's water quality.

ES – 3.1.12 Restoration of Marshes

Development of a GIS analysis tool – SDSS – by which to prioritize potential homeowners assistance and relocation project areas based on historical conditions, damages from storm surge and coastal flooding, and location to existing natural undisturbed lands (i.e. potentially State of Mississippi or Federal lands).

ES – 4.1 Plan Formulation

ES – 4.1.1 Goals and Objectives

ES – 4.1.1.1 Objectives

- Recommend solutions that would assist the people of Coastal Mississippi in their efforts toward recovery of pre-hurricane conditions in the areas of coastal erosion, preservation of fish and wildlife, and prevention of saltwater intrusion;
- Recommend measures that would provide for sustainability of the overall natural system;
- Recommend continued study of specific problem areas that require further study to arrive at viable solutions;
- Recommend implementable projects directed at recovery of biological resources along the coast of Mississippi to pre-hurricane conditions, and to examine potential measures that might be implemented to increase sustainability of those resources during future events;
- Recommend measures that would provide short-term or long-term recovery of natural resources;
- Recommend implementable projects directed at either the stabilization or retreat of saltwater intrusion in the coastal zone exacerbated by the hurricanes, and to examine opportunities for minimization of saltwater intrusion during future events; and
- Recommend implementable projects directed at recovery of shore erosion protection measures along the coast of Mississippi to their pre-hurricane conditions, and to examine the opportunity for potential increases in the level of protection.

ES – 4.1.2 Planning Constraints

Development of some potential measures is constrained by legal and technical laws and/or regulations and they consist of the following:

- NPS Management Policies, Wilderness Act, and Gulf Islands National Seashore Enabling Legislation
- T&E Species and/or Critical Habitat
- State of Mississippi, Coastal Zone Management Plan
- State of Mississippi, Water Quality Standards
- Clean Water Act (CWA)
- National Historic and Preservation Act (NHPA)
- Clean Air Act (CAA)
- Essential Fish Habitat (EFH)
- Environmental Justice
- Protection of Children
- Coastal Barrier Resources Act (CBRA)

Managing sediment to benefit a region potentially saves money, allows use of natural processes to solve engineering problems, and improves the ecosystem. As a management method, Regional Sediment Management (RSM) includes the entire environment, from the watershed to the sea, accounts for the effect of human activities on sediment erosion as well as its transport in streams, lakes, bays, and oceans, and protects and enhances the nation's natural resources while balancing national security and economic needs. RSM is the Corps's standard operating practice for managing sediment on a holistic approach (i.e. regionally) rather than a project specific approach. The Corps recognizes that actions at one specific location have affects regionally. RSM will be considered during evaluation, design, and implementation of potential measures.

The State of Mississippi as part of Gulf of Mexico Alliance has acknowledged that sediment resources are integral to accomplishing many restoration initiatives. It is also recognized that there is a need for a better understanding of regional sediment systems and processes to inform decisions about projects and actions that use or affect sediment resources. Mississippi is actively involved in the development of a Gulf RSM Master Plan as an implementation action for the Gulf Alliance Conservation and Restoration Workgroup with the objective to develop a regional master plan that uses the understanding of sediment dynamics (inputs, outputs, movement) to manage sediment resources towards implementing environmental restoration, conservation, and preservation while reducing coastal erosion, storm damages, and associated costs of sediment management. The regional sediment management plan will also help link sources of sediment with sediment needs, provide a basis for assessing competing needs for sediment, and foster more cost-effective sediment management.

ES – 4.1.3 Public and Agency Involvement

- Meetings with Federal, State, and local entities
- Public Scoping
- Public Workshop
- Public Hearing

ES – 4.1.4 Plan Formulation Process

The plan formulation process began with defining the overall comprehensive natural system and its current state post-hurricanes. Development of a comprehensive list of problem areas consisting of single or multiple problems associated with a given site that were first identified as having been caused or exacerbated by the hurricane events identified with a) coastal erosion; b) damage to fish and wildlife resources; and c) saltwater intrusion.

Hurricane-caused problem areas were solicited from, and then discussed, with members of the public, state, local, and other Federal agencies, representatives of industry and commerce, and resource agencies concerned with study area resources, at a series of open meetings. The meetings also included web-casts intended on reaching those that could not physically attend one of the in-field meetings.

Hurricane-caused problems were investigated in a series of site investigations conducted in partnership with local representatives including municipalities, state resource agencies, and Federal partners, to ensure a comprehensive list of the problem areas were developed to address a full range of suitable measures and plans to deal with the identified problems.

ES – 4.1.4.1 Screening Criteria

After an initial screening of problem areas to determine their link to the hurricanes, a list of potential problem-solving measures was developed for each problem area. Each problem area was then evaluated in relation to:

a) its potential inclusion as a project tentatively selected for Construction;

b) its potential inclusion as a project requiring additional preconstruction engineering design for specific features (i.e. a long-term solution that needs more technical analyses based on the complexity of the system);

c) its potential for inclusion as project(s) under a Longer Term Comprehensive Plan;

d) its potential inclusion as a project requiring additional Feasibility Studies (i.e. requiring extensive evaluation); and

e) its potential inclusion as a project requiring Advanced Design Studies for Innovative Concepts.

The list of measures developed for each problem area was more fully developed, and specific measures formulated for each site. These measures were then evaluated and screened once again, according to their continued technical, environmental, and cost-effectiveness feasibility, based on more detailed input from the resource agencies, public and private entities, and technical staff, and their ability to be combined into multi-purpose alternatives, capable of dealing with more than one identified problem at a given site. Selection of a measure and/or multiple measures would accomplish the overall goals and objectives - hurricane damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resources purposes - of the MsCIP effort. One measure may reduce saltwater into an area(s); however, it does not adequately reduce hurricane and storm damages and/or preservation of fish and wildlife. Thus, several measures will likely be combined in order to fully accomplish the MsCIP goals and objectives.

The screened list of measures was then combined into a group of well-balanced alternatives, that included both non-structural and if applicable, structural measures that could potentially address the

entire suite of ecological problems plaguing an individual site or problems area. Formulation of these alternatives also incorporated the following criteria:

- Does a potential alternative provide for potential preservation of fish and wildlife and their habitats?
- Does a proposed action or project negatively impact low income or minority populations and/or children [i.e. Executive Orders (EOs) Environmental Justice and Protection of Children]?
- Does a proposed alternative provide a potential reduction in coastal erosion?
- Does a proposed alternative provide a potential reduction in the extent or level of saltwater intrusion?
- Does the proposed project fit in, with, or compliment the objectives of the State of Mississippi and/or locals plans and desires for the area?
- Does the proposal contribute to the short-term or long-term recovery of Coastal Mississippi?

Using these questions, as screening criteria in a narrowing of the potential list of measures, the MsCIP PDT provided for formulation of better project components and alternative plans. This guided the process so that each alternative formulated incorporated measures that would be complimentary while also being mutually exclusive measures that would be evaluated as components of separate alternatives for the following criteria.

- Effectiveness
- Completeness
- Acceptability
- Efficiency (cost-effectiveness)

The following measures were forwarded for potential inclusion in a list of alternatives for the study area:

- Ecosystem Restoration for Preservation of Fish and Wildlife;
- Freshwater Diversion for Prevention of Saltwater Intrusion;
- Barrier Islands Restoration; and
- SAV Restoration Program

The screened list of measures was then combined into a group of well-balanced alternatives that addresses the entire suite of problems plaguing an individual site or problem area. The following alternatives, then, were developed and carried forward for further analysis:

1. The No-Action Plan
2. Freshwater Diversion at Violet, Louisiana
3. Purchase, removal of structures, and ecosystem restoration within historical wetlands previously developed
4. Restoration of Barrier Island Ecosystems
5. Restoration of SAVs within Mississippi Sound
6. Projects from Interim Report carried for further consideration

7. State of Mississippi *Seven-Point Strategy* Initiative Plan

ES – 4.1.5 Tentatively Selected Plans

The Environmental Tentatively Selected Plan, which will be incorporated into the overall Integrated MsCIP Comprehensive Main Report/Programmatic EIS, envisions the construction of environmental restoration projects that would ensure preservation of fish and wildlife, prevent saltwater intrusion, and provide stabilization of the State of Mississippi's shorelines in order to reduce or eliminate coastal erosion and restore lost fish and wildlife habitat by identifying degraded critical components of the vital coastal system. Potential projects include freshwater diversion projects at Violet, Louisiana in order to physically move freshwater into the Western Hancock County Marshes, which have severely degraded over the years due to levee systems in eastern Louisiana and along the Pearl River. Comprehensive restoration of barrier islands (i.e. Ship Island Breach and the supplemental placement of sand source in the littoral zones) would also be recommended in order to restore the islands and continue Mississippi Sound's biological productivity. Restoration of lost ecosystem functions where restoration needs are immediate due to unchecked wetland deterioration. As Coastal Mississippi residents are rebuilding much needed housing, there is an increase in development pressures on these valuable ecosystems due to housing shortages. The Environmental Tentatively Selected Plan would allow for restoration of storm damaged habitats and coastal systems and would prevent further destruction of these vital habitats. Wetlands in Coastal Mississippi can be restored to a sustainable level, one that coexists with human uses and communities. Restoring critical landforms, barrier shorelines, and historical hydrologic patterns are crucial to sustaining ecological and geomorphological function. The Environmental Tentatively Selected Plan has emphasized interagency cooperation as dedicated staff members include representatives from the MDMR, USFWS, and NPS. Additionally, we have collaborated with other resource agencies that include USEPA, USGS, NRCS, NOAA Fisheries, MDEQ, NWS, MDOT, and SHPO. The Environmental Tentatively Selected Plan partners with the State and recommends for construction of those state projects that allows for recovery of badly damaged ecosystems. Additional collaboration has and will continue to occur with non-governmental organizations (NGOs), including TNC, Gulf Restoration Network, Sierra Club, Audubon Society, etc., in addition to Mississippi academic coastal engineers and biologists, such as USM, Gulf Coast Research Lab, and MSU, in order to accomplish widespread support for this environmental effort. A strong public involvement campaign has been used to ensure contributions have been submitted by local constituencies and stakeholders in order to create strong *buy-in* on potential restoration projects. All tentatively selected plans on ecosystem restoration have incorporated adaptive management capabilities, where needed.

ES – 5.1 Potential Projects

The Environmental Tentatively Selected Plan proposes for the construction of two (2) initial projects (i.e. Turkey Creek – Harrison County and Bayou Cumbest – Jackson County) identified based on the GIS SDSS analysis tool inputs. These two projects are identified as part of Phase I of a two Phased approach. These two initial projects give a basis for future ecological restoration sites identified to be developed under a longer term comprehensive effort (i.e. Phase II). Also, the plan recommends construction of a freshwater diversion structure project at Violet, Louisiana. The MsCIP PDT will closely work in partnership with the State of Louisiana in order to achieve both states diversion goals. Comprehensive barrier island ecosystem restoration (i.e. filling of the Ship Island Breach and littoral zones placement) and SAV restoration tentatively selected features are included in the project tentatively selected plans. Continued coordination with NPS, MDMR, MDEQ, USFWS, NOAA-PRD, NOAA-HCD, and other NGOs will also continue. The Governor of the State of Mississippi's *Seven-Point Strategy* for rebuilding coastal resources of the State has also been included as part of the

ecological recommended plan. Two State projects – Dantzler and Admiral Island – are being tentatively selected for construction. Again, these are part of the Phase I effort. During development of the interim report, several of the approximately 180 potential projects were developed in conjunction with local city and county government representatives and several were of an environmental nature. These will be tentatively selected under five separate categories as specified in *Section ES 4.1.4.1 Screening Criteria*. Franklin Creek, Jackson County is included in the 180 project list that is being tentatively selected for construction.

ES – 6.1 Summary

The MsCIP Comprehensive Plan establishes an environmental program for Coastal Mississippi that addresses specific concerns stated as required in the legislation which include prevention of saltwater intrusion, preservation of fish and wildlife, prevention of coastal erosion, and other water related issues, such as reduction in coastal flooding. This approach allows us to establish a program that can be carried forward into the future while building and fostering necessary partnerships and relationships with the citizens and local governments within the study area. This will provide for comprehensive solutions based on changing policies, future land-use trends, and availability of property.

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ACRONYMS

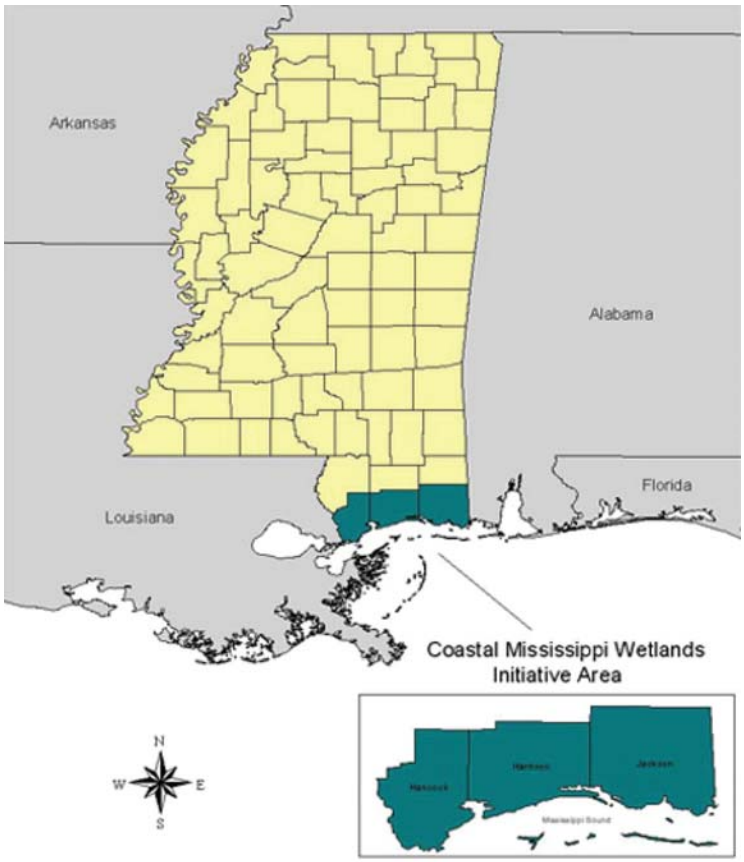
AAFU	Average Annual Functional Units
BFE	Base Flood Elevation
CAA	Clean Air Act
CEQ	Council of Environmental Quality
CFR	Code of Federal Register
Corps	U.S. Army Corps of Engineers
Corps-HQ	U.S. Army Corps of Engineers, Headquarters
CRBA	Coastal Barrier Resources Act
CWA	Clean Water Act
DOI	U.S. Department of Interior
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
ER	Ecosystem Restoration
ERDC	Engineering Research and Development Center
ETR	External Technical Review
FCCE	Flood Control and Coastal Emergency
FDR	Flood Damage Reduction
FEMA	Federal Emergency Management Agency
FHI	Functional Habitat Index
FIS	Flood Insurance Study
ft^3/s	cubic feet per second
GIS	Geographic Information System
GMEI	Cooperative Gulf of Mexico Estuarine Inventory and Study
HARP	High Hazard Area Risk Reduction Plan
HCD	Habitat Conservation Division
HEC-FDA	Hydrologic Engineering Center's Flood Damage Analysis
HGM	Hydrogeomorphic Model
HSDR	Hurricane storm damage & reduction
ITR	Independent Technical Review
LOD	Line of Defense
m^2	square mile

MDEQ	Mississippi Department of Environmental Quality
MDMR	Mississippi Department of Marine Resources
MDOT	Mississippi Department of Transportation
MsCIP	Mississippi Coastal Improvements Program
MSU	Mississippi State University
NAVD	North American Vertical Datum
NEPA	National Environmental Protection Act
NERR	National Estuarine and Research Reserve
NHPA	National Historic and Preservation Act
NGOs	Non-Government Organizations
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources and Conservation Service
NWS	National Weather Service
PDT	project delivery team
ppt	parts per thousand
PRD	Protective Resources Division
PSGH	Potential Seagrass Habitat
RSM	Regional Sediment Management
SAVs	submerged aquatic vegetation
SDSS	Spatial Decision Support System
SHPO	State Historic Preservation Officer
T&E	threatened and endangered
TED	Turtle Excluder Device
TNC	The Nature Conservancy
U.S.	United States
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Service
USM	University of Southern Mississippi
WRDA	Water Resources and Development Act

CHAPTER 1. COASTAL MISSISSIPPI ENVIRONMENT

1.1 Introduction - An Environmental Framework for Coastal Mississippi

In response to major damages on the coast of Mississippi as a result of the 2005 Hurricane Katrina, Congress directed the Corps to conduct an analysis and design for comprehensive modifications and improvements in the Mississippi Coastal area for the purposes of hurricane damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife [i.e. prior to the 1950s development period (Corps 1984)], prevention of erosion, and other related water resources purposes. Coastal Mississippi was the point of impact of the greatest tidal surge that has hit the mainland of the U.S. in its recorded history. Hurricane Katrina affected over 90,000 m^2 of the Gulf Coast region and caused almost complete destruction of several large coastal communities while seriously damaging numerous others. The destruction was on a scale unmatched by any other natural disaster in U.S. history. The loss to Coastal Mississippi is unprecedented and has presented a high cost to the nation with a complete fisheries failure being declared by the Commerce Secretary, marine debris covering valuable productive water bottoms, exacerbated coastal erosion, loss of maritime forests, degraded water quality, increased pollution, widespread debris fields throughout coastal wetlands, degraded coastal preserve lands owned and maintained by the MDMR (Figures 1.1-1 and 1.1-2), increased risks to infrastructure and human life, danger to fish and wildlife including T&E species and their critical habitats, and the loss of an entire way of life. Losses to many commercially important fisheries stock, foraging areas, nurseries, and etc. have been felt economically in the overall region. Spawning, breeding, and foraging grounds of fish and shellfish were severely impacted resulting in rising prices and once readily available resources are experiencing shortages.

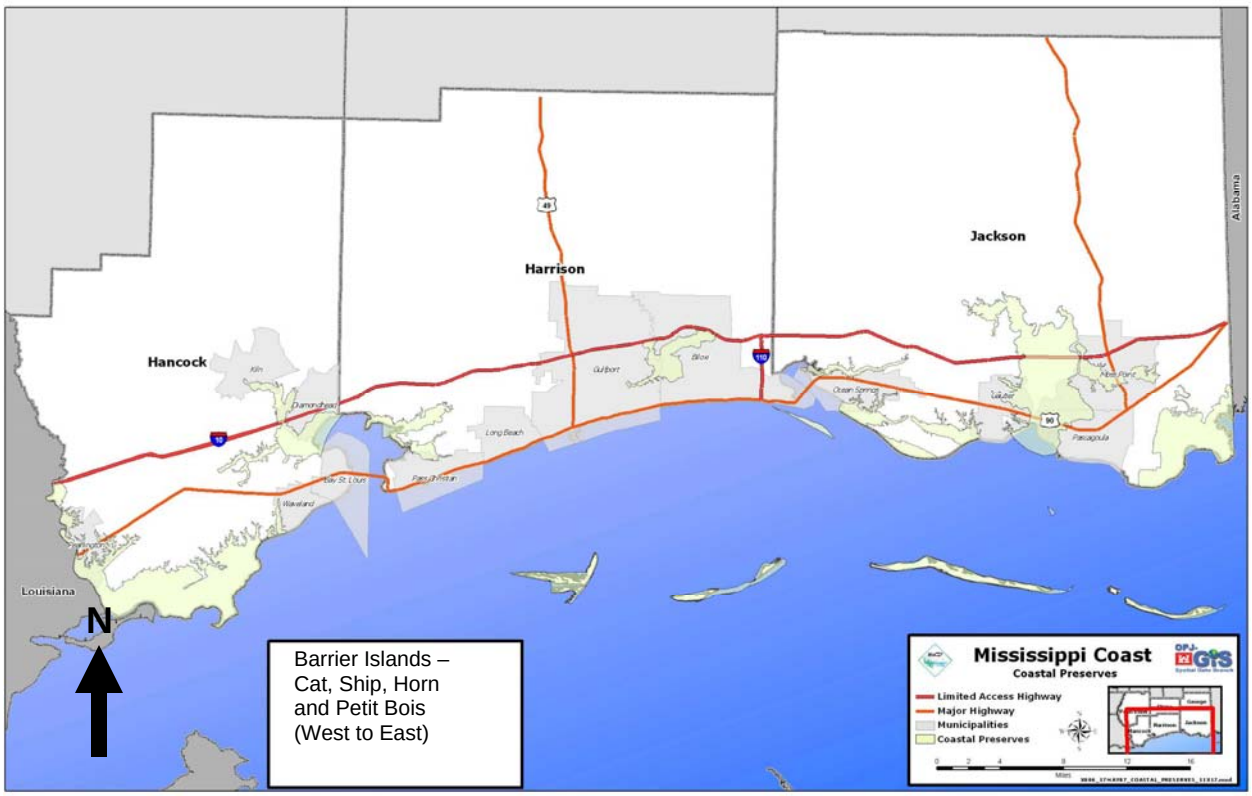


Source: MDMR

Figure 1.1-1. Coastal Mississippi Map

Wetlands have historically provided natural protection from storm surges, coastal erosion, and flooding and a reduction in these natural systems (i.e. filling in of wetlands) has greatly impacted the Gulf Coast. The Comprehensive Plan will address and employ a wide array of restoration techniques

to include vegetative plantings, river diversions, hydrologic restoration, marsh creation, shoreline protection, sediment trapping, and stabilization of the barrier islands.



Source: MDMR

Figure 1.1-2. MDMR Coastal Preserves – State Lands Map

The area or the zone where water meets land can be described in various terms – it is a buffer area, the land-water interface, or an ecotone - an area where the terrestrial ecosystem transitions into the aquatic ecosystem. Critical habitats exist in this ecotone area: swamps, marshes, coastal ridges, coastal forests, littoral zone, dunes, and beaches. These areas serve as vital breeding areas, nursery grounds, and areas where much of the massive amounts of organic carbon needed to fuel aquatic food chains are produced. These are areas where sediments, nutrients and even contaminants eroded from the uplands can be detained before entering the aquatic system and energy from the water, through waves, tides, and surges can be captured and mitigated before impinging upon the upland. These sediments can contain nutrients that are critical to water quality and wetland building. And when terrestrial organisms, like humans beings, encroach upon this ecotone between land and water, there can be devastating consequences, such as flooding, loss of property and even loss of life.

Fundamentally, the environmental framework (as well as much of the tentatively selected comprehensive plan) for the MsCIP is the protection, restoration, enhancement and re-establishment of the natural buffering capacities of these **coastal ecotone** areas. These land-water ecotone areas outline every barrier island, beach, bay, stream, and river on the coast, thereby creating a comprehensive, system-wide, network of areas that are critical both to the ecosystem and to society. These coastal ecotones have been eroded by natural and man-made forces, thus decreasing the resiliency of the Mississippi Coastal system.

1.1.1 Creation and Dynamic Nature of the Coastal Ecotones

The current geomorphology, and by extension, the ecology of coastal Mississippi is defined by its geological history. Oivanki (1993) states that the last major low-stand of sea level was about 18,000 years ago, and sea level has been rising ever since that time. The sea level at that time was about 350 feet below its present level, which shifted the shoreline to about 70 to 80 miles of its present position. Streams and rivers cut deep valleys into the landscape. As the glacial ice melted, these valleys were covered with water. The Back Bay of Biloxi, St. Louis Bay and the Pascagoula River valley are all present day expressions of these drowned valleys. As the landscape eroded, the drowned valleys began to fill, creating the extensive riverine swamp systems, such as those in the Pascagoula and Pearl River basins. Thus, the eastern and western ends of the MsCIP project area have broad expanses of riverine swamps, which are largely absent from Harrison County.

These geologic patterns have resulted in very different present day shoreline types in the three coastal counties. For example, Hancock County shoreline is 50% marsh, Harrison County shoreline is dominated by artificial beach, and Jackson County is 18% marsh and 32% washover terrace (Oivanki 1993a).

The five principal barrier islands, Petit Bois, Horn, East Ship, West Ship and Cat, are the result of the emergence of offshore sand shoals approximately 3,000 to 4,000 years ago. The location of the islands and the source of their sand was determined by the longshore drift pattern established by Dauphin Island in Alabama, which accumulated sand from the Florida shoreline and directed it parallel to the coast offshore (Otvos 1979).

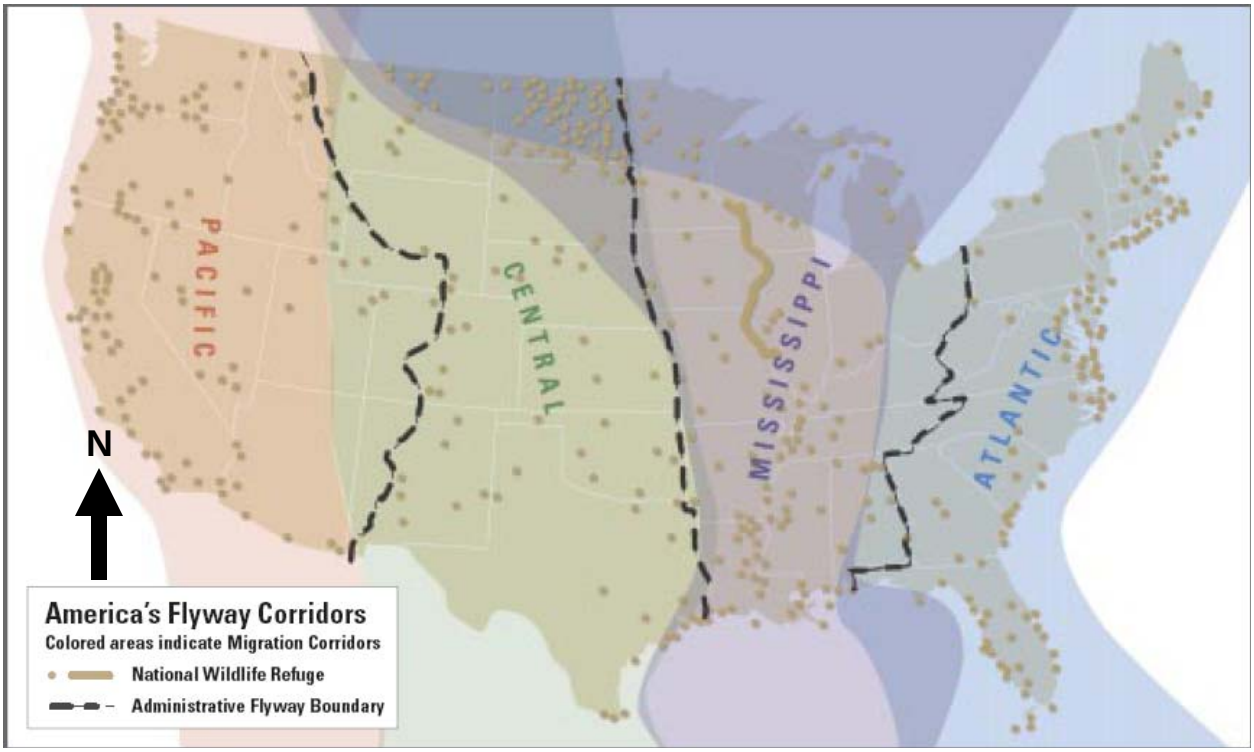
All of these geologic processes have formed, shaped and continue to rework the coastal ecotone. The ecotone, the ribbon of area at the land-water interface is dynamic, constantly shifting based on the local geology, re-working itself after extreme events and human perturbation. The current expression of eustatic sea level rise causes the coastal ecotone to move “upland” or northward. It is a continuation of a trend that started about 18,000 years ago. In some places, subsidence or compaction or other factors have caused the relative sea level rise to be locally greater than eustatic sea level rise. When the upland migration of the coastal ecotone is limited due to geology or manmade features, such as seawalls, bulkheads, or waterways, a net loss of the ecotone can occur, as well as damage to the manmade structures.

The anthropogenic loss of the coastal ecotone can be documented by looking at estimations of wetland loss on the Mississippi Coast. Eleuterius (1973) noted that approximately 1,000 acres of marshland was filled on the Mississippi Coast prior to the 1930’s. However, wetland loss accelerated after that time. Oivanki et al. (1995) conducted a study that showed that 13% of the total coastal march area in the Mississippi coast zone was lost between the 1950’s and 1992. The amount of wetland loss was highest in Jackson County and lowest in Harrison County. Developed land use tripled during the study period. It is the desire of the State of Mississippi to replace about 10,000 acres of this loss as stated.

1.1.2 Importance of the Coastal Ecotones to the Fish and Wildlife Resources of Coastal Mississippi

The coastal ecotone in Mississippi provides a vital habitat for fish and wildlife that is found in no other place in the world. The annual waterfowl migrations, both spring and fall, are one of the most amazing spectacles in nature. Driven by changing weather conditions and the search for food, certain species of waterfowl will migrate thousands of miles stopping only briefly to rest and replenish their nutrient reserves. Others migrate more slowly and have longer stopovers en route. Yearly variation in weather, food supplies, and available habitat will greatly affect these migration patterns. Largely because of the success of early banding programs, it became possible in the early

1930's to map the main migration corridors or flyways, used by waterfowl on their annual fall migration. That information became the concept of the four flyway corridors – Atlantic, Mississippi, Central, and Pacific – upon which biologists now focus their management (Figure 1.1.2-1). The MsCIP study area falls within the Mississippi Flyway. The longest migration route of any in the Western Hemisphere lies in this flyway. Its northern terminus is on the Arctic coast of Alaska and its southern end in Patagonia. Well timbered and watered, the entire region affords ideal conditions for the support of hosts of migrating birds. The two rivers that mark it, the Mackenzie emptying on the Arctic coast and the Mississippi in the Gulf of Mexico, have a general north-and-south direction, another factor in determining the importance of this route which is used by large numbers of ducks, geese, shorebirds, blackbirds, sparrows, warbler and thrushes. The majority of North American land birds, seeking winter homes in the tropics that come south through the Mississippi Flyway take the short cut across the Gulf of Mexico in preference to the longer, though presumably safer, land or island journey by way of Texas or the Antilles (Association of Fish and Wildlife Agencies 2008).



Source: USFWS

Figure 1.1.2-1. America's Flyway Corridors (*USFWS 1996b)*

Although waterfowl are what most people think of when they hear the word flyway or migration, many other birds migrate as well. Approximately two thirds of the breeding bird species of eastern United States forests migrate to tropical wintering areas in the Caribbean, Mexico, and Central and South America (Keast and Morton 1980). The movement of birds across the Gulf of Mexico each spring and fall is a prominent feature of Nearctic-Neotropical bird migration system (Ramos 1988). From early April through mid-May, the day-to-day consistency of migration across the Gulf of Mexico is rarely interrupted, and then only when strong cold fronts are positioned over the southern Gulf of Mexico (Gauthreaux 1971). Even with favorable weather, migrants use coastal habitats in large numbers.

The coastal woodlands and narrow barrier islands that lie scattered along the northern coast of the Gulf of Mexico provide important stopover habitat for Neotropical landbird migrants (Moore et al.

1990). They represent the last possible stopover before fall migrants make a non-stop flight (18-24 hr) of greater than 1,000 km, and the first possible landfall for birds returning north in spring (Moore and Kerlinger 1987). Unfortunately, the loss of coastal habitat suitable for forest-dwelling migrants is fast accelerating due to the extensive development of coastal regions (Moore and Simons 1989). Habitats along the northern coast of the Gulf of Mexico are fragmented, and many woodlands average only a few hectares in area. Development in the coastal zone is likely to continue the fragmentation of stopover habitat in the future (Moore and Simons 1989). As stopover habitat is transformed or degraded, continued migration of these species is jeopardized. A study of the distribution of spring trans-Gulf migrants among five plant habitats on Horn Island found that the distribution of migrants deviated from that expected based on availability of habitats. Migrants settled most frequently in scrub-shrub, forest, and relic dune habitats (Moore et al. 1990). Birds are the ultimate indicator of ecological quality. Clean air, clean water, and abundant, diverse habitats are essential for birds to continue to survive and flourish. Without a healthy ecosystem, bird populations will diminish and species will disappear, along with the quality of life for people on this planet.

Approximately two (2) dozen large estuaries are present along the coastline of the Gulf of Mexico between the Mexican border and the Florida Keys. Over one-half of all stream discharge that takes place to the oceans bordering the United States is discharged into the Gulf of Mexico. A substantial portion of this first enters the estuaries, carrying with it large quantities of suspended sediment and nutrients.

Mississippi Sound is fed from the north by eight coastal mainland watersheds and drainage from the south by tidal exchange from the Gulf of Mexico. From west to east the mainland drainages include: Lake Borgne, the Pearl River, the Jourdan River, the Wolf River, the Tchoutacabouffa River, the Pascagoula River, and Mobile Bay. Combined drainage area from streams and rivers entering the Mississippi estuarine basin is approximately 19,660 square miles (mi^2). The Pearl River and Pascagoula River drainage areas far exceed those of Biloxi and St. Louis Bays. Pascagoula River has a drainage area of 9,400 mi^2 with an average discharge of 15,185 cubic feet per second (ft^3/s). Pearl River drains 8,700 mi^2 and has an average discharge of 12,890 ft^3/s. The combined drainage area for rivers emptying into Biloxi and St. Louis Bays is 1,400 mi^2 with an average discharge of 2,790 ft^3/s (NMFS 1998).

The influx of rivers creates a salinity gradient within the Sound (Priddy et al. 1955). Both east-west and north-south gradients occur in the Sound in addition to vertical gradients. Generally, positive salinity gradients exist from the mainland seaward and vertically, surface to bottom (Gulf of Mexico Fisheries Management Council 1998). Surface salinity is influenced by the discharge of freshwater from large rivers and is reduced during periods of higher flow in late spring and early summer (Thompson et al. 1999). Temperature follows expected salinity trends. Levels of dissolved oxygen are usually above lethal limits. The Pascagoula and Pearl Rivers, Bayou Casotte, and Biloxi Bay are the primary sources of nutrients entering the Mississippi Sound. The temporal and spatial variability of estuarine salinity is dependent on water supply, evaporation, and mixing, and also management, which includes the direct influence of activities, such as water withdrawal for inland irrigation projects and diversions, and the indirect effects of global climate change. Oysters grow faster in areas with fluctuating salinities within their normal ranges, compared to constant salinity (Pierce and Conover 1954). Oyster reefs of commercial importance are subtidal and form aggregates that cover thousands of acres of the Mississippi Sound. The aerial extent of oyster reefs in Mississippi is estimated at 10,000 to 12,000 acres, of which over half is located in the western Mississippi Sound south of Pass Christian.

The eighty-mile-long body of water north of the string of five barrier islands is the Mississippi Sound, a large dynamic estuary extending from Mobile Bay in Alabama on the east to Lake Borgne in Louisiana to the west. Mississippi Sound is located within the very center of what fisheries biologists term the Fertile Fisheries Crescent. The Gulf of Mexico produces 28 to 30 percent of the total fishery

products of the United States. Gunter (1963) showed that between 1936 and 1962, production from the Gulf of Mexico increased at a rate of 7 times its former production, with the shrimp fishery being the most valuable in the country. The Fertile Fisheries Crescent has been called “the core of the Gulf’s $800 million fishing industry.” Mississippi Sound forms a major part of the Fertile Fisheries Crescent within the northern Gulf of Mexico.

Large quantities of freshwater are emptied into Mississippi Sound by the Pascagoula and Alabama Rivers on the east and Pearl River along the western state line and to an extent, the Mississippi River further west. Several freshwater coastal streams empty into Mississippi Sound in-between the Pascagoula and Pearl Rivers providing nutrient rich freshwater which results in the Sound’s great productivity. It is within this brackish estuarine water that several species of fish, classified as aquatic resources of national importance, thrive from the shallow waters to the deep sea 70 miles offshore.

The Fertile Fisheries Crescent can be divided into three sections, the West Florida Shelf, The Mississippi-Alabama Shelf and the Louisiana-Texas Shelf. The Mississippi-Alabama Shelf extends from the DeSoto Canyon westward to the Mississippi River Delta. Sediments within this area range from more carbonate in the eastern part to mostly terrigenous nearer the Mississippi River Delta. Bottom features within the area are small peaks of cemented together sediments called “pinnacles”, dense fields of reef-like mounts, and low ridges that run parallel to shore. Also located within nearshore waters are hard bottoms and rock outcroppings.

Recent studies have determined of the total fishes found within the northern Gulf of Mexico, excluding the southern Florida reef habitats, approximately 1,200 species, almost 400 species are found within the Mississippi-Alabama Continental Shelf. The Mississippi Sound estuary plays a key role in these numbers by providing prime habitat for various lifestages of red snapper, tuna, redfish, Spanish and king mackerel, grouper, speckled trout, jack crevalle, cobia, amberjack, marlin, and various species of sharks. Mississippi Sound’s productivity is unequalled in the Gulf which makes it ideal for avid sport fishermen, commercial fishing, and local recreational use. Biloxi, Mississippi, located in the center of Coastal Mississippi was once known as “The Seafood Capital of the World” and in 1910 canning factories located here shipped over 15 million cans of oysters, more than any place else in the world.

The fishing industry contributed $1.1 billion to the state’s economy prior to the devastation by Hurricane Katrina. According to Mississippi Department of Marine Resources, during a five-year average before the storm, Mississippi shrimp accounted for five to seven percent of all the shrimp landings in the U.S. The commercial seafood industry which includes the harvesting, processing and distribution of all seafood products created a total economic impact of $900 million in 2003. The total ex-vessel value of commercial landings amounted to $46 million while the total plant-gate value of commercial seafood production was $338 million in 2003. The recreational fishing industry which includes saltwater and freshwater fishing produced a total economic impact of $463 million in 2001 and $1,306 million in 1996. This once thriving commercial fishery always has and will continue to play a significant role in the overall economy, both on a regional and national level.

1.1.3 Impacts from Hurricanes of 2005

The destruction caused by the hurricanes of 2005 came in two forms: the wind and tidal action of the hurricane itself. When Hurricane Katrina struck the Gulf Coast, it was a Category 3 hurricane; it had been as high as Category 5 as it moved through the Gulf of Mexico. The hurricane was also massive, which meant that these intense winds were spread over a wide area – in fact the entire Gulf Coast. The same forces that wrecked New Orleans damaged or destroyed wetlands along the Gulf Coast. Barrier islands took the initial damage. Wetlands suffered less from wind damage than from flood waters that dumped saltwater, trash, and toxic chemicals into the fragile ecosystems.

When saltwater is introduced into a freshwater habitat it kills the vegetation – i.e. valuable wet pine savannah habitat.

Disturbance of soils and vegetation, such as vegetation covered by trash or complete removal of trees and/or marsh grasses, in coastal wetlands has allowed an excessive amount of exotic species to colonize the area. The destruction of wetlands and coastal habitat occurred in a sensitive area for birds. As previously discussed, the northern Gulf Coast is a stopping point for birds in migration; it also serves as nesting ground for many species of terns and other waterbirds. Damage to the barrier islands was particularly bad for the nesting species; nests the following couple of years were lower for several species. Threatened birds in the area include a rare Sandhill Crane subspecies. Twelve important bird areas lay in Hurricane Katrina's path: two in Florida and ten on the northern Gulf Coast. The hardest hit were Breton NWR and the Gulf Islands National Seashore.

The habitats of several endangered species were altered by the hurricanes. The endangered Alabama beach mouse has lost several acres of primary and secondary dunes that serve as habitat, and has lost scrub forest habitat, where it finds prey, to saline ocean waters. Along the Alabama coast, some nesting sites for the endangered Kemp's ridley sea turtle have been destroyed, and forested areas have been blown down in the Noxubee National Wildlife Refuge in Mississippi, where the listed red-cockaded woodpecker has habitat.

The Gulf Coast states are significantly forested and are major producers of lumber and plywood. The U.S. Department of Agriculture (USDA) Forest Service estimated 19 billion board feet of timber damaged on over 5 million acres in Mississippi, Alabama, and Louisiana. This would translate into an estimated $5 billion loss in potential timber revenues according to the Forest Service. The forested area damaged represents 30% of the total timberland in the affected region, 90% of which occurred on non-federal lands. Eighty percent of the damage occurred in Mississippi. The Mississippi Forestry Commission issued a news release estimating that 1.3 million acres of forestland in the state had been damaged, with commercial timber valued at about $1.3 billion; urban tree damage in Mississippi was estimated at $1.1 billion.

Some scientists believe that the risk of long-term damage of toxic floodwaters entering the Gulf of Mexico is not high. They contend that tidal flows and flushing of Gulf waters will dilute substances to non-harmful levels. Specifically, scientists contend that bacterial contaminants will die off quickly, and that other organic material will degrade with natural processes. Other scientists offer a different perspective on the impacts of toxic waters in the Gulf of Mexico. They contend that toxic chemicals and excess nutrients will severely deplete fisheries by killing fish and will contaminate sediments.

The Gulf Coast where Hurricane Katrina struck is an especially important center of commercial and recreational fishing, producing 10% of the shrimp and 40% of the oysters consumed in the U.S. Further, commercial shrimpers fishing out of or delivering to Alabama, Mississippi, and Louisiana ports account for almost half of all U.S. shrimp production. Hurricane Katrina has destroyed or severely damaged fishing boats and processing and storage facilities throughout this area. The impact of Katrina on fish populations, habitat, and their viability for consumption was significant.

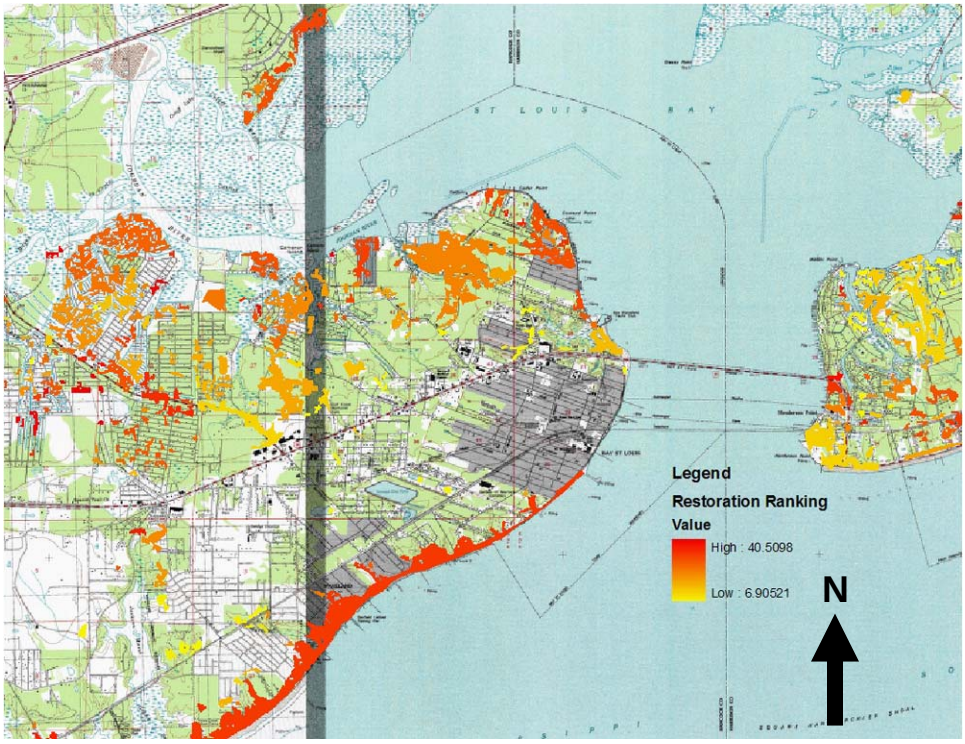
1.1.4 Relationship Between the Coastal Ecotones and the Multiple Line of Defenses Concept

The MsCIP effort developed multiple arrays of Line of Defenses (LODs) to protect the Mississippi coast and its citizens from future storm events. These LODs are structural measures that have specific locations along Coastal Mississippi starting from the barrier islands moving inland to north of Interstate-10. LOD 1 restores lost habitats – beaches, dunes, coastal forests, and emergent marshes - at the barrier islands offshore of Mississippi to provide that first natural barrier against future storms. The barrier island ecotone – water and land interface – covers the entire area and is

essential for numerous fish and wildlife species. Furthermore, this area is an essential coastal ecotone allowing the future persistence of Mississippi Sound – i.e. creating the fertile brackish waters from the mixing of freshwater from the rivers and salty waters from the Gulf of Mexico. LOD 2 restores lost beach and dune habitat along the coastal mainland while also providing an added natural buffer to the mainland. This ecotone – water and land interface – provides an important habitat to many migratory bird species stopovers to farther destinations, nesting least terns, wintering piping plovers, and many other important bird species. LOD 3 elevates existing roadways and seawalls while also protecting communities by ring levees. This defense protects the very people dependent upon these vital coastal resources. This structural defense along with LODs 4 and 5 - inland barriers and surge gates across water bodies and a critical boundary north of Interstate-10 – provides the required protection and enables future sustainability of human beings living along the Gulf Coast as they have done for hundreds of years. These LODs provide sustainable living the coastal resources and also for the people of Coastal Mississippi.

1.1.5 Relationship Between the Coastal Ecotones and Storm Damages

A hydric soil is one that is defined as “a soil formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part.” (Federal Register, 1994) Since the soils of these areas formed under hydric conditions due to the proximity of water. The spatial extent of the coastal ecotone can be indicated by the presence of these hydric soils. Analysis through GIS shows that 76% of all of the houses seriously damaged (damage estimated as greater than 90%) by Katrina, as defined by FEMA, were also located in areas mapped as hydric soils or areas composed of dredged material from adjacent channels. Figure 1.1.5-1 provides the overlay of the FEMA-damaged maps with the soil conditions that shows the ranking of ecological restorability potential. This correlation is an additional demonstration that the importance of restoring the coastal ecotone extends beyond ecological interests into insuring the well-being of the human population.



Source: Corps

Figure 1.1.5-1. FEMA Damaged Maps Overlaid upon Soil Conditions

1.1.6 Relationship between the Proposed Restoration Projects and the Environmental Framework

The MsCIP Comprehensive Plan presents a very complex challenge to identify Mississippi coast recovery plans. The investigation was focused on 3 components – environmental, non-structural and structure plans – to achieve an array of protection and restoration measures. While developing these components, the team ensured that the specific measure or a compilation of measures addressed the 2005 congressional authorization of:

- future hurricane storm and flood damage reduction;
- prevention of saltwater intrusion;
- prevention of coastal erosion;
- preservation of fish and wildlife; and
- other water related resources (reduction of flooding).

Ultimately, several hundred measures were identified ranging from restoring the barrier islands at varying levels, raising existing structures' elevation, constructing ring levees around communities, building surge gates across water bodies, restoring dune and beaches, developing housing assistance and relocation programs, and restoring wet pine savannah, emergent tidal marsh, and scrub shrub habitats. These measures were screened throughout the plan formulation process in order to develop alternatives. The comprehensive nature of the MsCIP effort resulted in the ability to implement certain alternatives while others required additional study. Thus, the team categorized identified measures into the following management components:

- Additional Study and Design (designated as orange in Table 1.1.6-1);
- Advanced Engineering and Design (designated as green in Table 1.1.6-1); and
- Construction (designated as purple in Table 1.1.6-1).

1

Table 1.1.6-1.
MsCIP Comprehensive Approach

Proposed Restoration Project	Portion of the Ecotone to be Addressed	Ecological/Societal Functions to be Addressed	Comprehensive Plan Objectives to be Addressed
Freshwater Diversion, Escatawpa River, MS	Littoral areas, emergent wetland areas	Enhanced oyster production, enchanced productivity of brackish marshes	3, 4, 5, 6
Other Coastal Wetland and Forest Restoration	Emergent Tidal Marsh Scrub/Shrub	Enhanced productivity of emergent tidal wetland, habitat enhancement, relocation of human development out of the coastal ecotone for public safety	1, 2, 3, 5, 6
Levee Projects – Belle Fontaine, Gulf Park Estates, Pascagoula/ Moss Point, Pearlington, Gautier, Ocean Springs, Bay St. Louis	Reduces flooding	Adds protection to human development out of the coastal ecotone for public safety zone	1, 2, 6
Long-term High Hazard Area Risk Reduction Plan	Restore natural flooding buffer	Restore natural buffer zone, relocation of human development out of the coastal ecotone for public safety	1, 2, 6
Freshwater Diversion of the Mississippi River	Littoral areas, emergent wetland areas	Enhanced oyster production, enchanced productivity of brackish marshes	3, 4, 5, 6
High Hazard Area Risk Reduction Plan	Emergent tidal marsh, forested wetlands	Enhanced productivity of wetlands and forested wetlands in order to restore natural buffer zone	1, 2, 6
Moss Point Municipal Relocation Component	Restore natural flooding buffer	Restore natural buffer zone, relocation of human development out of the coastal ecotone for public safety	1, 2, 6
Waveland Floodproofing	Restore natural flooding buffer	Restore natural buffer, relocation of human development out of the coastal ecotone for public safety zone	1, 2, 6
Forest Heights Hurricane and Storm Damage Reduction Component	Reduces flooding	Adds protection to human development out of the coastal ecotone for public safety zone	1, 2, 6
Turkey Creek Ecosystem Restoration	Wet Pine Savannah Wetlands	Enhanced productivity of wetlands Removes structures from project area	1, 2, 3, 6
Dantzler Restoration Area, Ansley	Wet Pine Savannah Wetlands	Enhanced productivity of wetlands	1, 3, 6

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Table 1.1.6-1.
MsCIP Comprehensive Approach (continued)

Proposed Restoration Project	Portion of the Ecotone to be Addressed	Ecological/Societal Functions to be Addressed	Comprehensive Plan Objectives to be Addressed
Franklin Creek Ecosystem Restoration	Wet Pine Savannah Wetlands	Moves Residents out of Harms Way (MsCIP Interim Project) Enhanced productivity of wetlands	1, 2, 3, 5, 6
Bayou Cumbest Ecosystem Restoration, Pearlington, Pearlington South, Port/West, Chapman Road, Diamondhead, Delisle, Ellis Property, Brickyard Bayou, Biloxi River – Shorecrest , Biloxi River – Eagle, Jourdan River – I-10 Development, Pine Island, Fort Point, St. Martin, Keegan Bayou	Emergent Tidal Marsh Scrub/Shrub	Enhanced productivity of emergent tidal wetland, habitat enhancement, relocation of human development out of the coastal ecotone for public safety	1, 2, 3, 5, 6
Admiral Island Ecosystem Restoration Lakeshore, Bayou Caddy/Lakeshore, Clermont Harbor Bayou La Croix, Shoreline Park, Pine Point East, Pine Point West, Pass Christian Site – Bayou Portage,	Emergent Tidal Marsh Scrub/Shrub	Enhanced productivity of emergent tidal wetland, habitat enhancement, relocation of human development out of the coastal ecotone for public safety	1, 2, 3, 5, 6
SAV Pilot Project at Bayou Cumbest	SAV – *Ruppia maritime*	Enhance fishery production	3, 6
Beach and Dune Ecosystem Restoration	Coastal Dune Habitat	Buffer mainland from storm surge and waves energy	1, 2, 3, 5, 6
Barrier Island Restoration, Biloxi Front Beach – South of Highway 90	Littoral zones, beach, dunes, emergent tidal marsh	Buffer mainland from storm surge and waves energy, enhanced productivity of emergent tidal marsh, enhance productivity of SAVs in littoral areas, enhance fisheries production	1, 2, 3, 4, 5, 6
Deer Island Ecosystem Restoration	Coastal Forests, Emergent Tidal Marsh	Enhanced productivity of wetlands	1, 2, 3, 5, 6

Footnote: Objectives - Green – Tentatively Selected Elements, Purple – Site Specific Elements, Orange – System Wide Elements. 1. Reduce loss of life caused by hurricane and storm surge by 100%; 2. Reduce damages caused by hurricane and storm surge by $150M-$200M annually; 3.Restore 10,000 acres of fish and wildlife habitat including coastal forests, coastal wetlands, wet pine savannah, submerged aquatic seagrasses, oyster reefs, and beaches and dunes by the year 2040; 4. Manage seasonal salinities within the western Mississippi Sound, such that optimal conditions for oyster growth (surrogate for other aquatic resources, 15 ppt during summer months) are achieved on an annual basis by 2015; 5. Reduce erosion to barrier islands, mainland, and interior bay shorelines by 50%; 6. Create opportunities for collaboration with local, state, and Federal agencies to facilitate implementation of programs and activities that maximize the use of resources in achieving the comprehensive goal.

1.1.7 Analysis Tools Used in the MsCIP Project to Identify and Assess the Coastal Ecotones

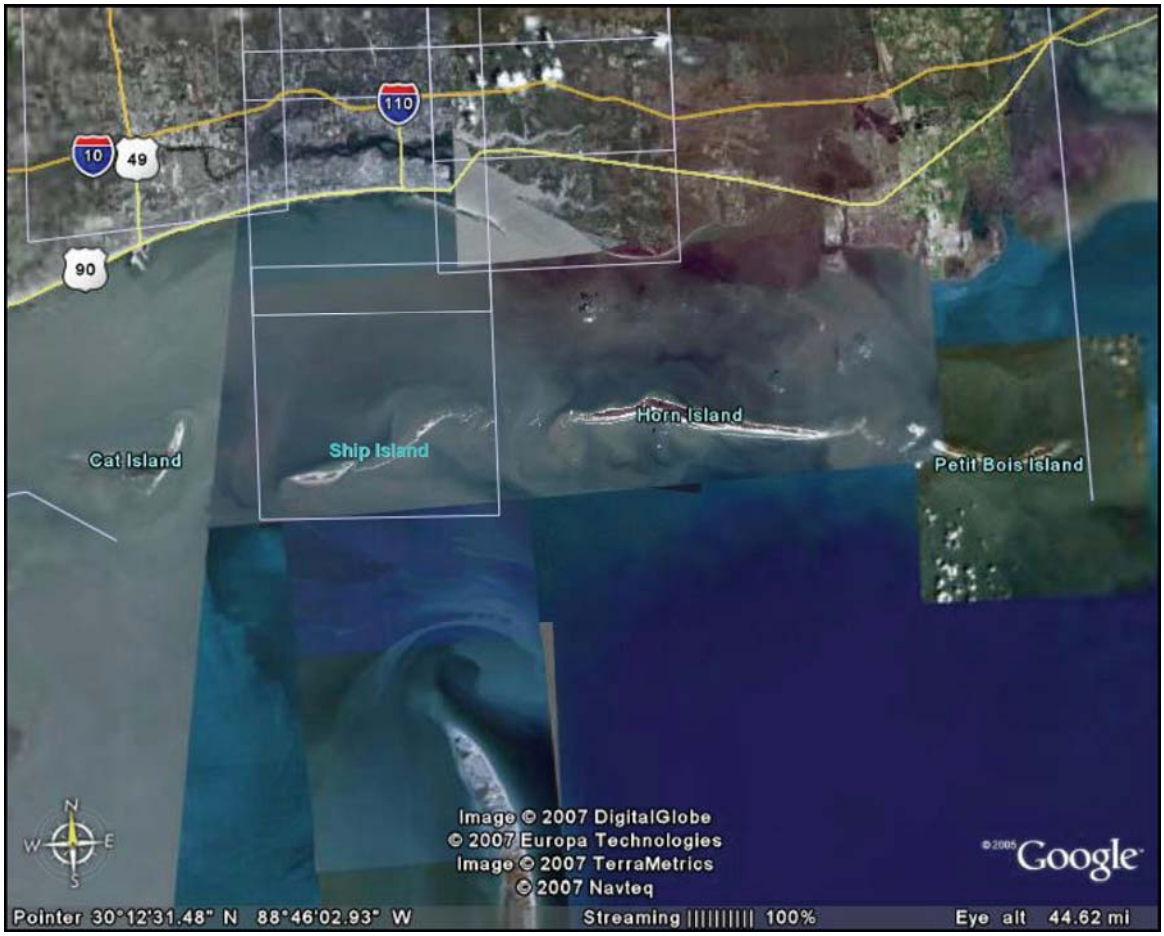
At the 8th Annual Coastal Development Strategies Conference in Biloxi, Governor Haley Barbour said in his keynote speech, "Our goal is not to get it like it was; our goal is to get it how it can be." Governor Barbour urged local officials among some 400 attendees to take the advantage of post-hurricane recommendations from the Governor's Commission on Recovery, Rebuilding and Renewal, and create smart growth community plans for generations ahead. This is still to date the worst disaster in the history of the U.S. yet it provides great potential for ecological recovery and associated sustainable development. Hurricane Katrina provided a blank canvas to make the coast of Mississippi the premier ecological setting that promotes sustainable development. This once-in-a-lifetime opportunity allows us to restore natural resources, provide protection to coastal residents, while also promoting future use of Coastal Mississippi by generations to come.

In other U.S. disasters, those impacted areas are bought by the Federal government – typically the FEMA – for the sole purpose of moving humans out of hazardous areas. Unfortunately, the natural ecosystem is not considered and those remaining structures are left behind. The vacant land is not restored to its historical ecological setting. With the MsCIP effort, not only would the land be purchased but also restored to its historical ecological habitat – i.e. emergent tidal marsh, wet pine savannah, dunes, beaches, scrub shrub, etc. The MsCIP team developed a GIS based SDSS tool to quickly identify and prioritize potential wetland restoration areas throughout Coastal Mississippi. The SDSS tool evaluated potential wetland restoration sites that had been initially selected based on having a non-natural land cover (i.e. urban, deforested, and agricultural land cover, based on MDMR 2001 land cover GIS layer) and were located in the 100-year floodplain. Numerous potential environmental restorations sites were initially identified but later screened by certain ecological characteristics. Ultimately, what the environmental team found was the SDSS identified areas that were historically wetlands – i.e. emergent tidal marsh – which were also developed. These ecotones – water and land interface – were and are still essential for fish and wildlife, natural buffers from storm surge, and overall health of the ecosystem. Restoring these systems provides benefits to both the ecosystem and humans.

The HGM approach was applied to develop functional indices and protocols for the assessment of wetland functions at those site-specific scales. HGM allowed the team to quantifiably evaluate biological, chemical, and physical functions of wetlands - a critical part of the coastal ecotone. Thus, allowing the MsCIP team to select the optimal environmental restoration plan based on the biological, chemical, and physical benefits.

1.2 Description of the Natural System

The primary study area consists of the three coastal counties comprising the State of Mississippi: Hancock, Harrison, and Jackson counties; and the coastal (offshore) ecosystem including its barrier islands (Figures 1.2-1 and 1.2-2). This area ranges in elevation from sea level to about 30 feet. The essentially flat to gently undulating, locally swampy Coastal Lowlands are underlain by alluvial, deltaic, estuarine, and coastal deposits and merge with the fluvial-deltaic plains of the streams of the area. This portion of Coastal Mississippi has been classified as an alluvial coast, a terraced, and deltaic plain (Corps, Mobile District 1984). According to the Cowardin et al (1979), *Classification of Wetlands and Deepwater Habitat of the United States*, there are five major wetland and deepwater systems, four of which are found within Coastal Mississippi. They include marine, estuarine, riverine, and palustrine wetland systems.



Source: Google Earth

Figure 1.2-1. Aerial Photograph of Mississippi Coast



Source: Corps

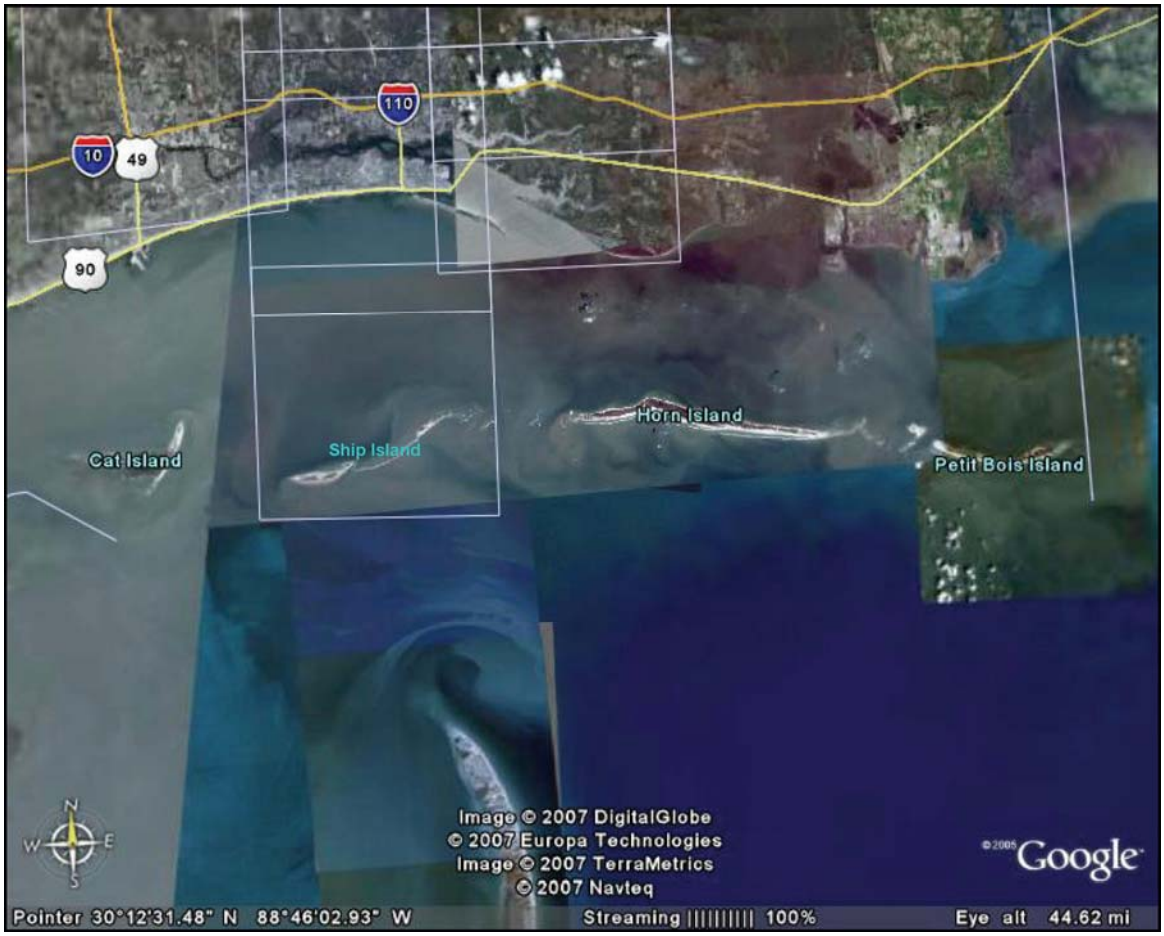
Figure 1.2-2. Coastal Mississippi Ecological Resources

1.2.1 Marine System

The marine system is defined as the open ocean overlying the continental shelf and its associated high energy coastline. Within Coastal Mississippi, the marine system is the area along the Gulf of Mexico front south of the barrier islands. It is comprised of the intertidal beachfront of the barrier islands along the Gulf of Mexico, and subtidal habitat which consists of the unconsolidated sandy or silty water bottoms.

1.2.1.1 Barrier Islands

Mississippi's mainland is bordered on the south by Mississippi Sound, a shallow body of water that separates the coast from four (4) barrier islands that lie approximately 11 to 13 miles offshore (Figure 1.2.1.1-1). The string of barrier islands are comprised of dynamic and diverse habitats and are part of a complex integrated system of beaches, dunes, marshes, bays, tidal flats, and inlets. These barrier islands are located along a littoral drift zone that moves sand westward creating three elongated islands and then to the westward most island (i.e. Cat) where littoral currents are not as well defined.

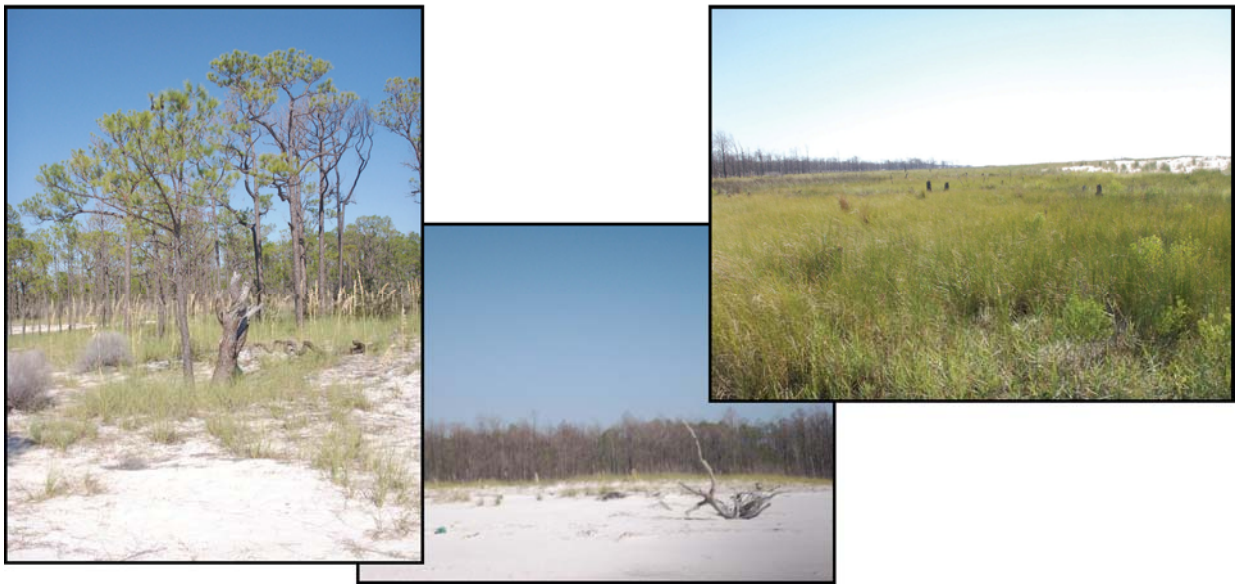


Source: Google Earth

Figure 1.2.1.1-1. Coastal Mississippi

From east to west, the islands are Petit Bois, Horn, Ship, and Cat. Ship Island was breached by prior hurricanes and now is actually two small islands, West Ship Island and East Ship Island, with a shallow sand bar between the two. Since Hurricane Camille in 1969, this breach has existed with varying amounts of natural rebuilding between later storms. The western ends of both Petit Bois and Ship Islands have migrated westward into maintained navigation channels and the continuing littoral drift of the sand into the channels is causing an artificial termination of the migration. However, recent redirect of placing dredged sand in the designated littoral zone disposal sites (i.e. sand-bypassing) assists in continuing the littoral drift. A new island has emerged on the west side of the channel from Petit Bois Island, created from dredged sand being placed on the west side of the channel. This island is known as Sand Island.

All of Petit Bois, Horn, and Ship Islands and part of Cat Island are within the boundaries of the Gulf Islands National Seashore under the jurisdiction of the NPS (Figure 1.2.1.1-2). In most cases, the boundary extends one mile seaward from the shore of the island. Petit Bois and Horn Islands have also been designated as Wilderness Areas by Congress, which affords additional significance and protection than is applicable to the other islands.



Source: Corps

Figure 1.2.1.1-2. Horn Island

Under current conditions, the islands provide a natural boundary between the water's salinity [~33 parts per thousand (ppt)] of the open Gulf of Mexico and the brackish water found in Mississippi Sound. Salinity in the Sound during low flow periods range from 10 to 30 ppt. Highest salinities occur just south of Pascagoula and Gulfport and the lowest salinities in the Lake Borgne-Pearl River area.

Loss of the barrier islands would increase salinity in Mississippi Sound; thus, greatly changing ecological habitats that exist, which could lead to saltwater intrusion, increased wave action, and the destruction of wetlands. Increased salinity within Mississippi Sound would impact shellfish and many other forms of marine life. At the Chandeleur Islands in Louisiana, loss of those island masses allows us to anticipate potentially similar environmental changes. Initial assessments in the Chandeleur system are showing SAVs diminishing, marsh erosion ongoing/accelerating, and wave energy having no natural barrier. Like Cat Island on the Mississippi barrier islands, Chandeleur Islands are a remnant of a delta lobe from the Mississippi River where wave action created a beach that remained as a island after sea level rise and erosion removed the land mass between the island and the mainland.

The NPS is currently assessing eventual fate of the barrier islands in light of climate change, sea level rise, and other anthropogenic impacts that have already, or could lead to a disruption of the natural sediment transport and budget system that the islands are dependent upon for their very survival. The Service is concerned East and West Ship Islands will not recover naturally due to the aforementioned causes. Consequently, NPS is contemplating management actions focused upon restoring the sediment transport and budget system in order to sustain the barrier islands in perpetuity.

1.2.2 Estuarine System

Estuarine systems within Coastal Mississippi consist of deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open partly obstructed or sporadic access to the open ocean and in which ocean water is occasionally diluted by freshwater runoff from the land. Mississippi Sound consists of both sub-tidal and inter-tidal estuarine systems.

1.2.2.1 Mississippi Sound

Mississippi Sound is a shallow coastal lagoon along northern Gulf of Mexico from Mobile Bay, Alabama, in the east to Lake Borgne, Louisiana, in the west. It extends from the Mississippi coastline to a string of sandy barrier islands, which separate it from the Gulf of Mexico. The Gulf Intracoastal Waterway parallels the mainland coast offshore through the entire length of Mississippi Sound. Mississippi Sound receives both high saline waters from the Gulf of Mexico and freshwater from the streams/rivers, which drain some 20,000 m^2 of land area (Corps 1984). Circulation is driven by tides modified slightly with the wind. Gulf waters enter the Sound through the deep passes between the barrier islands with the help of tidal forces. This mixing of freshwater runoff and saline waters has created a dynamic estuarine ecosystem. Mississippi Sound receives its major freshwater flow from the Pascagoula and Pearl Rivers and is critical to the survival of numerous birds, mammals, fish, and other marine organisms of national importance.

Many different habitat types are found in and around the estuarine ecosystem, including shallow open-waters, salt marshes, sandy beaches, mud and sand flats, oyster reefs, river deltas, tidal pools, and SAVs. These diverse ecosystems serve a variety of critical functions necessary to sustain a vital thriving commercial fishing industry of national economic significance.

Mississippi Sound is identified as EFH for postlarval and juvenile red drum, Spanish mackerel, and white and brown shrimp. In addition to EFH designated for white and brown shrimp, Spanish mackerel, and red drum, the estuary provides nursery and foraging habitat that supports various species including economically-important marine fishery species, such as black drum, spotted seatrout, southern flounder, Gulf menhaden, bluefish, croaker, mullet, and blue crab. These estuarine-dependent organisms serve as prey for other important fisheries, such as mackerels, snappers, and groupers, and highly migratory species, such as billfishes and sharks. These habitats produce nutrients and detritus, important components of the aquatic food web, which contribute to the fishery productivity of the Mississippi Sound estuary. Several of the species, such as T&E species, brown shrimp (*Penaeus aztecus*), red drum (*Sciaenops oellatus*), and pink shrimp (*P. duorarum*) listed by NOAA Fisheries, are identified as being of national economic importance in Section 906(e)(1) of the Water Resources Development Act (WRDA) of 1986 and, therefore, are aquatic resources of national importance. Mudflats and sand flats provide valuable habitat for oysters and other important shellfish. SAVs provide vital foraging habitat and refuge for all stages of fish.

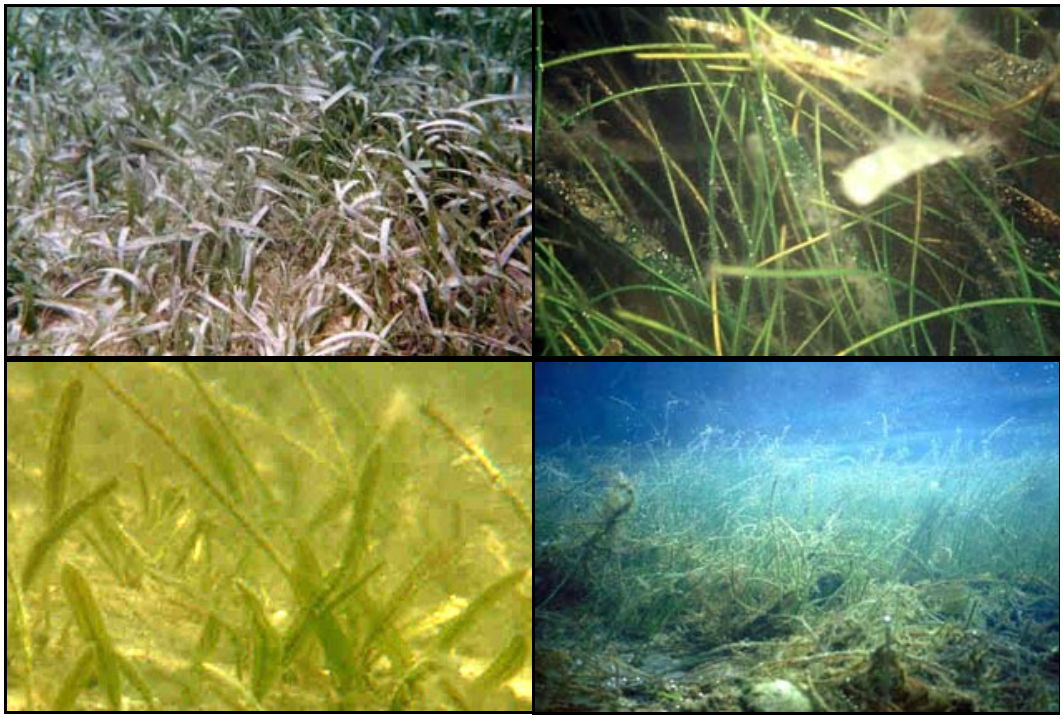
Marshes act as filters removing pollution from runoff with wetland plants and soils that act as natural buffers improving water quality, storing floodwaters, and reducing coastal erosion. Diminished and degraded habitats are less available to support healthy populations of wildlife and marine organisms and less able to perform the economic, environmental, and aesthetic functions that help to sustain Coastal Mississippi. According to the National Coastal Condition Report II, Gulf Coast estuaries are among the most productive natural systems, producing more food per acre than the most productive Midwestern farmland and are second only to Alaska for domestic landings of commercial fish and shellfish. Shrimp landings in the Gulf of Mexico accounted for 80% of the total U.S. shrimp landings in 2000.

The hurricane-induced loss of fisheries to Coastal Mississippi is unprecedented in national history and has presented a high cost to the nation. Following Hurricane Katrina, the Commerce Secretary declared a complete fisheries failure due to the extensive devastation to the processing facilities, docks, loss of boats, degradation of habitat, deposition of marine debris, and degraded water quality. Losses to many commercially important fisheries stock, foraging areas, nurseries, etc. have been felt economically in the region. Increased salinity due to continued degradation of the barrier islands will result in detrimental impacts to the vital economic fisheries industry that the estuarine environment sustains. Furthermore, increased turbidity decreases foraging efficiency of certain fish species. Increased turbidity disperses

pollutants and contaminants found in bottom sediments throughout the water column. Marine debris causes obvious adverse effects on coastal resources detrimental to various species' survival, such as T&E sea turtles mistaking plastic bags for their preferred diet of jellyfish. Aesthetics and recreational activities are also negatively impacted by the presence of marine debris. An essential ingredient to reduce marine debris generated on a long-term basis is the use of educational and outreach efforts. Opportunities exist to partner with local, state, and Federal outreach programs as part of an overall comprehensive approach.

1.2.2.2 SAVs

SAVs or seagrasses are currently restricted to the northern shores of the barrier islands and small patches throughout the immediate shorelines. These areas are characterized by *Diplanthera wrightii* (Shoal grass)*, Cymodocea manatorum* (Manatee grass), *Thalassia testudinum* (Turtle grass), and *Ruppia maritime* (Widgeon grass) (Figure 1.2.2.2-1). Approximately 20,000 acres of SAVs were present in Mississippi Sound prior to 1969; however, in late 1969, Hurricane Camille caused a substantial destruction of these areas (Moncrieff 1998).



Source: Unknown

Figure 1.2.2.2-1. Seagrasses

SAVs serve as nursery areas for fish and shellfish, such as shrimp and crabs, and as food for ducks. The continued survival and growth of SAVs may be threatened by the cumulative effects of man's activities, in addition to, natural processes in the coastal marine environment. Natural causes of SAV decline, such as disease, storm events, salinity fluctuation, and hypoxic (i.e. low oxygen) events, coupled with declining water quality caused by anthropogenic eutrophication (i.e. man-made overloading of nutrients) currently threaten the health of many SAV systems (Montague and Ley 1993, Durako and Kuss 1994, Olesen and Sand-Jensen 1994, Zieman et al 1999). These habitats provide vital refuges, feeding, resting, staging, and spawning grounds for a variety of species found in Mississippi Sound and also in the Gulf of Mexico. Past studies throughout the years have attributed anywhere from 50% to 90% of all marine species to utilize this vital habitat at some point in their life stage.

As of 1998, only 2,000 acres remained (Moncrieff 1998). Dramatic decreases in SAVs along the north shoreline of Horn Island have been observed. An approximate 5,000 acre decrease in coverage was calculated for the period between 1969 and 1992. The overall distribution of SAVs among Mississippi's other barrier islands has also decreased considerably in the same time period, with Cat Island losing approximately 430 acres, Ship Island losing approximately 1,280 acres, and Petit Bois Island losing approximately 1,300 acres. Areas of SAVs along Coastal Mississippi's mainland have also declined. Buccaneer State Park is estimated to have lost about 150 acres while Point-aux-Chenes Bay has lost approximately 680 acres. The following three (3) areas were documented in which the potential seagrass habitat was less than the historical distribution of SAVs, indicating habitat loss. Dog Keys Pass, Horn Island, and Point-aux-Chenes Bay all exhibited this pattern with approximately 930 acres, 1,200 acres, and a 770 acres loss, respectively. By 1975, vascular seagrasses had been reduced to 33% and algal cover had been reduced by 41%. Additional losses of seagrass beds from 1971 to 1975 occurred as a result of the prolonged exposure to low salinity-water during the springs and winters of those years.

Seagrasses in Mississippi Sound are threatened by the cumulative effects of both natural events and anthropogenic activities in the coastal environment. The primary factors contributing to the decline of seagrass populations in Mississippi Sound are an overall decline in water quality, physical loss of habitat, decreased availability of light, extended periods of depressed salinity, and physical disturbances, such as tropical storms and hurricanes. In 1973, 67.6% of potential seagrass habitat was vegetated; however this amount was reduced to 13.4% percent by 1992 (Eleuterius 1973, Moncrieff 1998). The loss of previously vegetated areas in Mississippi Sound that are considered potential seagrass habitat totals 54.2% (Moncrieff 1998). Seagrass habitat loss in Mississippi Sound coincides with areas where rapid coastal erosion and massive long-term movement of sand have occurred (Moncrieff et al 1998). The coastal development is likely to result in indirect and cumulative adverse affects on seagrass beds by contributing to elevated nutrient levels, higher sediment loads, and the introduction of contaminants, leading to degraded water quality.

The adverse effects from natural perturbations, as evident by the catastrophic effects from Hurricane Camille on the seagrass beds, have been substantial and long-lasting. Continued physical loss of habitat, fluctuating salinity (i.e. erosion of barrier islands), and declining water quality will weaken the condition of existing beds and inhibit the revegetation of those areas that represent potential seagrass habitat. Opportunities exist to partner with other Federal or State resource agencies or with established NGOs, such as TNC. TNC has named the Mississippi Sound's marine habitat as one of their priority conservation areas on the Gulf Coast, which involves identification of SAVs, specifically seagrasses, as a critical target for protection and restoration. TNC states numerous publications have demonstrated that seagrass beds or meadows are critical habitat for many recreational and commercial marine fisheries species, such as shrimp, crabs, scallops, redfish, speckled trout, and mullet, and due to an increase in activities related to inshore fisheries and the increase in shallow draft recreational boating in most areas around the Gulf, propeller scarring has been identified as a serious threat to the integrity of seagrasses. Propeller scarring destabilizes the substrate as well as uproots the seagrasses themselves. This damage has been shown to be reversible, provided the seagrasses have the time to regenerate, and even then, can be unpredictable according to studies done in Texas in Redfish Bay.

Increased turbidity within Mississippi Sound causes less light penetration through the water column, which results in the lack of SAVs photosynthesis. Replanting seagrass beds has been found to be expensive and not always successful. It is imperative that a public outreach and awareness building campaign begin that would include signage and materials to promote recreational boat use that is compatible with these sensitive areas. Opportunities exist to partner with Federal, state, and local resource agencies as well as NGOs. Extensive coordination with the NPS, responsible for managing and operating the Gulf Islands National Seashore, would be required for areas of potential restoration within park boundaries. Involvement of local schools,

colleges and universities with ongoing research programs would also help to identify and pinpoint specific problems for development of potential solutions.

1.2.2.3 Mississippi Shoreline-Manmade beaches and seawalls

The majority of the shoreline in Coastal Mississippi consists of manmade beaches beyond concrete seawalls. A few remaining areas along the shoreline consist of more natural areas, such as expanses of marsh along the western and eastern borders of the state. Before the construction of roadways along the Coastal Mississippi shorelines, the beach did not exist as it does today. The shoreline facing Mississippi Sound was a natural marsh, similar to that found along stretches of the South Carolina “Low Country” (Corps, Mobile District 1984). As development occurred and the beachfront roads and seawalls were constructed, i.e., U.S. Highway 90 along the entire stretch of shoreline in Harrison County, this marsh was filled in to create the sandy beach. This beach was built for protection of the roadways and seawalls and also added esthetic benefits to the region. The marsh habitat was destroyed and/or eliminated along with its associated storm surge protection.

A natural beach and dune system, located along Belle Fontaine in the central portion of Coastal Mississippi, is the only natural beach remaining and has experienced severe erosion to a point that it is virtually non-existent. Seawalls have been constructed along portions of this eroding beach for protection of property, which has exacerbated beach erosion. The seawalls confine the wave energy and intensify the erosion by concentrating the sediment transport processes in an increasingly narrow zone. The beaches continue to disappear resulting in the seawalls directly exposed to the full force of the waves.

Two major deep draft Federal navigation projects are located along Coastal Mississippi, Gulfport Harbor in Harrison County and Pascagoula Harbor in Jackson County. These Federal channels serve two international ports located along the shoreline. Numerous small navigation projects and boat harbors are also located along Coastal Mississippi’s shoreline. The ports, harbors, and navigation channels received major damage as a result of Hurricane Katrina and repairs and/or reconstruction is still on-going.

Deer Island is a small mainland island located just offshore of Ocean Springs and Biloxi. The island experienced some hurricane damaged. The Corps, Mobile District has an existing Section 204: Beneficial Use of Dredged Material project and is currently working on a Section 528 of WRDA of 2000 project at the island. This recent project will restore the island to its 1850s footprint (i.e. beach/dune system, coastal maritime forest, and emergent marsh).

The beach of Coastal Mississippi provides a unique habitat for a variety of plants and animals. For example, 75% of migratory waterfowl live in or depend on coastal beaches during their lifespan (USFWS 1990b). Dune vegetation provides nesting areas for several kinds of birds, such as least terns, and animals, such as mole crabs and rodents. The beaches also provide numerous recreational opportunities for people. Boating, fishing, swimming, walking, beachcombing, bird-watching, and sunbathing are among the numerous activities enjoyed by beachgoers. The esthetic aspects of a beach/dune system provide additional benefits, even inspiring works of art and literature.

Beaches provide some protection to residents living near the waterfront by acting as a buffer against the high winds and waves of powerful storm systems or turbulent seas. MDMR has obtained funding through Federal Coastal Impact Assistance Program (CIAP) to begin initial phases of a project that would create manmade marshes along parts of the Coastal Mississippi shoreline. This project would provide a measure of bio-filtration of water-borne pollutants, and mitigate wind erosion of sand, as well as prevention of coastal erosion and siltation protection for sites selected for construction. Projects of this nature would be consistent with and offer additional opportunities for partnering with the State of Mississippi, especially during preliminary

development of project goals, evaluation, and public input as potential sites are identified and evaluated.

1.2.2.4 Wetlands – Tidal Marsh

Coastal wetlands include swamps and tidal flats, coastal marshes, and bayous. They form in sheltered coastal environments often in conjunction with river deltas, barrier islands, and estuaries. They are rich in wildlife resources and provide nesting grounds and important stopovers for waterfowl and migratory birds, as well as spawning areas and valuable habitats for commercial and recreational fish. Intertidal and subtidal bottoms are populated by communities of macrofauna whose structure is dependent upon substrate, salinity, temperature, depth, and ecological relationships.

Coastal wetlands can be dominated by saltwater, as found along the Gulf coast of Louisiana, or they can contain a complex and changing mixture of salt and freshwater, like the estuaries of the Chesapeake, Galveston, and San Francisco Bays. Mississippi Sound is bordered to the east and west by two expansive marsh systems, Grand Bay Marshes along the eastern boundary and Hancock County Marshes along the western boundary. The Pascagoula River marsh system is located primarily inland of the shoreline and will be discussed in context with the freshwater rivers.

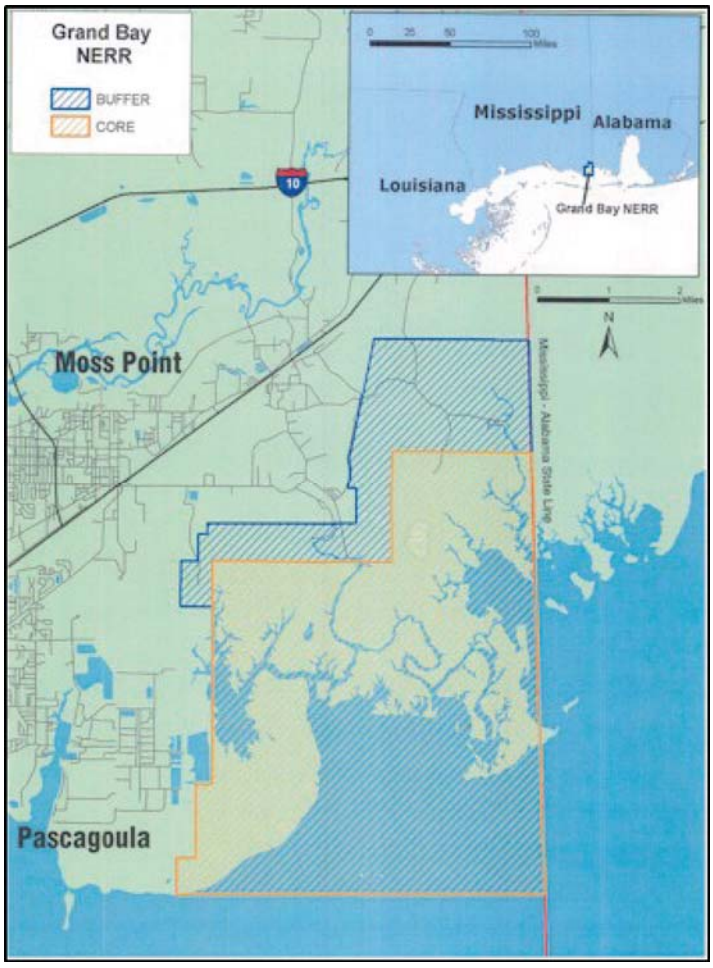
Western Hancock County along Mississippi Sound consists of extensive marshes that have suffered from lack of sediment and freshwater flows resulting in increased saltwater intrusion and coastal erosion. The lack of sediment has resulted in a reduction of natural accretion and marsh building. The Grand Bay marshes and wet pine savannahs along the eastern portion of the state have also experienced severe coastal erosion and are further threatened by increased saltwater intrusion.

Wetlands, marshes, and nearshore marine and estuarine habitat are the nursery grounds for the entire marine food chain in the Gulf of Mexico. Pollution, development, and other factors are destroying such habitat throughout the Gulf region. As this habitat is destroyed, it further depletes the species that form the base of the food chain throughout the Gulf of Mexico. Numerous species of marine flora and fauna begin their life cycles in marshes and wetlands. Ultimately, the entire Gulf of Mexico ecosystem is threatened by the accelerated destruction of this habitat. Failure to address the loss of this habitat in the Gulf of Mexico region threatens the long-term health of the entire ecosystem and human culture, with the attendant loss of billions of dollars of marine-related resources.

1.2.2.4.1 Grand Bay Marsh – Jackson County

Historically, the estuarine marsh within the Grand Bay National Estuarine Research Reserve (NERR) represented the former deltaic environments of the Pascagoula and Escatawpa Rivers in eastern Jackson County (Figures 1.2.2.4.1-1 and 1.2.2.4.1-2). The outlets of these rivers have shifted westward over time, severely limiting the inflow of freshwater, nutrients and sediments into the Bayou Cumbest area of the NERR. Several attempts have been made over the past 50 years to reroute freshwater from the marshes to the north to add additional freshwater to the estuary. Until recent years, minimal flow from the Escatawpa River existed into Bayou Cumbest through the system of meandering oxbows from the Holocene Pascagoula River.

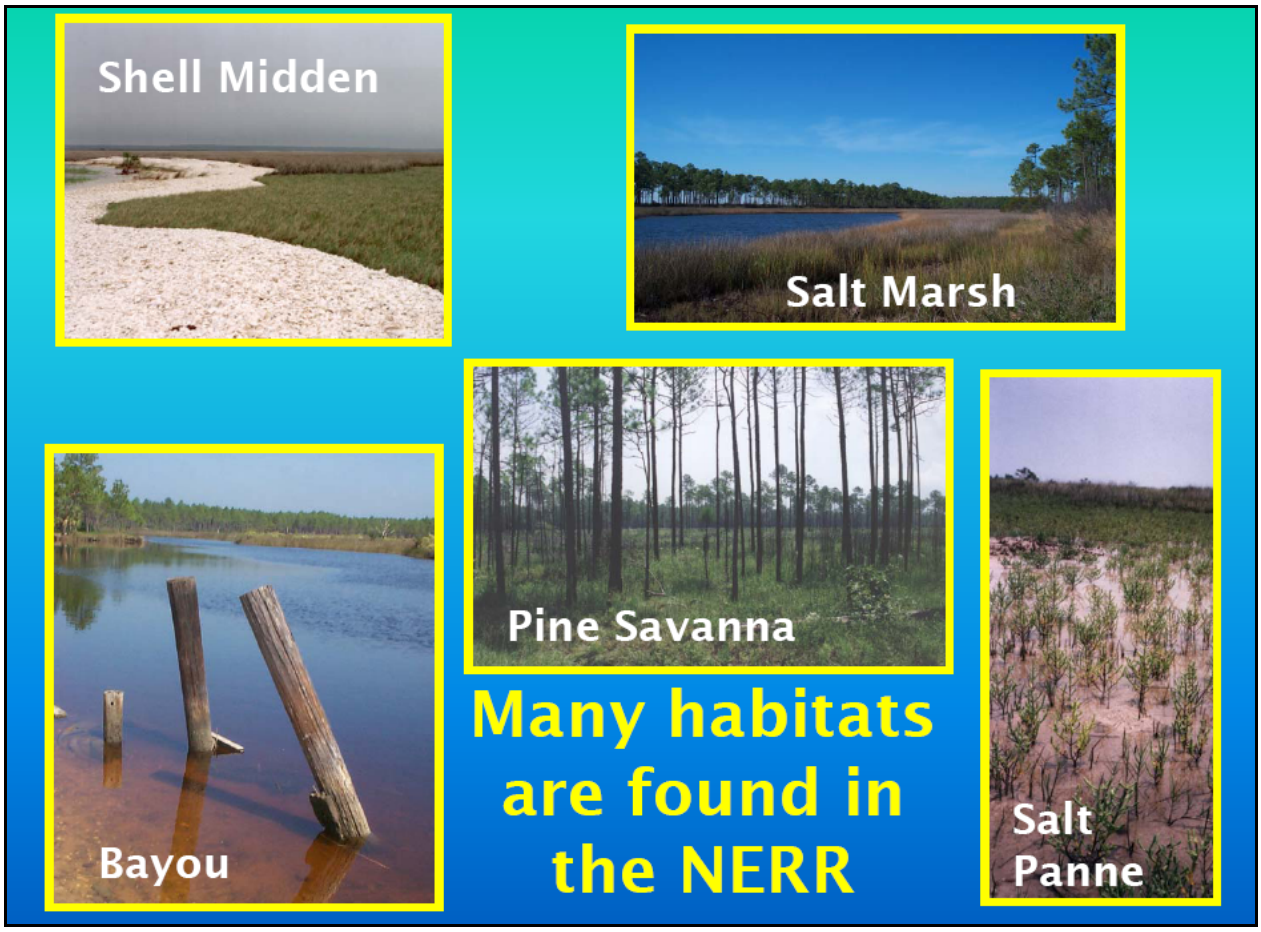
Currently it is speculated that much of the freshwater entering the Grand Bay NERR estuary is from surface runoff through Bayou Cumbest and Bayou Heron, within the Bangs Lake Hydrologic Unit, measuring approximately 21,374 acres. Human disturbances to the area have altered historic sheet flow and surface water flows into the area, as well as the natural migration of the Pascagoula and Escatawpa Rivers.



Source: MDMR

Figure 1.2.2.4.1-1. Grand Bay Marsh – Jackson County

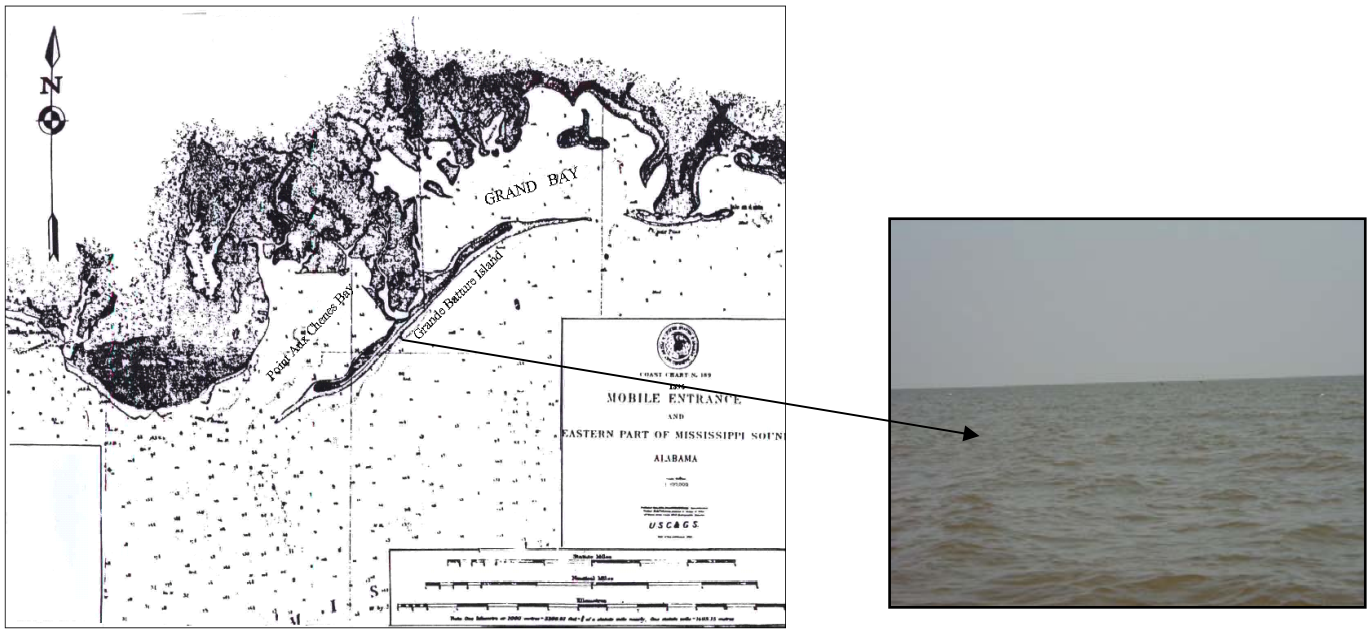
The Grand Bay marshes lie within the gently sloping, lower Gulf coastal plain. It is thought that the Pascagoula River once flowed through these marshes, emptying into Point Aux Chenes Bay, forming a rich delta. Sometime after the sea reached its current level, however, the river changed its course and now flows into the Mississippi Sound approximately five miles west of the Grand Bay NERR. This natural diversion of the river water and its associated sediments away from Point Aux Chenes Bay has led to a condition that has resulted in the retrograding (erosion) of this estuarine system. Currently, the only major channels within the NERR are Bayou Cumbest and Bayou Heron. These tidal bayous are relatively small and have slow-moving, tea-colored waters that are rich in tannins, a natural by-product of decaying vegetation.



Source: MDMR

Figure 1.2.2.4.1-2. Grand Bay Marsh – Jackson County

The Grand Batture Islands located at the mouth of Point Aux Chenes Bay once formed a significant chain of islands on the southern boundary of the reserve (Figure 1.2.2.4.1-3). However, between the years of 1853 and 1950, coastal erosional forces ate away at the islands until today they are little more than giant mud lumps (i.e. shoals). Because these islands are no longer large enough to protect the bay from high winds and waves, the sensitive coastal salt marshes located along the fringe of the bay are being eroded away at an alarming rate (over 30 feet per year).



Source: MDMR and Corps

Figure 1.2.2.4.1-3. Grand Batture Islands – Remnants of only a Shoal

1.2.2.4.2 Hancock County Marsh – Hancock County

This is the second largest continuous marsh area in the state. The boundary of this 13,570-acre preserve includes all of the adjoining marshlands bordering Mississippi Sound from the Pearl River to Point Clear (Figure 1.2.2.4.2-1). This saline marsh area includes a historically significant captured relic barrier island (Campbell Island) and an Indian shell midden (Cedar Island) over 1,600 years old. Included within the marshes are several low ridges and small hummocks that are above mean high tide. Most important of these areas are Point Clear Island and Campbell Island, which are sandy areas with characteristics similar to the barrier islands. The islands of this marsh support several rare plant species including one of the rarest shrubs in the U.S., the tiny-leaved buckthorn (*Sageretia minutiflora*), found on the shell midden. The marsh area is also well-known for an abundance of waterfowl.



Source: Corps

Figure 1.2.2.4.2-1. Hancock County Marsh – Hancock County

The largely mesohaline area of Bayou Caddy and Point Clear Island consists of a mosaic of elevation zones bordering both sides of old dune/ridge systems (Point Clear Island and Campbell Island to the west) that are forested (pines, cedar, oak). The Pearl River and associated river swamp are freshwater tidal with bald-cypress (*Taxodium distichum),* blackgum (*Nyssa sylvatica var biflora* and *Nyssa aquatica*) balancing the swamp canopy. This area is experiencing saltwater intrusion as less freshwater inflows from the west due to extensive levee systems of the Mississippi River and smaller systems in Plaquemines Parish in Coastal Louisiana. As the salt tolerance of species in the tidal marshes and seagrasses is exceeded, changes in the food web and reductions in fish and shellfish productivity occur. Also, the yield of estuarine-dependent fisheries, such as shrimp, will be influenced by the quality of the habitat over time.

1.2.3 Riverine System

Riverine systems are bounded on the landward side by upland, by the channel bank, or by wetlands dominated by trees, shrubs, and persistent emergents. Cowardin et al (1979) divides the riverine system into four sub-systems: tidal, lower perennial, upper perennial, and intermittent, two of which are found in Coastal Mississippi. These include freshwater tidal marsh and lower perennial emergent wetlands. Coastal Mississippi's freshwater resources are very important in maintaining healthy aquatic ecosystems and are under continuing urban and industrial development pressure as the population continues to grow and rebuilding efforts are underway. Coastal marshes and forested wetlands located throughout the many freshwater coastal streams play a vital role in the sustainability of Coastal Mississippi for the future. Most rivers cutting through the low-lying coastal plain flow slowly to the sea and deposit their sand-sized sediment in bays and estuaries before reaching the coast. The river's suspended load of finer particles settles out in the sounds and bays that are protected by barrier islands and spits. Freshwater and sediments from these systems are essential to the continued existence of estuaries, marshes, and the species that depend on these habitats for survival. As wetlands continue to degrade or are being filled as development continues, valuable habitat available to support healthy populations of wildlife and marine organisms are lost and are not being effectively replaced. Additionally, water quality suffers due to many point and non-point sources of contamination near the coastal population centers. A comprehensive review and appropriate measures for preservation, restoration, and enhancement of the many components that make-up the diverse and vital coastal ecosystems will ensure sustainability of Coastal Mississippi. Additionally, the wetlands associated with the rivers storage floodwaters, both from the river systems and from storm surge, buffer the upland areas.

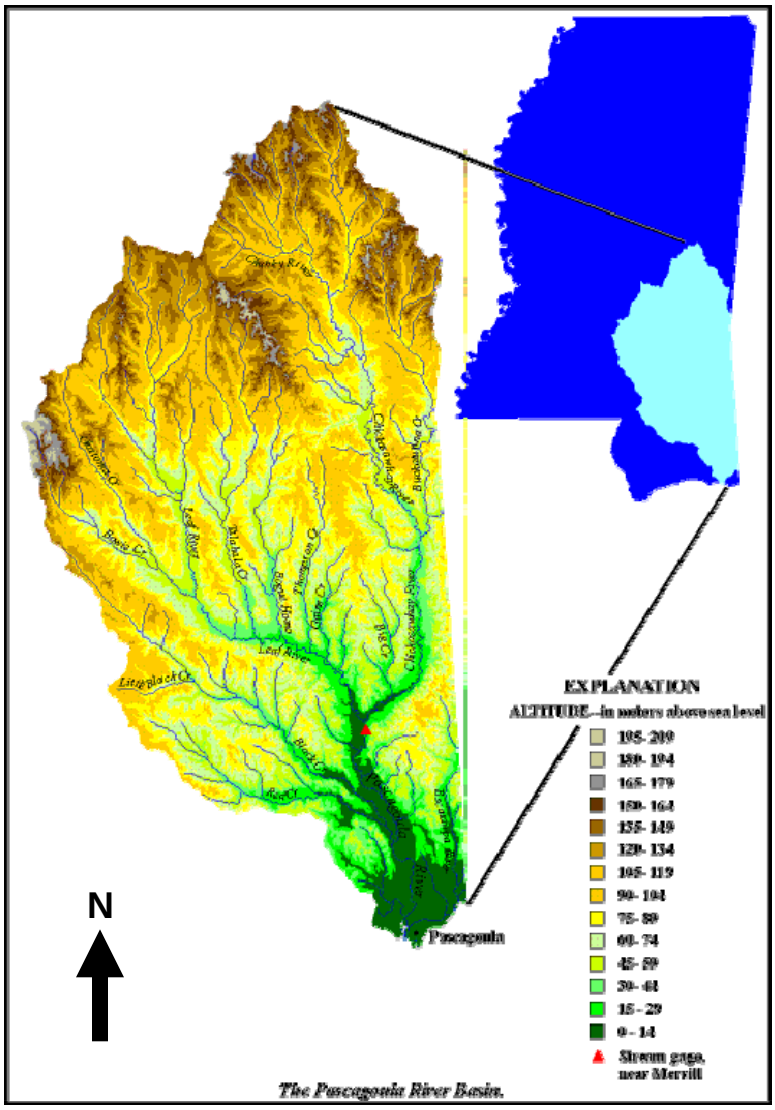
1.2.3.1 Tidal and Lower Perennial Riverine Systems

The USGS lists approximately 10 major drainage basins within the State of Mississippi and of these, two are located within the Coastal Mississippi Study Area (Corps 1984). These two basins include the Pascagoula River and its tributaries within the eastern portion of the state and the Coastal Streams Basin located within Coastal Mississippi. Additionally, the Pearl River makes up the western boundary of the state within Coastal Mississippi.

1.2.3.1.1 Pascagoula River Basin – Jackson County

The Pascagoula River Basin covers an area of about 8,800 m^2 in southeastern Mississippi (Figure 1.2.3.1.1-1). The Pascagoula River is formed by the confluence of the Chickasawhay and the Leaf Rivers. From this confluence, the river flows southward for about 80 miles before emptying into the Gulf of Mexico. Okatoma Creek, a tributary of the Leaf River, is a particular favorite to canoeists. The Escatawpa River, located mostly in Alabama, flows into the Pascagoula River very near the Gulf Coast. Elevations in the Pascagoula River Basin range from sea level to about 650 feet above sea level. About 72% of the basin is forested and about 21% is

agricultural land. Near the coast are low-lying flatlands and marshlands. Farther inland, the landforms consist primarily of low rolling hills and broad, flat flood plains. The economy of the area is based, as it has been since prior to the Civil War, heavily on lumber, the manufacture of wood products, and shipbuilding. The City of Pascagoula on the densely populated Mississippi Gulf Coast is one of the great shipbuilding centers of the world. Tourism, commercial fishing, and oil and gas production are also significant components of the economy in the basin.



Source: USGS

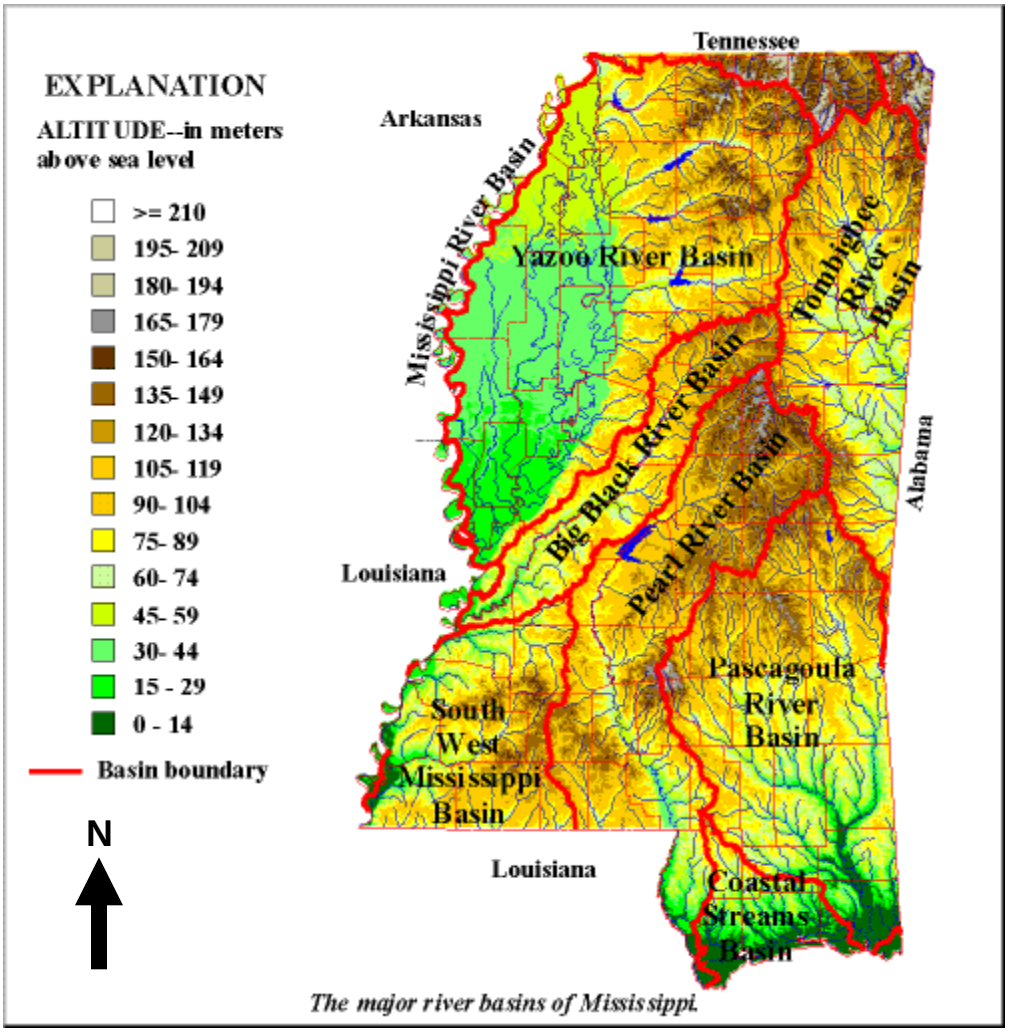
Figure 1.2.3.1.1-1. Pascagoula River Basin

Stream conditions in the Pascagoula River Basin are mostly natural, or unmodified in appearance, and have clear water. Some streams are considered “black-water streams” because they are stained by tannic acid leached from vegetation. Water quality generally is good to excellent with only localized contamination problems. Historically, industrial point sources and urban runoff near major population centers have caused water quality problems. Pascagoula River Basin is critical habitat for Gulf sturgeon and represents critical breeding, migrating, and wintering habitat for 327 additional species of birds.

1.2.3.1.2 Coastal Streams Basin – Harrison County

The Coastal Streams Basin (Figure 1.2.3.1.2-1) covers an area of about 1,650 m^2. Unlike most of the other basins in Mississippi, the streams and creeks do not all flow into a single main stream within the basin. Instead, most of the streams discharge directly into the Gulf of Mexico. Some of the larger streams in the basin include Bayou la Croix, Tuxachanie Creek, and the Tchoutacabouffa, Biloxi, Little Biloxi, Wolf, and Jourdan Rivers. Headwaters for these streams generally are in the northern part of the basin, and the streams discharge into either St. Louis Bay or the Back Bay of Biloxi. Elevations in the Coastal Streams Basin range from sea level to almost 420 feet above sea level. Much of the basin consists of gently rolling to hilly terrain. Silviculture and agriculture are principal uses of the basin. About 74% of the basin is forested, and about 12% is agricultural land. Most industries are located near the larger population centers.

Use of surface water in the Coastal Streams Basin is relatively large. About 300,000 gallons/day are used for irrigation, about 400,000 gallons/day are used for livestock, and about 20 million gallons/per day are used for industry.

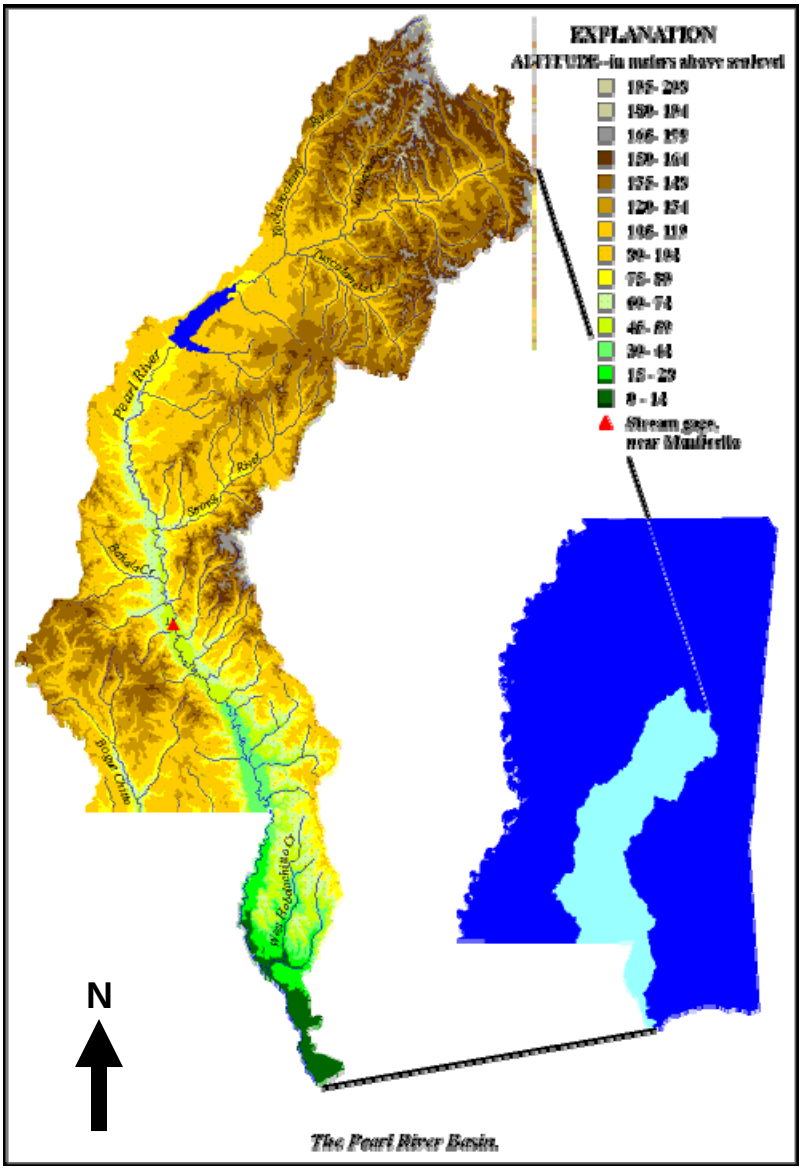


Source: USGS

Figure 1.2.3.1.2-1. Coastal Streams Basin

1.2.3.1.3 Pearl River

The Pearl River Basin covers an area of about 7,800 m^2 (Figure 1.2.3.1.3-1). The headwaters of the Pearl River consist of several tributaries in east-central Mississippi. From there the Pearl River flows southwesterly, forming the boundary between Louisiana and Mississippi in the southern part of the basin, and discharging into the Gulf of Mexico. Near the coast, the river becomes estuarine, bounded by salt marsh and affected by tidal influence.



Source: USGS

Figure 1.2.3.1.3-1. The Pearl River Basin in Mississippi

The Pearl River is about 490 miles long and divides into the Pearl River and the West Pearl River about 50 miles above the mouth. Significant tributaries include the Yockanookany and Strong Rivers. Elevations in the Pearl River Basin range from sea level to almost 700 feet above sea level. Much of the upper two-thirds of the Pearl River Basin consist of gently rolling to hilly terrain. In the southern part of the basin, the land is much flatter. About 65% of the basin is forested, and about 30% is agricultural land. The timber industry and the manufacture of wood products dominate the economy of the lower basin, whereas soybeans and poultry are the major

components of the economy in the upper basin. This is the largest urban area in the State, the Jackson Metropolitan area, is located in this basin.

The flow of the Pearl River near Monticello averages 54,600 gallons/second. However, in the past, flow has been as low as about 2,000 gallons/second and as high as about 913,000 gallons/second. Use of surface water in the Pearl River basin is relatively large. About 1.2 million gallons/day are used for irrigation, about 6.2 million gallons/day are used for livestock, about 30.7 million gallons/day are used for industry, about 220,000 gallons/day are used for sand and gravel mining, and about 33 million gallons/day are used for municipal drinking-water supply.

Turbidity is often high in the upper two-thirds of the Pearl River basin; however, the water quality of streams is generally fair. In the southern third of the basin, streams generally have a fast, deep flow and generally are of fair to good water quality. Water quality impacts occur below Jackson and at Columbia due to point and non-point sources of contamination.

Channel diversions at the lower end of the Pearl River can leave the original river channel near Picayune virtually dry during low-flow conditions. Deforestation and water diversion are major concerns in the portion of the Pearl River basin nearing Coastal Mississippi. Deforestation and lack of streamside management zones increase the occurrence of cut banks and bank erosion contributing unnatural amounts of sediment into the system. Use of pesticides has also created problems with runoff.

1.2.3.2 General Problems in Riverine Systems

Increased development adjacent to streams and rivers and within their floodplains have caused extreme flooding conditions within most watersheds. The storm surge associated with Hurricane Katrina was so severe that it depicted this problem on an extreme scale. An example of this is what happened throughout the Pascagoula River watershed where the limits of the storm surge were seen several miles north of the coastline. Businesses and residences were flooded as far as 30 miles north due to the low elevations found within the watershed. Areas were flooded that had never experienced problems with flooding before. As a result of this, the base flood elevation maps throughout Coastal Mississippi are undergoing changes.

Numerous watersheds within close proximity to the coast and associated connected drainageways are flood hazards due to past development and associated impacts by landuse modification. Additionally, a number of these waterbodies have been determined impaired by the USEPA and MDEQ due to nutrient levels. A prime example of this can be seen in the Turkey Creek watershed. Turkey Creek, a small flowing channel, has been named by MDEQ as an impaired body of water that has been impacted by encroachment, changing landuse patterns, and channel modifications resulting in loss of habitat, flooding, and degradation of a once natural waterway.

Ongoing programs through local waterway citizen groups are in the process of identifying sensitive habitat that is at risk due to negative impacts associated with increased development. This development results in the loss of valuable adjacent wetlands, fragmentation and loss of vital wildlife habitat, loss of channel structure that provides fisheries habitat, and increased sedimentation due to runoff associated with natural landuse modification. Opportunities exist to partner with these waterway user groups (i.e. NGOs) in order to supplement their ongoing efforts of ecosystem restoration and habitat enhancement around these sensitive waterbodies and their associated wetlands, which would help reduce coastal flooding and erosion. A large part of the comprehensive plan will develop the framework needed to build these relationships with local efforts that are underway and gaining momentum.

1.2.3.3 Freshwater Emergent marsh

Freshwater marshes act in many ways like salt marshes, but the biota reflect the increased diversity made possible by the reduction of the salt stress found in saltwater marshes. Plant diversity is high, and more birds use these freshwater marshes than any other marsh type. Because they are inland from the saline parts of the estuary, they are close to urban centers, which make them more prone to human impacts associated with urbanization, runoff, development pressures, etc. The freshwater newly emergent marshes are formed in pro-grading deltas that depend on flooding waters to supply their nutrient needs. One of the challenges facing the sustainability of the freshwater marsh is a lack of sediment from upstream. Also, pollutants from upstream wash downstream, which could cause an eutrophic environment that harms the plants. Lack of sediment hampers natural accretion and causes further erosion and subsidence. Old fill, houseboats, sewage runoff pollution, and erosion further exacerbate the problems. Marshes serve as floodwater retention and over time, the loss of these marshes has contributed to increased flooding throughout the coast, especially in the developed areas south of Interstate-10.

Oyster Bayou is a prime example of what has been described. Oyster Bayou was once a small tributary to Mississippi Sound that meandered through the historic grounds of Jefferson Davis' mansion, known as Beauvoir. As a result of the U.S. Highway 90 construction, development of the Mississippi Coast Coliseum, and many other residential and commercial developments, Oyster Bayou has been degraded and no longer functions as a natural system. Local efforts are currently underway to restore Oyster Bayou; however, additional study/efforts are needed to effectively restore this natural system. Projects like this one provide opportunities for the MsCIP efforts to again partner with local restoration efforts.

Emergent marshes absorb and dissipate wave energy and somewhat reduce storm surge. The Pascagoula River basin received major flooding damage during Hurricane Katrina due to the large storm surge. Even though the tidal range is low, because the inland slope is so slight, freshwater marsh still are tidally influenced but are mostly overridden by wind driven tides and storm runoff. Many species of ducks and waterfowl use these freshwater systems, which are important components of the Mississippi Flyway, the direct route of migrating waterfowl (i.e. their north-south route). Many species use Coastal Mississippi as overwintering grounds for foraging of diverse invertebrates, plant roots, and tubers. These freshwater systems have been designated as critical habitat for the threatened Gulf sturgeon, an anadromous fish that use both the Pearl and Pascagoula River systems for staging, spawning, migration routes, and feeding. The juvenile Gulf sturgeon may spend several years upriver before migrating back to the ocean. This valuable habitat is important for survival of the species. The freshwater marsh serves as havens for shrimp, crabs, etc, during periods of droughts which causes higher salinity within the estuary and salt marshes.

1.2.4 Palustrine System

The palustrine system includes all nontidal wetlands dominated by trees, shrubs, and persistent emergents. It also includes small, shallow, permanent or intermittent waterbodies, such as ponds or coastal plain depressional wetlands. Coastal Mississippi is interlaced with a rich and diverse complex system of vital wetlands that provide floodwater storage, groundwater recharge, water filtering and purification systems, as well as wildlife habitat that include Pine Savannahs, headwater slopes (Bayhead Drain), swamps, and ephemeral pools.

1.2.4.1 Pine Savannah

Pine Savannah wetlands found in Coastal Mississippi provide for diverse habitat for a number of plants and animals including many T&E species found only in these unique habitats. Pine Savannah wetlands are commonly referred to as sponges that provide floodwater retention,

groundwater recharge, and water purification. This wetland habitat is under increased developmental pressures due to the extreme and urgent housing need faced by Mississippians as they are trying to rebuild. This habitat is becoming fragmented and with the increased development, fire maintenance is increasingly harder to perform. Due to the nature of the flat coastal plains with little relief, these lands are some of the first to be considered for housing development. Urbanization and developmental pressure have created what are commonly referred to as forested wetlands. These wetlands are significantly different than what occurred naturally in Pine Savannah habitats. Lack of fire and altered hydrology allow hardwoods, various shrub species, and increased pine basal area to dominate what should be emergent grasses with very few pines in the overstory layer. Fragmentation causes loss of wildlife corridors and contiguous expanses of habitat necessary for continued species existence. Coastal Mississippi has lost over half of its Pine Savannahs due to urbanization throughout the area; thus, creating a threatened ecosystem that in turn is home to many T&E species. Because of the loss of these habitats, the species dependent upon them are increasingly becoming diminished.

1.2.4.2 Depressional Wetlands

A unique depressional wetland type, locally just known as “ponds” exists in the central Gulf coastal plain. Ponds are rain filled by mid-winter, remain high until mid-April, and then drop through October with some drying completely through the heat of the summer. They are typically shallow and flat bottomed. Vegetation changes abruptly from surrounding lands.

Ponds are widespread throughout the southeast but are especially prevalent in the coastal plain because of the flat terrain. Based on substrate which is predominantly citronelle soil-based ponds and are formed through the dissolution and removal of kaolinitic clays from surface rainfalls on a runoff, and shallow seepages. These are naturally occurring and are located in the central Gulf coastal plain from Pearl River County, Mississippi to Okaloosa, Florida. These areas are not afforded protection through the CWA through the Corps’ regulatory program due to isolation rules. These habitats are lost directly by conversion to agriculture and forestry. They are temporarily wet portions of the year and landowners may not realize they exist. Additionally, they’re adversely affected by land management of the adjacent uplands. The resultant changes in hydrology, and management of uplands degrades water quality. Lack of burning also results in tree growth and a reduction of the herbaceous community.

The ephemeral nature of the ponds prevents the persistence of fish, which allows uninhibited use by breeding amphibians. Amphibians have very important functions within the food chains of both aquatic and terrestrial systems. Amphibians consume aquatic vegetation as well as invertebrates and other vertebrates, and in the absence of fish, are usually the top predators in freshwater systems. Consequently amphibians influence the population dynamics of other organisms, as well as the cycling of nutrient and the flow of energy. Concerns have increased about declines and disappearances of the amphibian populations worldwide, with habitat destruction and modification being major causes cited (Wake and Morowitz 1991). These small wetlands are extremely valuable for obtaining biodiversity. Loss causes direct reduction in the connectivity in the remaining species population. They’re also being lost to invasive exotics, such as privet and Chinese Tallow.

1.2.4.3 Headwater Slopes – Seeps, Bayhead Drains

Slope wetlands normally are found where there is a discharge of groundwater to the land surface. They normally occur on sloping lands; elevation gradients may range from steep hillsides to slight slopes. Slope wetlands are usually incapable of depressional storage because they lack the necessary closed contours. Principal water sources are usually groundwater return flow and interflow from surrounding uplands as well as precipitation. Hydrodynamics are dominated by downslope unidirectional waterflow. Slope wetlands can occur in nearly flat

landscapes, if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturation subsurface and surface flows and by evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Changes in hydrology and deforestation and landclearing for development have caused a decline in these type wetlands throughout Coastal Mississippi.

1.2.4.4 Swamps – Bottomland Hardwood, Cypress – Tupelo

Trees in forested wetlands have developed several unique adaptations to the wetland ecosystem, creating what is commonly referred to as swamps. Tree adaptations commonly seen in swamps include cypress knees, wide buttresses and adventitious roots that provide gas transport to the rhizosphere. Swamp primary productivity is closely tied to hydrologic conditions, such as standing water, pulsing hydro-periods, and high water. Swamps have been shown to be nutrient sinks. This is true particularly in studies of nitrogen budget (i.e. farm fields runoff, golf courses, and yards fertilizer) and the swamps have been investigated for their value as nutrient sinks when wastewater is applied. Coastal Mississippi swamps are predominantly vegetated with cypress – tupelo species and bottomland hardwoods, known as river swamps, specifically the Pascagoula River Swamp and the Pearl River Swamp.

1.2.4.4.1 Cypress Tupelo Swamp

Cypress tupelo swamps were once common throughout the southeastern U.S. and only a small portion now remains (Figure 1.2.4.4.1-1). These swamps were abundant throughout the Pascagoula and Pearl River basins but have declined due to extensive logging operations during the late 1800s. Brandt and Ewel (1989) estimated only approximately 10% of cypress tupelo swamps found in pre-settlement times still remain in the U.S., particularly in the southeast including Coastal Mississippi. Removal of these trees created changed conditions, which altered hydrology and converted natural systems into open water and sometimes even mesic forests. When deepwater swamps are drained or when their dry period is extended dramatically, they become invaded by pine or hardwood species, which results in changes to functions of the wetlands. An example of reduced functions would be the loss of water purification, which results in a decline in overall water quality. Historically, farming, community development and urbanization resulted in portions of natural lands becoming developed while communities that thrived around the logging industry, such as Moss Point, Pascagoula, Gautier, and Pearlington, emerged. The remaining swamps continue to be impacted by non-point source runoff from surrounding urbanization. Ongoing logging operations continue to threaten and degrade these coastal swamps. This valuable commodity still exists today. Demands for housing continue to threaten the resource as filling occurs for future development further inland from the coastline and is commonly referred to as urban sprawl.



Source: Corps

Figure 1.2.4.4.1-1. Cypress Tupelo Swamp

1.2.4.4.2 Bottomland hardwood forests

E. P. Odum describes these as an interface of man's most vital resource, mainly water and his living space, the land (1981). Major expanses of riparian ecosystems have been drained and

cleared for agriculture and development. Bottomland hardwood forests are generally low-lying flat extensive floodplain swamps with strong seasonal hydrologic pulses with well developed soils.



Source: Corps

Figure 1.2.4.4.2-1. Bottomland Hardwood Forests

Bottomland hardwood forests provide floodwater retention and are valuable for many animals that seek its refuge, diversity of habitat, and abundant water, or that use it as a corridor for migration (Figure 1.2.4.4.2-1). The bottomland hardwood is an essential component of the Mississippi Coastal Birding Trail, ecotourism in South Mississippi that is part of the National Audubon Society. These areas are crucial for supporting neo-tropical migrant species. Protecting habitat produces more eco-tourism dollars. One of the major attractions and highly used sites exist along the Pascagoula River swamp, especially on the Lower Pascagoula Wildlife Management Area. The bird watching industry is large in the country and is growing in popularity. This area is part of the global network of Important Bird Areas. As these habitats are altered, filled, or destroyed, this ecosystem becomes fragmented causing decreases in populations of the dependent species. Increased flooding to nearby communities and residential development leads to further channelization to streams throughout the developed area, which creates further habitat destruction and fragmentation causing species to further decline. Thus, reduced breeding habitat and wintering habitat along with threats during migration, predation, or competition from other species, such as exotics and possible contaminants, such as direct exposure to chemicals, further negatively impact these habitats. It has been estimated that approximately $104 billion dollars are spent in the U.S. on eco-tourism per year (USFWS 2001a). In comparison, we, as a nation, only spent $88 billion on new car sales.

1.2.5 Upland Forests

Coastal Mississippi upland forests are comprised of pine plantations, mixed pine hardwood, and maritime forests. Healthy forests are an important resource in the southeastern U.S. They provide clean air, jobs, recreation, tourism, healthy habitats for wildlife, and construction materials for homes. Coastal Mississippi has abundant uplands forests and some of those areas are owned by the USDA Forest Service. However, the majority of uplands forests are privately owned. The USDA Forest Service uses numerous practices to restore the health of the South's forests, such as thinning forests to reduce the risk of devastating diseases and insects from both private and public forestlands. The South's forests are different from those of 200 years ago and they continue to change. Urbanization, the absence of fire, harvesting, fragmentation, forest ownership, and forest uses are but a few components of this change. Current threats to upland forests in Coastal Mississippi are urbanization, lack of fire management, and harvesting of timber.

Maritime forests are located primarily along the coastline, coastal ridges, and on the barrier islands and are predominantly vegetated with live oaks, southern magnolia, redbay, yaupon, saw palmetto, and Spanish moss. These forests act as a barrier between the mainland and the sea because of their great tolerance of salt spray. This absorbs the salt spray before it can reach more sensitive species found further inland. Live oaks are disease resistant and are very dense, which helps them to stand up to hurricane winds. The live oak forests, historically referred to as

Naval Live Oaks were harvested in early naval vessel construction during the 1800s. When migratory birds fly from South and Central Americas, this forest is important habitat because it is the first land the birds reach for several hundred miles. Migratory birds stop here to rest before continuing their migration northward.

The majority of upland forests in Coastal Mississippi is comprised of the mixed pine hardwood forest. These are widespread throughout and are under increased pressure due to urban sprawl as more and more residential and commercial ventures are developed. These forests are a result of past logging operations that changed the natural succession of native forests forever. They provide good hard mast for several species of wildlife including the Louisiana Black Bear, a federally listed threatened species.

An unnatural forest found throughout Coastal Mississippi consists of pine plantations, which are planted for harvesting. This is an agriculturally regulated crop throughout the southeast. Intensive pine plantation management practices are aimed at short rotation (12 or 15 years or less) and managed intensively with herbicides and fertilizers for maximum production for pulpwood and paper. These areas also require an intense site preparation to clear debris for planting, control residual vegetation, and to improve drainage. This often results in excessive sedimentation, changes in hydrology and non-point source pollution that includes runoff from herbicide treatments and fertilization. The areas frequently experience heavily compacted soils with fragipan development, which permanently alters the sites. Natural forests are lost to pine plantations and are planted with loblolly pines, a non-native plant. As a result of Hurricane Katrina and the associated losses of loblolly pines, studies were conducted that proved the native Longleaf was able to withstand higher winds and more people are becoming interested in planting this native species. This practice would be more beneficial even within a non-natural plantation setting.

1.3 Fauna

Many species of invertebrates and vertebrates make up the various fauna population along the Gulf coast. Invertebrate populations in Mississippi Sound and the nearshore area of the Gulf of Mexico transfer energy through the coastal food web. Microscopic estuarine zooplankton live throughout the water column with limited mobility. Larval stages of benthic forms and eggs and larval stages of many fish species are often interspersed throughout zooplankton. Many important commercial species feed upon zooplankton.

Vittor and Associates (1982) investigated the macrofauna of Mississippi Sound and selected areas in the Gulf of Mexico. Over 532 taxa from offshore Mississippi and Alabama and 437 taxa from the Mississippi Sound were identified. Densities of individuals varied from 910 to 19,536 individual/ yard^2 for the offshore and 1,200 and 38,863 individual/ yard^2 for the Sound area. Abundance of macrofauna is temporal with greatest densities occurring from fall to spring.

Oyster production in Mississippi depends on public reefs managed by the MDMR. The State of Mississippi accounts for about 13% to 17% of Gulf oyster landings. Reefs are located along the coast across the entire state with the largest reefs near the western boundary. According to a 1966 survey by W.J. Demoran, there were 9,934 acres of oysters. At that time, there were 582 acres of planted oyster beds. Additional acreage has been planted. A few small areas of oyster bottom have been leased for private development; however, production from these areas has been negligible. There have been considerable annual variations in size of productive areas due to natural ecological fluctuations, such as freshwater flow into the oyster beds. Many of Jackson County's most productive areas have been closed to harvest due to increased pollution associated with coastal development.

Many commercially important species of crustaceans are harvested in Mississippi Sound and the nearshore of the Gulf of Mexico. Brown shrimp (*Penaeus aztecus*) is the main shrimp species

harvested by commercial fishermen in the Gulf of Mexico and is the most important commercial species in the Mississippi Sound and Mobile Bay area. White shrimp and blue crab are also harvested within the study area. In addition to those commercial species, there is a very diverse community of crustaceans within Mississippi Sound and adjacent waters including a wide variety of forms and habitat preferences. Epibenthic crustaceans dominate the diet of flounder, catfish, croaker, porgy, and drum.

Christmas and Waller (1973) reported 138 fish species in 98 genera and 52 families taken from areas across Mississippi Sound. The major fisheries landed along the Mississippi Gulf coast are anchovies, menhaden, mullet, croakers, shrimp, and oyster. Jackson County, primarily the ports of Pascagoula and Moss Point, receives greater than 85% of all Mississippi landings, including all industrial fish (menhaden), 95% of the mullet, trout, and red snapper, and 74% of the croaker landed (Corps 1992).

The Cooperative Gulf of Mexico Estuarine Inventory and Study (GMEI) observed 251 fish species in its estuarine study area from a list of 294 fish species from Mississippi estuaries and continental shelf waters off Mississippi (Christmas and Waller 1973). The bay anchovy (*Anchoa mitchilli*), Gulf menhaden (*Brevoortia patronus*), Atlantic croaker (*Micropogon undulates*), spot (*Leiostomus xanthurus*), butterfish (*Perilus burti*), and sand seatrout (*Cynoscion areanarius*) composed 93 percent of the total number of fish collected. Over 93 percent of the fish caught were in the families *Engraulidae* (bay anchovy), *Clupeidae* (Gulf menhaden), and *Sciaenidae* (seatrout and spot).

The finfish industry in Mississippi is composed of two segments: menhaden and edible finfish (Posadas 2001). The state's menhaden industry is centered in Pascagoula and is responsible for Mississippi's fifth-place national ranking in total pounds of seafood landed. The Gulf fishing fleet contains approximately 50 large vessels owned by individual processing firms. Mississippi is a very small producer of edible finfish obtained commercially, with fewer than 30 individuals participating full-time (Posadas 2001). More than 300 commercial licenses are sold annually for the harvest of edible finfish, however, indicating many part-time participants. In addition, trawlers catch foodfish incidental to shrimping and industrial fishing. Total foodfish landings average about one million pounds annually.

The blue crab, *Callinectes sapidus*, and its smaller cogener, the Gulf crab, *Callinectes similes*, are abundant in Mississippi coastal waters. About 200 commercial crab licenses are sold annually in Mississippi, but only about 60 fishermen trap crabs. The other licenses are sold to allow for incidental harvest in other fisheries.

Annual landings from 1972 to 1992 averaged 1,378,831 pounds. Average annual landings from 1993 through 2000 declined markedly to 524,383 pounds; however, the reduced landings can be attributed to social, economic, and regulatory changes that have taken place in the fishery rather than major declines in stock abundance. The average number of blue crab trappers declined from 61 during the 1970s and 1980s to 42 during the 1990s (Guillory 2001). These accounts of the landings do not include crabs taken in local waters and landed in neighboring states, nor those taken on a subsistence or recreational basis.

While seafood landings in Mississippi are significant, the bulk of economic activity is generated by the processing sector. Much of the seafood processed in Mississippi is landed in other Gulf states. There are 32 processing plants and 22 wholesale operations in Mississippi, employing about 1,300 people. A study by Mississippi State University's Coastal Research and Extension Center documents the total economic impact of the Mississippi seafood industry: $489 million annually, including $256 million in income and about 28,000 man-years of employment (Posadas 2001).

Coastal wetlands of Mississippi Sound, St. Louis Bay, Biloxi Bay, Pascagoula Bay, and the tidal Pascagoula River provide the resource base for commercial and marine recreational fishing and

tourism in Mississippi. The dockside value of commercial fish landings in Mississippi was almost $42 million in 1995. Recreational fisheries also play an important role in the state's economy. In 1991, 500,000 people spent more than $236 million fishing in Mississippi's waters, generating almost $14 million in state sales tax, resulting in $131 million in earnings, and supporting more than 8,000 jobs. Approximately one-quarter of the recreational fishing occurs in coastal waters. Communities such as Moss Point, Pascagoula, Gautier, Ocean Springs, Biloxi, Long Beach, Gulfport, Pass Christian and Bay St. Louis all depend on fishing to support their local economies (NOAA 2002).

Coastal Mississippi supports an array of reptiles, amphibians, birds, and mammals. Reptiles and amphibians found in the area include snakes, turtles, lizards, toads, frogs, salamanders, and crocodilians. Coastal Alabama and Mississippi have a great diversity of reptiles including 23 species of turtles, 10 species of lizards, 39 species of snakes, and the alligator. Eighteen species of salamanders and 22 species of frogs and toads are indigenous to the coastal region.

Mammals found within the area include marsupials, moles and shrews, bats, armadillos, rabbits, rodents, carnivores, even-toed hoofed mammals, and dolphins. Mammals occur within all habitats of the system, using underground burrows, the soil surface, vegetative strata, the air, and the water for feeding, resting, breeding, and bearing and rearing young. There are 57 species of mammals found in the area. Several species of mammals include the raccoon, river otter, gray fox, striped skunk, mink, whitetailed deer, bottlenose dolphin, beaver, possum, and nine-banded armadillo. A number of whales are known to occur offshore Mississippi and Alabama and occasionally are sighted within the Mississippi Sound.

Over 300 species of birds have been reported as migratory or permanent residents within the area, several of which breed there as well. Shorebirds include osprey, great blue heron, great egret, piping plover, sandpiper, gulls, brown and white pelicans, American oystercatcher, and terns. Birds of the area eat a great variety of foods, are also food to many predators, and exhibit a diversity of nesting behaviors.

On September 9, 2005, within 2 weeks after Hurricane Katrina struck coastal Mississippi, the U.S. Commerce Secretary announced a formal determination of a fishery failure in the Gulf of Mexico due to the devastation. This declaration was in response to a virtual fishery shutdown in the affected states, including Mississippi, due to major flooding, damage to fishing boats and fishing ports, waterways clogged with debris and closed processing facilities. This action was made through provision of the Magnuson-Stevens Fishery Conservation and Management Act, which makes Federal relief funds available to assess the impacts, restore the fisheries, prevent future failure and assist fishing communities' recovery efforts. The Administration is working with Congress and the State to identify on-the-ground needs and develop an emergency plan to meet those needs.

Environmental monitoring including analyses of fish, water, and sediment samples collected from coastal waters of the Mississippi has begun by Federal and State resource agencies including the MDMR, MDEQ, PRD and HCD of NOAA, USEPA, the Food and Drug Agency, and others. Toxicology surveys taken from Gulf of Mexico waters, marine species, and sediment samples, after Hurricane Katrina have determined no elevated toxins of bacteria exist and NOAA has stated no cause for concern. The samples were tested for toxins that might have been released into the marine ecosystem after hurricane flooding, such as pesticides and fire retardants, and results have shown all levels are well below Federal guidelines for safe seafood consumption. The samples were tested for potential bacteria such as *E. coli* and none harbored the bacteria. The presence of *Vibrio* bacteria was found as expected and all fish, crab, and shrimp should be thoroughly cooked prior to consumption as recommended by the Food and Drug Agency. It has been concluded that Gulf seafood was deemed safe for human consumption; NOAA is continuing its sampling program to detect potential trends or changes that might occur over time.

NOAA recently completed a survey which depicts that Hurricane Katrina did not cause a reduction in fish and shrimp populations in offshore areas for the Gulf of Mexico. Additionally, NOAA annual surveys of shrimp and bottomfish, completed in November 2006, shows some species, such as the commercially valuable and overfished red snapper, to have a higher population in 2005 than the average populations between 1972 and 2004 which could be a result of the reduction in fishing activities in the Gulf of Mexico since Hurricane Katrina. NOAA will continue to monitor potential population changes due to damaged habitats, nursery areas and wetlands.

Oyster reefs have been seriously impacted by Hurricane Katrina and all reefs in coastal Mississippi will remain closed until further notice. Many boats were damaged or lost, and many processing facilities were damaged or destroyed. There are signs the reefs are beginning some of the healing processes on their own; however, much work will be needed to restore the oyster reefs to their former prime condition. Extensive sampling of the reefs is currently being conducted by the MDMR to provide information needed to plan extensive long-term recovery activities. Initial assessments of the reef conditions are underway but at present, are incomplete. Conditions of the reefs are highly variable. Generally, offshore areas were heavily scoured. Recent very heavy oyster spat set (less than one inch in length) was found in some of these areas with no spat set in other areas. Some light SAVs, marsh grass and drift wood were found. Inshore reefs generally had moderate to very low numbers of live oysters in some areas with other areas revealing no live oysters. Some of these areas had a good recent oyster spat set, typically lower than the offshore reefs (MDMR Press Release September 23, 2005).

Greater amounts of debris were found closer to shore than in the offshore areas and consisted of housing materials, such as lumber, siding and wire screens, SAVs, marsh grass, roots, twigs, pine needles, branches, palmetto and other leaves. Some oysters were found to be spawning. Deep gullies and holes were cut into the waterbottoms in many places by the extreme currents of Hurricane Katrina. Mud also covered many of the samples collected both inshore and offshore. Dredging proved to be very difficult due to the amount of debris in the water and reef contours having changed (MDMR Press Release September 23, 2005).

The initial assessments indicate that a majority of the commercial oyster resource and substrate have been scoured away, buried by sedimentation and debris, or moved. Additional assessments will be conducted by MDMR to better define the extent of loss of oyster resource or habitat. Cooperation from all parties is vital for reconstruction and revitalization of the Mississippi Oyster Program and reefs. Assistance has been received and additional assistance is expected from many local, state, and federal agencies in order to develop programs to involve the oyster fishermen and industry in this recovery effort.

1.4 Federal T&E Species and Their Critical Habitats

1.4.1 Baseline Conditions

Coastal Mississippi is home to 20 federally listed T&E, or candidate species. Federally listed species known to occur within the project area are shown on Table 1.4.1-1. Several other T&E species are known from marine habitats in the Gulf of Mexico. These species are blue whale (*Balaenoptera musculus*), finback whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), Sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), hawksbill sea turtle (*Eretmochelys imbricata*), and leatherback sea turtle (*Dermochelys coriacea*). These T&E marine species might be occasional visitors to the project area.

Table 1.4.1-1.
Federally Listed Rare T&E Species

Common Name	Scientific Name	Status	County	Habitat
Alabama red-bellied turtle	*Pseudemys alabamensis*	LE	Harrison, Jackson	Submerged aquatic vegetation in brackish coastal rivers; freshwater reaches
Black pine snake	*Pituophis melanoleucus ssp. lodingi*	C	Harrison, Jackson	Fire-dependent, upland longleaf pine forests
Brown pelican	*Pelecanus occidentalis*	LE	Hancock, Harrison, Jackson	Feeds over water in coastal areas, nests on small islands.
Eastern indigo snake	*Drymarchon corais couperi*	LT	Harrison, Jackson	Fire-dependent, upland longleaf pine forests
Gopher tortoise	*Gopherus polyphemus*	LT	Hancock, Harrison, Jackson	Fire-dependent, upland longleaf pine forests
Green sea turtle	*Chelonia mydas*	LT	Hancock, Harrison, Jackson	Shallow coastal waters with SAV and algae, nests on open beaches.
Gulf sturgeon	*Acipenser oxyrhynchus desotoi*	LT	Hancock, Harrison, Jackson	Migrates from large coastal rivers to coastal bays and estuaries
Inflated Heelsplitter	*Potamilus inflatus*	LT	Harrison	Soft, stable substrata in slow to moderate currents of tributaries and large rivers
Kemp's Ridley sea turtle	*Lepidochelys kempii*	LE	Hancock, Harrison, Jackson	Nearshore and inshore coastal waters, often in salt marshes
Loggerhead sea turtle	*Caretta caretta*	LT	Hancock, Harrison, Jackson	Open ocean; also inshore areas, bays, salt marshes, ship channels, and mouths of large rivers
Louisiana black bear	*Ursus americanus luteolus*	LT	Hancock, Harrison, Jackson	Bottomland hardwood forest; frequently ranges into other habitats
Louisiana quillwort	*Isoetes louisianensis*	LE	Hancock, Harrison, Jackson	Small blackwater streams with sand and gravel substrate and forest cover
Manatee	*Trichechus manatus*	LE	Hancock, Harrison, Jackson	Fresh and salt water in large coastal rivers, bays and estuaries.
Mississippi gopher frog	*Rana capito sevosa*	LE	Harrison, Jackson	Fire-dependent, upland longleaf pine forests; open, ephemeral upland pools
Mississippi sandhill crane	*Grus canadensis pulla*	LE	Jackson	Wet pine savannah
Pearl darter (Pascagoula River System)	*Percina aurora*	C	Jackson	Rivers and large creeks with sand and gravel bottoms and flowing water.
Piping Plover	*Charadrius melodus*	LT	Hancock, Harrison, Jackson	Barrier islands and coastal beaches
Red-cockaded woodpecker	*Picoides borealis*	LE	Harrison, Jackson	Fire-dependent, upland longleaf pine forests
Yellow-blotched map turtle	*Graptemys flavimaculata*	LT	Jackson	Rivers and large creeks with habitat suitable for basking

LT = listed threatened, LE = listed endangered, C = candidate for listing, PE = proposed endangered
Source: Mann, 2000. Bald eagle was delisted from threatened in August 9, 2007.

1.4.1.1 Alabama Red-bellied Turtle

The Alabama red-bellied turtle (*P. seudemys alabamensis*) is a relatively large freshwater turtle with a carapace (top shell) length of up to 13 inches (Figure 1.4.1.1-1). The plastron (bottom shell) is orange to red in color; the carapace is olive green, brown, or black, accompanied by

distinct vertical markings in yellow, orange or red. The Alabama red-bellied turtle is distinguished from other similar species by the stripes of color on its head, and also the shape of the upper jaw (USFWS 1989). This turtle primarily feeds on aquatic plants and is most common in sluggish bays and bayous in brackish marshes adjacent to the main channels of large coastal rivers (Mann 2001). In Alabama, the turtle is known from the lower reaches of the Alabama River and its tributaries in Baldwin and Mobile Counties. In Mississippi, recent surveys have located Alabama red-bellied turtles in the lower reaches of the Old Ft. Bayou, Escatawpa, and Pascagoula Rivers in Jackson County, and Tchoutacabouffa and Biloxi Rivers in Harrison County (Mann 2001).



Source: USFWS

Figure 1.4.1.1-1. Alabama Red-Bellied Turtle Photograph

This turtle was listed as endangered by the USFWS on 16 June 1987; it is threatened by low reproductive success and taking of adult turtles. Although adult turtles spend most of their time feeding and basking in SAV, they must return to land to lay eggs. Disturbance of nests and destruction of eggs has been identified as major threats to the population; local residents collect eggs and live turtles for food. Recreational use of natural sand beaches have also disturbed nests and dredged material areas, such as Gravine Island in Alabama (USFWS 1989). Feral pigs, crows, and fire ants also raid nests to eat turtle eggs. Some collection of these turtles for the pet trade still persists, as does trawling to collect turtles for food. Some turtles are harvested accidentally by commercial fishermen in nets, traps, and trawls. Recovery efforts include learning more about the life history of the species; protecting nests in recreational areas; preventing destruction of aquatic vegetation used for basking, cover, and food; preventing taking of eggs and adult turtles through law enforcement; and educating the public about turtle conservation.

1.4.1.2 Black Pine Snake

The black pine snake (*P. melanoleucus lodingi*) is one of 15 subspecies of a widespread snake species commonly called bullsnake or gopher snake (Figure 1.4.1.2-1). This non-venomous snake with black or dark brown scales and a reddish or white snout can grow up to 8.3 feet in length (Jordan 1998). Black pine snakes feed on small mammals, but will also take other vertebrates, such as birds, lizards and other snakes. The black pine snake was once known in longleaf pine forests from extreme southeastern Louisiana, east to southern Mississippi, to extreme southwestern Alabama (Jordan 1998). Recent surveys have found the highest concentration of black pine snakes in DeSoto National Forest in Mississippi, including habitat in Harrison County (USFWS 2001b). The snakes are known from eight other Mississippi counties and three counties in Alabama. Black pine snake is believed to be extirpated from Louisiana

(Natureserve 2001a), and has been listed as a candidate for protection under the Endangered Species Act.



Source: USFWS

Figure 1.4.1.2-1. Black Pine Snake Photograph

Black pine snakes require well-drained, upland longleaf pine forest with few shrubs and abundant herbaceous vegetation. Historically, these conditions were maintained with frequent wildfires. Longleaf pine forests were once abundant in the southeastern U.S., but have been reduced to less than 5% of their former range (USFWS 2001b). Degradation, fragmentation, and fire suppression of upland longleaf forests is thought to be responsible for the decline of black pine snakes (Natureserve 2001a). Conversion of upland habitats to urban development, agriculture, and pine plantation have made habitat unsuitable for the species. Pine snakes avoid forests with a dense mid-story shrub layer, which is often the result of fire suppression (USFWS 2001b). There is evidence that the snakes use the underground portions of rotting pine stumps for shelter. Modern forestry practices that remove stumps and downed trees before replanting threaten the survival of black pine snakes (Natureserve 2001a). Direct human impacts such as roadkill, shooting, and collecting black pine snakes for the pet trade are thought to be significant threats to the snake's survival (USFWS 2001b).

1.4.1.3 Brown Pelican

The brown pelican (*P. occidentalis*) is a large brown and gray seabird with a characteristic long bill attached to an expandable pouch used for capturing prey (Figure 1.4.1.3-1). Brown pelicans can reach up to 8 pounds and have wingspans of more than 7 feet (USFWS 2001c). These birds are known from marine environments in coastal areas of the U.S.; they feed by diving for small fish. Breeding pairs use small coastal islands for nesting, building nests in trees or on the ground. The brown pelican suffered dramatic population losses during the middle of the 20th century because DDT poisoning impaired reproductive success. Since DDT use was banned in the U.S., brown pelican populations have increased or stabilized. In the Southeastern U.S., the brown pelican is considered endangered only in Mississippi and Louisiana (USFWS 2001c). Threats to brown pelicans include disturbance of nesting colonies, entanglement in fishing gear, oil and toxic chemical spills, severe storms, heavy tick infestations, and unpredictable food availability (USFWS 2001c).



Source: USFWS

Figure 1.4.1.3-1. Brown Pelican Photograph

1.4.1.4 Eastern Indigo Snake

The Eastern indigo snake (*D. corais couperi*) is a large constrictor, usually 5 to 7 feet in length, with a heavy black body and red or orange on the chin and throat (Figure 1.4.1.4-1). This snake actively forages along wetland edges to feed on rodents, birds, reptiles, and amphibians. In coastal Mississippi, Eastern indigo snakes prefer high, dry, mature pinelands dominated by longleaf pine
(*P. palustris*), wiregrass (*Aristida stricta*), and turkey oak (*Q. laevis*). They are often found in association with gopher tortoises, using gopher tortoise burrows for shelter. The species is most abundant in peninsular Florida and south Georgia, although scattered populations persist in coastal Mississippi, Alabama, the Florida panhandle, and coastal South Carolina (Natureserve 2001b).



Source: USFWS

Figure 1.4.1.4-1. Eastern Indigo Snake Photograph

The eastern indigo snake is listed threatened by the USFWS. Species decline is thought to be directly related to the loss of mature longleaf pine forest in the Southeast coastal plain. Much of this habitat has been converted to pine plantation stocked with species other than longleaf pine. In other areas, fire suppression has allowed hardwood trees to invade and become dominant in former mature longleaf pine forests. The decline in the Eastern indigo snake may also be related to the decline in the gopher tortoise. Fewer gopher tortoises create fewer burrows, reducing shelter for the Eastern indigo snake as well as many other vertebrates and invertebrates. Research indicates that Eastern indigo snakes might require large areas of contiguous habitat in excess of 10,000 acres in order to thrive. Efforts are underway to restore longleaf pine forests in the southeastern U.S. and maintain these areas with prescribed fire. Commercial collection of these snakes for the pet trade (now illegal) has also caused the species to decline. However, Eastern indigo snakes are able to reproduce in captivity, which might facilitate captive breeding programs to reintroduce the species to appropriate habitat (Natureserve 2001b).

1.4.1.5 Gopher Tortoise

The gopher tortoise (*G. polyphemus*) is a terrestrial turtle with a carapace (top shell) length between 12 to 24 inches (USFWS 1990a). The carapace is dark brown to gray-black, and often worn smooth from moving through the deep burrows it digs for shelter (Figure 1.4.1.5-1). The gopher tortoise is found in the southeastern coastal plain from Louisiana to South Carolina, although it is rare and scattered throughout its range. Gopher tortoises can live for several decades. Depending on habitat quality, it may take between 10 and 20 years for tortoises to become sexually mature. Egg laying and nesting takes place in the spring months. Clutch size is usually between 5 and 9 eggs. Nest predation is high, with roughly 90 percent of gopher tortoise nests destroyed by predators such as raccoons, armadillos, and opossums. Predation on hatchling tortoises is also very high. Research indicates that hatchling mortality rates of more than 90 percent are not unusual (Natureserve 2001c).



Source: USFWS

Figure 1.4.1.5-1. Gopher Tortoise Photograph

Gopher tortoises are found in a variety of upland habitats. The best tortoise habitat consists of open upland woodlands with well-drained sandy soils suitable for easy burrowing. An open tree canopy lets in sunlight necessary for the growth of grasses and herbaceous plants on which the gopher tortoise feeds (USFWS 1990a). Sunlight is thought to be necessary for tortoise basking thermoregulation, and also for egg incubation while nesting (Natureserve 2001c). Periodic low-intensity fires have been observed to be beneficial to maintaining gopher tortoise habitat. In the western part of its range, including Mississippi, gopher tortoises inhabit xeric longleaf pine–scrub oak forests located on sand ridges. They may also found on the edges of crop fields, in pastures, and power line right-of-ways (USFWS 1990a).

The gopher tortoise has been listed threatened by the USFWS. The species population has undergone an 80 percent decline in the past 100 years (Natureserve 2001c). Decline is expected to continue because of habitat elimination and fragmentation. In the early 20th Century, gopher tortoises were collected for food. This problem has decreased, although tortoises continue to be adversely impacted by rattlesnake collectors who pour toxic substances down gopher tortoise burrows in order to flush out resident rattlesnakes. Road kill is also a persistent problem for adult turtles (Puckett and Franz 2001). The most frequently cited reason for gopher tortoise decline throughout its range is loss of habitat. Conversion of pinelands to agricultural lands has reduced

gopher tortoise habitat in Mississippi (Natureserve 2001c). Fire suppression in longleaf pine natural communities has resulted in an increase in shrub cover and a decrease in herbs and grasses used for food. Throughout its range, conversion of open woodlands to dense slash pine plantation monocultures has eliminated large tracts of suitable habitat. In Florida, urbanization has also eliminated gopher tortoises and tortoise habitat.

1.4.1.6 Green Sea Turtle

The green sea turtle (*C. mydas*) was listed on July 28, 1978. The breeding population off Florida and the Pacific coast of Mexico is listed as endangered while all others are threatened (NOAA 2001). Green sea turtles range throughout the Atlantic, Pacific, and Indian Oceans, primarily in tropical regions and shallow waters (except during migration), inside reefs, bays, and inlets. The green sea turtles are attracted to lagoons and shoals with abundant marine grass and algae on which the turtles feed.

Green sea turtles have been observed in the Mississippi Sound (Figure 1.4.1.6-1). In fact, a juvenile green sea turtle was captured in the mouth of Back Bay of Biloxi several years ago (Mann 2000, Mann, T. 2003. Personal comm.). The turtles are not known to nest on the Mississippi coast or barrier islands, but might be attracted to seagrass beds as a food source in nearshore waters (Gunter 1981).



Source: USFWS

Figure 1.4.1.6-1. Green Sea Turtle Photograph

Exploitation of green sea turtle nesting grounds either by human interference or pollution poses the greatest threat to these turtles. The greatest cause of decline in green turtle populations is commercial harvest for eggs and food in nesting areas outside the U.S. Incidental catch during commercial shrimp trawling is a continuing source of mortality that adversely affects recovery in North America (NOAA 2001). Today, turtle excluder devices (TEDs) pulled by shrimp boats help reduce mortality from net entanglement.

1.4.1.7 Gulf Sturgeon

The Gulf sturgeon (*A. oxyrhynchus desotoi*) was listed throughout its range as a threatened subspecies on September 30, 1991. The Gulf sturgeon, considered a subspecies of the Atlantic

sturgeon *(A. oxyrhynchus)*, is an anadromous fish, migrating from saltwater into large coastal rivers (Figure 1.4.1.7-1). Historically, the Gulf sturgeon occurred in rivers from the Mississippi River to the Suwannee River, and in bays and estuaries from Florida to Louisiana. Little is known about current population levels outside the Suwannee, Apalachicola and Pearl Rivers, but they are thought to have declined from historic levels.



Source: USFWS

Figure 1.4.1.7-1. Gulf Sturgeon Photograph

Adult fish spend 8 to 9 months each year in rivers and 3 to 4 of the coolest months in estuarine Gulf rivers. In the Suwannee River, adult sturgeons frequent areas near the mouths of springs and cool water rivers during the summer months. Adult fish tend to congregate in deeper waters of rivers with moderate currents and sandy and rocky bottoms. Seagrass beds with mud and sand substrates appear to be important marine habitats (Mason and Clugston 1993). The adult Gulf sturgeon is known to spend the fall and winter months in the estuary of Mississippi Sound and migration routes extend from the Sound to the Back Bay of Biloxi. Occurrences of the Gulf sturgeon have been documented within Mississippi Sound, Biloxi River, and Pascagoula River area. The Gulf sturgeon is known to spawn in the Pearl River system. Major threats to this rare, primitive species include physical barriers (e.g., locks and dams) to spawning grounds, habitat loss, and poor water quality.

On March 19, 2003, USFWS and NOAA designated 14 geographic areas among the Gulf of Mexico rivers and tributaries as critical habitat for the Gulf sturgeon (FR Vol. 68, No. 53). These 14 geographic areas encompass approximately 1,739 river miles and 2,333 square miles of estuarine and marine habitat. In Mississippi, the critical habitat includes 392 kilometers of the Pearl River, including Bogue Chitto, and 126 miles of the Pascagoula River, including the Leaf, Bouie, Chickasawhay, and Big Black Creek tributaries (FR Vol. 68, No. 53).

1.4.1.8 Inflated Heelsplitter

The inflated heelsplitter (*P. inflatus*), also known as the Alabama heelsplitter, was listed was listed as threatened throughout its range on September 28, 1990 (Figure 1.4.1.8-1). The inflated heelsplitter is a large freshwater mussel with a brown to black shell with green rays in young individuals (USFWS 1993). Like other freshwater mussels, the inflated heelsplitter feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton. The diet of inflated heelsplitter, like other freshwater mussels, comprises water (until encysted on a fish host) and fish body fluids (once encysted). The preferred habitat of this species is soft, stable substrata in slow to moderate currents. It has been found in sand, mud, silt and sandy-gravel, but not in large or armored gravel. It is usually collected on the protected side of bars and may occur in depths over 20 feet. The occurrence of this species in silt does not necessarily indicate that the species can be successful in that substratum. Adult mussels may survive limited amounts of silt, whereas juveniles would suffocate. In addition, it is possible that the species was established in an area

prior to deposition of the silt (USFWS 1993). George et al (1996) documented this species in the Lower Pearl River in 1996.



Source: USFWS

Figure 1.4.1.8-1. Inflated Heelsplitter

1.4.1.9 Kemp's Ridley Sea Turtle

The Kemp's Ridley sea turtle *(L. kempii)* was listed as endangered throughout its range (Gulf of Mexico and Atlantic Ocean) on December 2, 1970, and its status has remained unchanged (Figure 1.4.1.9-1). The Kemp's Ridley population has declined since 1947 (when an estimated 42,000 females nested in one day) to a nesting population of approximately 1,000 in the mid-1980s. The decline of this species was primarily due to human activities including collection of eggs, fishing for juveniles and adults, killing adults for meat and other products, and direct take for indigenous use. In addition to these sources of mortality, Kemp's Ridley sea turtles have been subject to high levels of incidental take by shrimp trawlers. Kemp's Ridley turtles are occasionally caught on fishing hooks and incidentally injured by recreational anglers and boaters (Mann personal communication, 2003). Today, under strict protection, the population appears to be in the earliest stages of recovery. The increase can be attributed to two primary factors: full protection of nesting females and their nests in Mexico, and the requirement to use TEDs in shrimp trawls both in the U.S. and Mexico (NOAA 2001).



Source: USFWS

Figure 1.4.1.9-1. Kemp's Ridley Sea Turtle Photograph

The major habitat for Kemp's Ridley sea turtle is the nearshore and inshore waters of the northern Gulf of Mexico, especially Louisiana waters outside of the nesting season. Kemp's ridley sea turtles are often found in salt marsh habitats; the majority nest on approximately 4.9 miles of beach between Barra del Tordo and Ostional in the state of Tamaulipas, Mexico. It is the only known major nesting beach in the world for this turtle.

1.4.1.10 Loggerhead Turtle

The loggerhead turtle (*C. caretta*) was listed as threatened throughout its range on July 28, 1978 (43 FR 82808), and its status has not changed (Figure 1.4.1.10-1). The loggerhead sea turtle is widely distributed throughout its range and may be found hundreds of miles out to sea as well as in inshore areas, such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers (Corps, Mobile District 2000). Loggerheads are known to migrate over long distances, with tagged specimens having been recaptured 1,200 to 1,500 miles from the point of release. Loggerheads are seen annually inshore in Mississippi Sound, but are more commonly seen offshore in the proximity of oil rigs (Mann personal communication, 2003). Most recent evidence suggests that the number of nesting females in South Carolina and Georgia may be declining, while the number of nesting females in Florida appears to be stable. Until the 1970s, loggerhead turtles were commercially harvested for their meat, eggs, leather, and fat. Its meat and leather are not as valuable as the green sea turtle, and its shell is of less value than the hawksbill. However, in places where regulations are not enforced, the harvest of turtle meat and eggs remains a problem. Because of their feeding behavior and their habit of wintering in shallow waters, loggerheads, along with Kemp's Ridley sea turtles, are more likely to be caught in large shrimp trawl nets and drown. Today, TEDs pulled by shrimp boats help reduce mortality from net entanglement by allowing turtles to escape from the nets. However, loggerhead turtles are hooked by recreational fishermen offshore near oil rigs and are frequently injured by being struck by boats and boat propellers (Mann personal comm. 2003).



Source: USFWS

Figure 1.4.1.10-1. Loggerhead Sea Turtle Photograph

Loggerheads are capable of living in a variety of environments, such as in brackish waters of coastal lagoons and river mouths. During the winter, they may remain dormant, buried in the mud at the bottom of sounds, bays, and estuaries. The major nesting beaches are located in the southeastern U.S., primarily along the Atlantic coast of Florida, North Carolina, South Carolina, and Georgia. As of 1981, there was no record of loggerhead turtles nesting in Mississippi, although a small group of these turtles were seen swimming off the western end of Horn Island

in 1976. Mississippi Heritage Program database includes a record for loggerhead turtle southeast of Deer Island (Mann 2000).

Loggerheads are know to nest annually in small numbers on the Gulf Island National Seashore in Mississippi, with one nest being documented on the mainland beach and one nest several years ago on Round Island (Mann personal comm. 2003).

1.4.1.11 Louisiana Black Bear

The Louisiana black bear (*U. americanus luteolus*) is one of 16 subspecies of American black bear (Figure 1.4.1.11-1). Black bears are large, bulky mammals that can grow to more than 600 pounds. The Louisiana black bear differs from other subspecies by having a longer, narrower skull and larger molar teeth (USFWS 1995). The Louisiana black bear was listed as threatened in its former range of Louisiana, southern Mississippi, and eastern Texas on January 7, 1992. Other black bear species that could occur in this area are treated as threatened due to similarity of appearance. Black bears are opportunistic omnivores that rely heavily on plant foods such as acorns and berries. Bears are also known to eat insects and carrion, and to raid garbage cans, agricultural crops, and bee hives (USFWS 1995).



Source: USFWS

Figure 1.4.1.11-1. Louisiana Black Bear Photograph

Louisiana black bears typically inhabit bottomland hardwood forests, but may also use other habitat types, especially when food is available. Bottomland hardwood forests feature the food sources and denning sites that are necessary for successful bear reproduction. Many different species of hardwood trees, shrubs, vines, and herbaceous plants provide food at different times of the year. Large hollow trees common in swamps provide ideal dens for winter hibernation and birthing young. Reproducing populations of Louisiana black bear are thought to be restricted to two large bottomland hardwood forest areas in Louisiana (USFWS 1995). The Tensas River Basin and Atchaflaya River Basin support several reproducing sub-populations of bears. Louisiana black bears can range long distances in search of food and have been sighted far from the Tensas and Atchaflaya River Basins. Bottomland hardwood forests along lower Pearl River and lower Pascagoula River have suitable habitat that might be occupied by Louisiana black bears (USFWS 1995). It is difficult to determine whether bears seen outside Louisiana are reproducing females, or only wandering subadult bears. There has been at least one confirmed sighting of a female with cubs in Mississippi, and USFWS monitoring data indicate that females will cross the Mississippi River from Louisiana to Mississippi (Rummel 2002).

Habitat loss is thought to be the primary threat to the survival of the Louisiana black bear. Former bear habitat had been reduced by 80 percent within its historic range by 1980 (USFWS 1995). Remaining bear habitat has been fragmented and degraded; degraded habitats often do not provide sufficient food for bears. As bears travel in search of food, they are more likely to come into conflict with humans, and human-related mortality is thought to pose a direct threat to Louisiana black bears. Education programs and strong penalties for poachers have been implemented to help reduce intentional harm to bears (USFWS 1995). Land acquisition and bottomland hardwood forest restoration efforts are underway to increase habitat available to bears. Fewer than 160 Louisiana black bears were thought to exist in breeding habitats in Louisiana in 1995 (USFWS 1995).

1.4.1.12 Louisiana Quillwort

Louisiana quillwort (*I. louisianensis*) is a primitive seedless wetland plant with a grass-like appearance, although it is actually more closely related to ferns (Figure 1.4.1.12-1). It has many simple, hollow leaves 1 to 2 inches wide and up to 24 inches long. Quillworts reproduce by producing spores in special structures embedded in the leaves. The Louisiana quillwort is restricted to gravel bars and sandy soils in or near shallow blackwater creeks and overflow channels in narrow riparian woodlands or bayheads in pine flatwoods and upland longleaf pine vegetative communities (USFWS 1996). This species has been documented in the Pleistocene High Terraces ecoregion in southern Mississippi. Louisiana quillwort was discovered in southeastern Louisiana in 1972. In 1996, it was known from a handful of sites in southeastern Louisiana and in two Mississippi counties, Jackson and Perry (USFWS 1996). Recent survey work however, has discovered this plant in more than 50 locations spread over 10 Mississippi counties (Natureserve 2001d).



Source: USFWS

Figure 1.4.1.12-1. Louisiana Quillwort Photograph

Louisiana quillwort is listed as endangered by the USFWS. Threats to quillwort populations include timber harvest, sand and gravel mining, construction, and other activities with potential to alter the hydrology of small stream habitats (Natureserve 2001d). Louisiana quillwort is adapted to dynamic stream ecosystems in which natural processes scour and redeposit individual plants and spores on constantly changing gravel bars and sandy streambanks. This species has not been observed to grow on silt substrates even when other habitat factors are appropriate (USFWS 1996).

1.4.1.13 Manatee

The West Indian or Florida manatee (*T. manatus*) was listed as an endangered species in 1967 (under a law that preceded the Endangered Species Act of 1973) throughout all or a significant portion of its range (USFWS 2001g). The manatee also is protected at the federal level under the Marine Mammal Protection Act of 1972.

The manatee (sometimes called sea cow) is found primarily along the coast of Florida. Most adult manatees are about 10 feet long and weigh 800 to 1,200 pounds, although some larger than 12 feet and weighing as much as 3,500 pounds have been recorded (Figure 1.4.1.13-1).

These “gentle giants” have a tough, wrinkled brown-to-gray skin that is continuously being sloughed off. Hair is distributed sparsely over the body. With stiff whiskers around its mouth, the manatee’s face looks like a walrus without tusks.



Source: USFWS

Figure 1.4.1.13-1. Manatee Photograph

Manatees spend their lives moving between freshwater, brackish, and saltwater ecosystems. They prefer large, slow-moving rivers, river mouths, and shallow coastal areas, such as coves and bays. Great distances may be covered as the animals migrate between winter and summer grounds. During the winter, the U.S.’ manatee population confines itself to the coastal waters of the southern half of peninsular Florida and to springs and warm water outfalls as far north as southeast Georgia. During summer months, manatees may migrate as far north as coastal Virginia on the east coast and the Louisiana coast on the Gulf of Mexico. Manatees are known to migrate through the study area, and several have been rescued in the study area during cold weather outbreaks (USFWS personal communication 2003). In fact, one or more manatees have been seen annually in Mississippi waters each year for the past decade (Mann personal communication 2003).

Manatees are adversely impacted by collisions with boats, crushing and drowning in canal locks, harassment by skin divers and boaters, entanglement in fishing line, toxins ingested during red tide (toxic algae bloom) events, and destruction of seagrass beds for boating facilities. Manatee population trends are poorly known, but deaths are thought to have increased steadily (6.1% a year, exponential regression, 1976 to 1991). Mortalities from collisions with watercraft are up 10.3% a year from 21% of all deaths in 1976–1980 to 29% in 1986–1991. Deaths of dependent calves are up 12% a year, from 14% to 24% of all deaths. The manatee has difficulty rebounding from these threats because of its late breeding maturity and its low reproductive rate. In general, the birth rate is not able to keep up with manatees killed by boats. The combination of high mortality rates and low reproductive rates have led to serious doubts about the species’ ability to survive in the U.S.

1.4.1.14 Mississippi Gopher Frog

The Mississippi gopher frog (*R. capito sevosa*) is a medium-sized, stocky frog with brown, black, or gray coloration and many dark spots and warts (Figure 1.4.1.14-1). Adult frogs reach approximately 3 inches in body length. These frogs spend considerable time underground in abandoned gopher tortoise burrows, mammal burrows, and under tree stumps (USFWS 2000). Mississippi gopher frogs breed in isolated ponds surrounded by sandy, upland, longleaf pine

forest. Breeding ponds only fill with water after substantial winter rains; Mississippi gopher frogs, therefore, do not reproduce successfully in drought years. The Mississippi gopher frog population has been reduced to approximately 100 known individuals near one breeding pond in Harrison County, Mississippi. Development projects in the vicinity of the pond have severed movement corridors that formerly helped sustain the frog population and otherwise have deteriorated remaining frog habitat. The species was at one time known from coastal counties and parishes from the Mississippi River in Louisiana east to the Mobile River in Alabama (USFWS 2000).

The Mississippi gopher frog was listed as endangered whenever found west of the Mobile and Tombigbee Rivers in Alabama, Mississippi, and Louisiana (USFWS 2001). Threats to the last remaining frog population include inbreeding, local changes in hydrology, fire suppression, sedimentation, toxic chemical runoff, and habitat destruction and fragmentation. The last remaining breeding pond used by the species is located within 656 feet of a proposed highway, housing development, and golf course (USFWS 2000).



Source: USFWS

Figure 1.4.1.14-1. Mississippi Gopher Frog Photograph

1.4.1.15 Mississippi Sandhill Crane

Mississippi sandhill crane (*G. canadensis pulla*) is a large wading bird similar in appearance to herons and other cranes (Figure 1.4.1.15-1). Sandhill cranes have gray feathers with long legs and neck. Adult sandhill cranes have a red patch on the forehead (USFWS 2001d). The Mississippi sandhill crane is a non-migratory subspecies of sandhill crane found only in Jackson County, Mississippi. Most sandhill cranes are migratory, but there are three recognized subspecies that do not migrate: Florida sandhill crane (*G. canadensis pratensis*), Cuban sandhill crane (*G. canadensis nesiotes*), and Mississippi sandhill crane. Somewhere between 110 to 120 Mississippi sandhill cranes existed in the wild in 2000 (Natureserve 2001e). An USFWS captive breeding program has been successful in reintroducing several breeding cranes to the Mississippi Sandhill Crane National Wildlife Refuge. These cranes are found in wet and dry open forests and savannahs with longleaf pine, slash pine, and cypress (*T. ascendens*). Mississippi sandhill cranes feed on live prey, such as amphibians, worms and insects. At certain times of the year, the cranes also eat plant foods, such as corn, roots, tubers, and pecans. Mississippi sandhill cranes reproduce slowly, raising only one chick per year. Hatching success is low, and very few young birds have been observed. Low population levels and inbreeding might be

responsible for low hatching success and a high rate of disease in Mississippi sandhill cranes (USFWS 2001d).



Source: USFWS

Figure 1.4.1.15-1. Mississippi Sandhill Crane Photograph

Critical habitat for the Mississippi sandhill crane covers about 26,000 acres in Jackson County. The main threat to the survival of this subspecies is loss and fragmentation of habitat. Conversion of open forests to dense pine plantation, fire suppression, encroachment of residential and commercial developments, roads that facilitate access to and fragment crane habitat, and chemical spraying on roadsides all contribute to population decline (Natureserve 2001e, USFWS 2001d). These cranes are territorial when nesting. Nests can be separated by a half mile or more. If the Mississippi sandhill crane population recovers, more suitable habitat will be needed so that adult cranes have space to hatch and rear young. Habitat maintenance, which requires occasional fire—either prescribed or wild, is increasingly difficult with the encroachment of suburbia and urban areas on crane habitat.

1.4.1.16 Pearl Darter

The pearl darter (*P. aurora*) is a small fish in the perch family that usually grows to just over 2 inches in length. It has a blunt nose, horizontal mouth, large eyes placed high on the head, and a black spot on the caudal fin (Figure 1.4.1.16-1). Pearl darters have been collected in rivers and large creeks with moderate current and sand and gravel substrates. It is not found in deep, sluggish pools, lacustrine ecosystems, or headwater creeks with insufficient flow. Chironomids and small crustaceans probably make up a large part of pearl darter diet (USFWS 2001e).

Never considered abundant, the pearl darter was once found in both the Pearl and Pascagoula River systems. It has not been collected in the Pearl River system since 1973. The pearl darter is thought to be restricted to 88 river miles of the Pascagoula River watershed (USFWS 2001e). The pearl darter has the potential to occur in the Pascagoula River and its tributaries in Jackson County. Threats include sedimentation from forestry and development in the watershed, permitted industrial and municipal discharges of toxic chemicals and sewage, sand and gravel mining, and proposed impoundments for reservoirs. Sand and gravel mining activities are ongoing in the Pascagoula River system. In-stream mining not only removes substrates preferred by the pearl darter, it also delivers sediment to aquatic habitats downstream. Holes in

river channels left by sand and gravel mining activities function similar to lake habitats, which pearl darters avoid (Natureserve 2001f).



Source: USFWS

Figure 1.4.1.16-1. Pearl Darter Photograph

1.4.1.17 Piping Plover

The piping plover *(C. melodus)* is a small, stocky, sandy-colored bird resembling a sandpiper (Figure 1.4.1.17-1). The adult has yellow-orange legs, a black band across the forehead from eye to eye, and a black ring around the base of its neck. Like other plovers, it runs in short starts and stops. When still, the piping plover blends into the pale background of open, sandy habitat on outer beaches where it feeds and nests. The bird's name derives from its call notes, plaintive bell-like whistles which are often heard before the birds are seen.



Source: USFWS

Figure 1.4.1.17-1. Piping Plover Photograph

The piping plover is listed as a federally threatened species within the watershed of the Gulf Coast as listed in the Federal Register, December 11, 1985. The piping plover breeds on sandy or pebble coastal beaches of Newfoundland and southeastern Quebec to North Carolina. These birds winter primarily on the Atlantic coast from North Carolina to Florida, although some migrate to the Bahamas and West Indies. Decline in piping plover populations has been linked to loss of breeding habitat. Shoreline development, river flow alteration, river channelization, and reservoir construction have all led to loss of breeding habitat. The piping plover is a federally threatened and state endangered shorebird. All piping plovers are considered threatened species under the Endangered Species Act when on their wintering grounds. The piping plover winters along the Gulf coast but does not nest in Mississippi. The Mississippi Natural Heritage Program database

indicates three over-wintering sightings of piping plovers: one along the beaches of Gulfport, one on Deer Island, and one on Ship Island.

Several factors are contributing to the decline of the piping plover along the Atlantic coast. Commercial, residential, and recreational development have decreased the amount of coastal habitat available for piping plovers to nest and feed. Human disturbance often curtails breeding success. Foot and vehicular traffic may crush nests or young. Excessive disturbance may cause the parents to desert the nest, exposing eggs or chicks to the summer sun and predators. Interruption of feeding may stress juvenile birds during critical periods in their development. Pets, especially dogs, may harass the birds. Developments near beaches provide food that attracts increased numbers of predators, such as raccoons, skunks, and foxes. Domestic and feral cats are also very efficient predators of plover eggs and chicks. Stormtides may inundate nests.

Piping plovers winter in coastal areas of the U.S. from North Carolina to Texas. Piping plovers begin arriving on the wintering grounds in July, with some late-nesting birds arriving in September. Behavioral observations of piping plovers on the wintering grounds suggest that they spend the majority of their time foraging (Nicholls and Baldassarre 1990). The international piping plover winter censuses of 1991 and 1996 located only 63 percent and 42 percent of the estimated number of breeding birds, respectively (Haig and Plissner 1992; Haig and Plissner 1993). Of the birds located on the U.S. wintering grounds during these two censuses, 89% were found on the Gulf Coast and 8% were found on the Atlantic Coast.

1.4.1.17.1 Critical Habitat for the Piping Plover

On August 9, 2001, the USFWS designated 137 areas along the coasts of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas as critical habitat for the wintering population of the piping plover. This includes approximately 1,798.3 miles of mapped shoreline and approximately 165,211 acres of mapped area along the Gulf and Atlantic coasts and along margins of interior bays, inlets, and lagoons.

Critical habitat identifies specific areas that are essential to the conservation of a listed species, and that may require special management considerations or protection. The primary constituent elements for the piping plover wintering habitat are those habitat components that are essential for the primary biological needs of foraging, sheltering, and roosting, and only those areas containing these primary constituent elements within the designated boundaries are considered critical habitat. The primary constituent elements are found in coastal areas that support intertidal beaches and flats (between annual low tide and annual high tide) and associated dune systems and flats above annual high tide.

1.4.1.17.2 Critical Habitat Designation/Land Ownership

The critical habitat areas contained within the conservation units described below constitute USFWS's best evaluation of areas needed for the conservation of the wintering piping plover. The USFWS may revise critical habitat through a rulemaking process if new information becomes available. USFWS calculated linear distances of critical habitat shoreline (in kilometers and miles) by ownership for the state of Mississippi. In addition, state-level values of area in hectares and acres were calculated for the critical habitat units by ownership (Table 1.4.1.17.2-1). Ownership for both the shoreline and units were broken into three classes (Federal—federally owned lands, State—state owned lands, and Other—non-Federal or non-state mapped lands). Assignment of ownership was based on existing digital state-level managed/protected lands geodata set (GIS data set) where possible. If no existing digital data were available, ownership was assigned based on other data sources. Detailed descriptions of critical habitat units for the piping plover are provided in Table 1.4.1.17.2-2.

Table 1.4.1.17.2-1.
Approximate Land Area of Designated Critical Habitat Units for Wintering Piping Plover (Rows)

Land Owner	Shoreline Ownership in Hectares (acres)	Shoreline Ownership in Kilometers (miles)
Federal	2,376 (5,870)	98.2 (61.4)
State	0 (0)	0 (0)
Other	1,479 (3,655)	105.9 (66.2)
Total	3,855 (9,525)	204.1 (127.6)

USFWS, 2001i

Table 1.4.1.17.2-2.
Piping Plover Critical Habitat in Mississippi

Unit	Description
MS-1	Lakeshore through Bay St. Louis. 41 ha (101 ac) in Hancock County. This unit extends from the north side of Bryan Bayou outlet and includes the shore of the Mississippi Sound following the shoreline northeast approximately 15.0 km (9.3 mi) and ending at the southeast side of the Bay Waveland Yacht Club. The landward boundary of this unit follows the Gulf side of South and North Beach Boulevard and the seaward boundary is MLLW. The shoreline of this unit is privately owned.
MS-2	Henderson Point. 34 ha (84 ac) in Harrison County. This unit extends from 0.2 km (0.12 mi) west of the intersection of 3rd Avenue and Front Street and includes the shore of the Mississippi Sound following the shoreline northeast approximately 4.4 km (2.7 mi) to the west side of Pass Christian Harbor. The landward boundary of this unit follows the Gulf side of U.S. Highway 90 and the seaward boundary is MLLW. The shoreline of this unit is privately owned.
MS-3	Pass Christian. 77 ha (190 ac) in Harrison County. This unit extends from the east side of Pass Christian Harbor and includes the shore of the Mississippi Sound following the shoreline northeast approximately 10.5 km (6.5 mi) to the west side of Long Beach Pier and Harbor. The landward boundary of this unit follows the Gulf side of U.S. Highway 90 and the seaward boundary is MLLW and the seaward boundary is MLLW. The shoreline of this unit is privately owned.
MS-4	Long Beach. 38 ha (94 ac) in Harrison County. This unit extends from the east side of Long Beach Pier and Harbor and includes the shore of the Mississippi Sound following the shoreline northeast approximately 4.4 km (2.7 mi) to the west side of Gulfport Harbor. The landward boundary of this unit follows the Gulf side of U.S. Highway 90 and the seaward boundary is MLLW. The shoreline of this unit is privately owned.
MS-5	Gulfport. 39 ha (96 ac) in Harrison County. This unit extends from the east side of Gulfport Harbor and includes the shore of the Mississippi Sound following the shoreline northeast approximately 4.8 km (3.0 mi) to the west side of the groin at the southern terminus of Courthouse Road, Mississippi City, MS. The landward boundary of this unit follows the Gulf side of U.S. Highway 90 and the seaward boundary is MLLW. The shoreline of this unit is privately owned.
MS-6	Mississippi City. 62 ha (153 ac) in Harrison County. This unit extends from the east side of the groin at the southern terminus of Courthouse Road, Mississippi City, MS, and includes the shore of the Mississippi Sound following the shoreline northeast approximately 7.9 km (4.9 mi) to the west side of President Casino. The landward boundary of this unit follows the Gulf side of U.S. Highway 90 and the seaward boundary is MLLW. The shoreline of this unit is privately owned.
MS-7	Beauvoir in Harrison County. Excluded. The proposed rule included this unit, but it was deleted for lack of evidence of regular use by piping plovers.
MS-8	Biloxi West in Harrison County. Excluded. The proposed rule included this unit, but it was deleted for lack of evidence of regular use by piping plovers.

Table 1.4.1.17.2-2.
Piping Plover Critical Habitat in Mississippi (continued)

Unit	Description
MS-9	Biloxi East in Harrison County. Excluded. The proposed rule included this unit, but it was deleted for lack of evidence of regular use by piping plovers.
MS-10	Ocean Springs West. 11 ha (27 ac) in Jackson County. This unit extends from U.S. 90 and includes the shore of Biloxi Bay following the shoreline southeast approximately 1.9 km (1.2 mi) to the Ocean Springs Harbor inlet. The landward boundary of this unit follows the Bay side of Front Beach Drive and the seaward boundary is MLLW. The shoreline of this unit is privately owned.
MS-11	Ocean Springs East. 7 ha (17 ac) in Jackson County. This unit extends from the east side of Weeks Bayou and includes the shore of Biloxi Bay following the shoreline southeast approximately 1.8 km (1.1 mi) to Halstead Bayou. The landward boundary of this unit follows the Bay side of East Beach Drive and the seaward boundary is MLLW. The shoreline of this unit is privately owned.
MS-12	Deer Island. 194 ha (479 ac) in Harrison County. This unit includes all of Deer Island, where primary constituent elements occur to the MLLW. Deer Island is privately owned
MS-13	Round Island. 27 ha (67 ac) in Jackson County. This unit includes all of Round Island to the MLWW and is privately owned.
MS-14	Mississippi Barrier Islands. 3,168 ha (7,828 ac) in Harrison and Jackson Counties. This unit includes all of Cat, East and West Ship, Horn, Spoil, and Petit Bois Islands where primary constituent elements occur to MLLW. Cat Island is privately owned, and the remaining islands are part of the Gulf Islands National Seashore.
MS-15	North and South Rigolets. 159 ha (393 ac) in Jackson County, MS, and 12 ha (30 ac) in Mobile County, AL. This unit extends from the southwestern tip of South Rigolets Island and includes the shore of Point Aux Chenes Bay, the Mississippi Sound, and Grand Bay following the shoreline east around the western tip, then north to the south side of South Rigolets Bayou; then from the north side of South Rigolets Bayou (the southeastern corner of North Rigolets Island) north to the northeastern most point of North Rigolets Island. This shoreline is bounded on the seaward side by MLLW and on the landward side to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur. Approximately 4.4 km (2.7 mi) are in Mississippi and 2.9 km (1.8 mi) are in Alabama. Almost half the Mississippi shoreline length is in the Grand Bay National Wildlife Refuge.

1.4.1.18 Red-Cockaded Woodpecker

Red-cockaded woodpeckers (*P. borealis*) are small- to medium-sized woodpeckers 8 to 16 inches long, with a 20 to 24 inch wingspan (Figure 1.4.1.18-1). White spots on black feathers give the bird a “ladder- back” appearance. Red-cockaded woodpeckers have a white cheek patch on either side of the head, as well as a black cap. Male woodpeckers have thin red streaks on the cheeks that are barely visible (Natureserve 2000). Red-cockaded woodpeckers nest and forage in mature pine stands frequently burned to promote an open understory and thick herbaceous layer. Research indicates that red-cockaded woodpeckers excavate nest cavities in pines 60 years or older (USFWS 1998a). The birds were once abundant in pinelands throughout the southeastern U.S., but fire suppression, subsequent hardwood encroachment, conversion to short-rotation pine plantations, and development have eliminated most suitable habitat.



Source: USFWS

Figure 1.4.1.18-1. Red-Cockaded Woodpecker Photograph

The red-cockaded woodpecker is listed by the USFWS as endangered throughout its range. Scattered populations exist from southeastern Oklahoma to southern Virginia, south to Florida and eastern Texas. In Mississippi, red-cockaded woodpeckers have been reported in Harrison and Jackson Counties.

1.4.1.19 Yellow-Blotched Map Turtle

The yellow-blotched map turtle (*G. flavimaculata*) is a small turtle that gets its name from the distinctive yellow blotches on its carapace (top shell) (Figure 1.4.1.19-1). The turtle has a greenish-black body covered with yellow stripes. The plastron (bottom shell) is yellow to tan in color. Adult male turtles have been observed with carapace length between 3.5 to 4.8 inches, while the normally larger female turtles have been observed with carapace length of 4.1 to 8.5 inches (USFWS 1993). Several prominent spine-like projections extend from the top of the carapace. Yellow-blotched map turtles are endemic to the Pascagoula River system. They live in the main channels of rivers and large creeks; they have also been observed in oxbow lakes (USFWS 1993). These turtles have been observed in the Pascagoula and Escawtawpa Rivers in Jackson County. Yellow-blotched map turtles avoid small streams where the surface of the water is shaded by bank vegetation. Aquatic insects and snails are thought to make up a large part of the turtles' diet. Turtles often bask on snags and logs that have fallen in the water. Nesting occurs during the summer months on sandbar beaches (USFWS 1993).



Source: USFWS

Figure 1.4.1.19-1. Yellow-Blotched Map Turtle Photograph

Yellow-blotched map turtle populations in the upper Pascagoula watershed have been in decline since the early 1990s. Navigation improvement projects to remove logs and snags from the Pascagoula River have taken away structures needed by the turtles for basking (USFWS 1993). Snag removal has also adversely impacted populations of the turtles' invertebrate prey that use snags as habitat. Gravel mining activities in the watershed have increased sedimentation and further impacted aquatic invertebrate populations. Four reservoirs and ongoing channel modification projects in the Pascagoula River system have altered or eliminated sandbars that turtles use for nesting. These small, colorful turtles are illegally collected for the pet trade, and basking turtles are used for target practice by some individuals (USFWS 1993). Some turtles have been observed to drown in illegal catfish traps.

Water pollution is a serious problem in some Pascagoula River tributaries. Permitted industrial and municipal effluents degrade water quality (USFWS 1993). Brine discharge from oil fields and a dioxin spill that once prompted a fishing ban in the Pascagoula River have also impacted river water quality. Sedimentation and water pollution are threats to aquatic invertebrates, a main food source for the turtles. Food availability is thought to be a limiting factor for turtle populations. Nest predation is likely to average between 90% and 100%, typical for similar turtle species. Few juvenile turtles were observed in a 1989 survey. Reproduction might be impaired by lack of nesting habitat, exclusion of the turtles from suitable nesting beaches by excessive human presence, or effects of chemical pollutants on turtle reproductive biology. Direct and indirect adverse impacts to yellow-blotched map turtles would be expected from point and non-point source discharges of toxic chemicals, brine, sewage, and sediment to the Pascagoula River system (USFWS 1993).

1.4.2 Historical Trends

1.4.2.1 Introduction

There are 14 T&E species that use terrestrial or freshwater aquatic habitats, in the three coastal counties in Mississippi. Several of these species are endemic to Mississippi or the Gulf Coast, while others migrate long distances to breed or winter in coastal Mississippi. Population declines in some of these species are linked to effects of habitat loss, taking for food or pets, or water pollution in Mississippi. In other species, declines have been linked to phenomena outside the study area. Because most T&E species are rare, population information is difficult to obtain. A review of current literature shows most of the populations of listed species appear to be in decline or have stabilized at levels below what many scientists believe will ensure the long-term

survival of the species. Populations of two listed bird species—the bald eagle (recently delisted) and brown pelican—appear to be increasing throughout the Southeast as effects of the now-banned pesticide DDT decrease with time. Although most of the listed species have habitat requirements more specific than the land use categories in the land use analysis, some useful conclusions can be drawn from the available data.

1.4.2.1.1 The Period of 1972 through 1992

Land area in Hancock, Harrison, and Jackson counties combined (excluding surface water) is just over 1.1 million acres. From 1972 to 1992, the largest land use change observed was a loss of more than 200,000 acres of pine forest. At the same time, agricultural lands and shrub-scrub and cutover land together increased by slightly more than 150,000 acres. Deciduous forest cover increased by about 40,000 acres. Urban land and land devoted to transportation infrastructure increased by more than 20,000 acres, while emergent wetlands declined by about the same amount. Overall, natural land cover declined by approximately 8 % from 1972 to 1992, while agricultural and shrub-scrub lands increased by more than half, and urban land by a third.

The decline of frequently burned, open-canopy longleaf pine woodlands has occurred throughout the southeastern U.S. in the past century. From 1972 to 1992, just over 200,000 acres of pine forest (including wet pine savannah) were lost in the three-county study area. Loss and fragmentation of mature pine forests are thought to be caused by a combination of fire suppression, hardwood encroachment, timber harvest, conversion to short-rotation pine plantations, and development (USFWS 1990a). Part of the observed increase of 40,000 acres of deciduous forest might be explained by fire suppression and hardwood encroachment in pine forests. The loss of the once-dominant longleaf pine forest has been implicated in the population declines for a number of now T&E species in the Southeast, including several species known from Hancock, Harrison, and Jackson Counties. Black pine snake, eastern indigo snake, gopher tortoise, Mississippi gopher frog, and red-cockaded woodpecker are all in some way dependent on frequently burned, open-canopy pine woodlands, and are in decline because of loss and fragmentation of their habitats throughout their range. Similarly, the population of the Mississippi sandhill crane that forages and breeds only in coastal wet slash pine savannah has been reduced to just over 100 birds. Population declines that led to the listing of these species were observed before 1992, and in many instances were underway before 1972.

Although habitat loss is frequently cited as a major cause for localized extinction of endangered species, the effects of habitat fragmentation are in many cases equally important. From 1972 to 1992, land use analysis shows losses of pine forests and emergent wetlands. Likewise, increases were observed in cutover land, shrublands, and deciduous forest, which reflect conversion of pine forest to these other types. Large areas of pine forest and wetlands have been fragmented into smaller habitats that are in many cases less suitable for the long-term survival of many species. For example, research indicates that eastern indigo snakes might require large areas of contiguous habitat in excess of 10,000 acres in order to thrive (Natureserve 2001b). Habitat fragmentation undoubtedly increased during the period from 1972 to 1992, and has been implicated as one of many continuing cumulative adverse impacts to T&E species.

Many species are listed as T&E for reasons beyond habitat loss and fragmentation. Trends in human behavior can be also significant to population dynamics of T&E species. Many of the federally listed reptiles in coastal Mississippi were at one time collected for the pet trade or for food. For example, Alabama red-bellied turtle eggs and adults have been collected for food by local residents (USFWS 1989). Gopher tortoises were also collected for food during the mid-20th century (USFWS 1990a), and eastern Indigo snakes were collected for the pet trade (Natureserve 2001b). The taking of listed reptiles and turtle eggs probably continued up until the time most the species were protected under the Endangered Species Act in the 1980s. Illegal

and accidental take is still likely to occur into the future, but take has been observed to decline as exploitable species become scarcer and more difficult to locate (USFWS 1989).

Land use in urban and agricultural settings has indirect effects upon the rest of the watershed. For example, pesticides and herbicides can run off agricultural lands and leave residues in nearby streams and wetlands. The pesticide DDT was implicated in the drastic population declines of the bald eagle and brown pelican in the middle part of the 20th century. Since DDT was banned, bald eagle and brown pelican populations have rebounded. Although the effects of DDT appear to be waning, other pollutants are thought to be responsible for declines in some aquatic species in the three-county study area. For example, populations of yellow-blotched map turtle and pearl darter are thought to have been adversely impacted by point and non-point source discharges of toxic chemicals, brine, sewage, sediment, discharge from oil fields, and a dioxin spill (USFWS 1993). Some of these sources of pollution could be reflected in the observed increases from 1972 to 1992 of more than 20,000 acres of urban and transportation land in the three-county area. Along with increases in urban land come increases in impervious surface, which increased by about 10,000 acres from 1972 to 1992. Impervious surface is known to increase the rate at which runoff reaches streams. Urban runoff is a known non-point source of sediment and chemical pollutants that can have adverse effects to aquatic life.

1.4.2.1.2 The Period of 1992 through 2000

The years 1992—2000 saw an increase of about 8,000 acres of urban land and about 50,000 acres of cutover/scrubland in the three-county study area. At the same time, the 1.1 million-acre three-county area lost about 15,000 acres of agricultural lands, about 6,000 acres of deciduous forest, about 5,000 acres of emergent wetlands, and roughly 34,000 acres of pine forests. Losses in agricultural lands and deciduous forest represent a reversal from the observed increases in these land use types from 1972–1992. The rate of pine forest loss slowed by about half in the period 1992–2000, while the rate of increase in cutover/shrub land stayed about the same. It is likely that efforts to replant pine trees in timber production lands are catching up to the rate of timber harvest in the region. Under natural conditions there is some degree of change expected between cutover land, pine forest, and deciduous forest. Natural phenomena, such as fires, floods, and hurricanes, can dramatically rearrange the landscape. Also, species dominance in vegetative communities can change as old trees die and new trees of different species take their place. Forests, wetlands, and agricultural lands that are converted to urban uses tend to remain in urban use for long periods of time however and seldom change back to natural environments.

Agricultural lands were not considered “natural” for the purposes of this study. Some T&E species (such as the gopher tortoise and Louisiana black bear), however, have been observed foraging in pastures and field edges (USFWS 1990a, USFWS 1995). If left uncultivated, agricultural lands have the potential to revert to forests, floodplains, or other natural land use types. The small increase in natural lands seen from 1992 to 2000 in the three-county area most likely came at the expense of agricultural lands; agricultural lands lost about 15,000 acres during that time. That 15,000 acres was split to supply the acreage increases seen in natural and developed lands. Although agricultural lands are not considered primary T&E species habitat, conversion of pastures and farms to urban lands represents a loss of land available for habitat restoration projects.

1.5 Essential Fish Habitat

The Magnuson Fisheries Conservation and Management Act of 1976 (the Act) was passed to promote sustainable fish conservation and management. Under the Act, the NOAA, HCD was granted legislative authority for fisheries regulation in the United States within a jurisdictional area located between three miles to 200 miles offshore, Exclusive Economical Zone depending

on geographical location. The NOAA, HCD was also granted legislative authority to establish eight regional fishery management councils responsible for the proper management and harvest of fish and shellfish resources within these waters. Measures to ensure the proper management and harvest of fish and shellfish resources within these waters are outlined in Fisheries Management Plans prepared by the eight councils for their respective geographic regions. The Mississippi Sound system and nearshore Gulf of Mexico is within the management jurisdiction of the Gulf of Mexico Fisheries Management Council.

NOAA, HCD recognized that many marine fisheries are dependent on nearshore and estuarine ecosystems for at least part of their life cycles. The Act was reauthorized, and changed extensively via amendments in 1996 (P.L. 104-297), which aimed to stress the importance of habitat protection to healthy fisheries. The authority of the NOAA, HCD and their councils was strengthened by the reauthorization to promote more effective habitat management and protection of marine fisheries. Specific marine environments important to marine fisheries are referred to as EFH in the Act and are defined as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity" (16 U.S.C. § 1802 (10)). The EFH regulations (at 50 C.F.R. 600 Subpart J) provide additional interpretation of the definition of EFH: "*Waters* include aquatic areas and their associated physical, chemical, and biological properties that are used by fishes and may include areas historically used by fishes. *Substrate* includes sediment, hardbottom, structures underlying the waters, and any associated biological communities. *Necessary* means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. *Spawning, breeding, feeding, or growth to maturity* covers all habitat types used by a species throughout its life cycle." Tables 1.5-1 and 1.5-2 provide those species managed by the Gulf of Mexico Fishery Management Council and those species managed in the Gulf of Mexico under federally implemented Fishery Management Plans.

Table 1.5-1. Gulf of Mexico Fishery Management Council

Shrimp Fishery Management Plan
- brown shrimp - *Farfantepenaeus aztecus*
- pink shrimp - *F. duorarum*
- royal red shrimp - *Pleoticus robustus*
- white shrimp - *Litopenaeus setiferus*

Red Drum Fishery Management Plan
- red drum - *Sciaenops ocellatus*

Reef Fish Fishery Management Plan
- almaco jack – *Seriola rivoliana*
- anchor tilefish - *Caulolatilus intermedius*
- banded rudderfish – *S. zonata*
- blackfin snapper - *Lutjanus buccanella*
- blackline tilefish - *Caulolatilus cyanops*
- black grouper- *Mycteroperca bonaci*
- blueline tilefish – *C. microps*
- cubera snapper – *L. cyanopterus*
- dog snapper – *L. jocu*
- dwarf sand perch - *Diplectrum bivittatum*
- gag grouper - *M. microlepis*
- goldface tilefish – *C. chrysops*
- goliath grouper - *Epinephelus itajara*
- gray snapper – *L. griseus*
- gray triggerfish - *Balistes capriscus*
- greater amberjack – *S. dumerili*
- hogfish - *Lachnolaimus maximus*
- lane snapper - *Lutjanus synagris*
- lesser amberjack - *S. fasciata*

Stone Crab Fishery Management Plan
- Florida stone crab - *Menippe mercenaria*
- Gulf stone crab – *M. adina*

Spiny Lobster Fishery Management Plan
- spiny lobster - *Panulirus argus*
- slipper lobster - *Scyllarides nodife*

Coral and Coral Reef Fishery Management Plan
- varied coral species and coral reef communities comprised of several hundred species

Coastal Migratory Pelagic Fishery Management Plan
- cobia - *Rachycentron canadum*
- king mackerel – *Scomberomorus cavalla*
- Spanish mackerel - *S. maculatus*

mahogany snapper – *L. mahogoni*
marbled grouper – *E. inermis*
misty grouper – *E. mystacinus*
mutton snapper – *L. analis*
Nassau grouper – *E. striatus*
queen snapper - *Etelis oculatus*
red hind - *Epinephelus guttatus*
red grouper – *E. morio*
red snapper - *L. campechanus*
rock hind – *E. adscensionis*
sand perch - *Diplectrum formosum*
scamp grouper - *M. phenax*
schoolmaster – *L. apodus*
silk snapper – *L. vivanus*
snowy grouper – *E. niveatus*
speckled hind - *E. drummondhayi*
tilefish - *Lopholatilus chamaeleonticeps*
vermilion snapper - *Rhomboplites aurorubens*
Warsaw grouper – *E. nigritus*
wenchman - *Pristipomoides aquilonaris*
yellowedge grouper *E .lavolimbatus*
yellowfin grouper – *M. venenosa*
yellowmouth grouper – *M. interstitialis*
yellowtail snapper - *Ocyurus chrysurus*

Table 1.5.2. Species Managed in the Gulf of Mexico under Federally Implemented Fishery Management Plans.

Billfish
blue marlin - *Makaira nigricans*
longbill spearfish - *Tetrapturus pfluegeri*
sailfish - *Istiophorus platypterus*
white marlin - *T. albidus*
Swordfish
swordfish - *Xiphias gladius*

Tuna
albacore - *Thunnus alalunga*
Atlantic bigeye - *T. obesus*
Atlantic yellowfin - *T. albacares*
skipjack - *Katsuwonus pelamis*
western Atlantic bluefin - *T. thynnus*
Sharks
Atlantic angel shark - *Squatina dumerili*
Atlantic sharpnose shark - *Rhizoprionodon terraenovae*
basking shark - *Cetorhinus maximus*
bigeye sand tiger - *Odontaspis noronhai*
bigeye sixgill shark - *Hexanchus vitulus*
bigeye thresher shark - *Alopias superciliosus*
bignose shark - *Carcharhinus altimus*
blacknose shark - *C. acronotus*
blacktip shark - *C. limbatus*
blue shark - *Prionace glauca*
bonnethead - *Sphyrna tiburo*
bull shark - *C. leucas*
Caribbean sharpnose shark - *R. porosus*
common thresher shark - *A. vulpinus*
dusky shark - *C. obscurus*

finetooth shark - *C. isodon*
Galapagos shark - *C. galapagensis*
great hammerhead - *S. mokarran*
lemon shark - *Negaprion brevirostris*
longfin mako shark - *Isurus paucus*
narrowtooth shark - *C. brachyurus*
Caribbean reef shark - *C. perezi*
oceanic whitetip shark - *C. longimanus*
porbeagle shark - *Lamna nasus*
sandbar shark - *C. plumbeus*
sand tiger shark - *O. taurus*
scalloped hammerhead - *S. lewini*
shortfin mako shark - *I. oxyrinchus*
silky shark - *C. falciformis*
sixgill shark - *H. griseus*
smalltail shark - *C. porosus*
smooth hammerhead - *S. zygaena*
spinner shark - *C. brevipinna*
whale shark - *Rhinocodon typus*
white shark - *Carcharodon carcharias*
night shark - *C. signatus*
nurse shark - *Ginglymostoma cirratum*
sharpnose sevengill shark – *Heptranchias perlo*
tiger shark - *Galeocerdo cuvieri*

CHAPTER 2. PROBLEMS AND OPPORTUNITIES

2.1 Problems

The problems caused by Hurricane Katrina within Coastal Mississippi are in association with the unprecedented storm surge and associated coastal flooding as a result of the large volumes of storm surge introduced into the system from the south, during the landfall of the tidal surge. Sediment and debris carried by the surge into many areas of the coastal system further impeded flow through drainage systems and has exacerbated existing coastal flooding, making the entire study area even more susceptible to inundation from smaller hurricanes, tropical storms, or even severe rainfall events.

The unprecedented storm surge has caused increased coastal erosion along the barrier islands coastline, the mainland shoreline, and along tidal and freshwater bodies throughout the study area. Some small communities in Coastal Mississippi suffered complete destruction, while others received unprecedented damage. The natural systems have further been degraded and in some cases, suffered complete destruction. Salt marshes and freshwater marshes suffered erosion and debris fill deposits on top of them. Coastal forests lost numerous trees as a result of the winds and numerous trees were killed due to salt spray as far inland as 20 miles. As a result, the natural environment has experienced further losses to fish and wildlife habitats and an overall decline in water quality. Due to the widespread destruction, there is increased development pressure being felt on remaining natural lands as people return and begin looking for housing. A number of residential and commercial developments are being proposed further inland of the coast, which has resulted in once natural lands becoming increasingly urbanized. This contributes to the ongoing problems that have faced Coastal Mississippi throughout the last two decades.

2.2 Opportunities

A comprehensive ecological analysis is being considered as part of the long-term efforts in Coastal Mississippi. This will ensure the stability and future sustainability of the natural system within Coastal Mississippi while enhancing the productivity of fish and wildlife habitat and restoring critical loss of fish and wildlife habitat that once existed. In addition to the environmental benefits, the economic benefits to the area will be realized for decades by preventing future damages to structures. Ongoing Corps programs, such as Continuing Authorities Programs, and opportunities exist to partner with the State of Mississippi and various other local NGOs to take advantage of ongoing established restoration programs. This partnering effort enables the Corps, Mobile District to ensure no duplication of efforts occurs while also building onto valuable relationships with State and local city and/or county governments and NGOs in order to ensure preservation of fish and wildlife habitat, restoration of ecosystems, prevention of saltwater intrusion, and ensure future sustainability of the diverse natural system that used to exist in Coastal Mississippi. Opportunities associated with the environmental component of the Comprehensive Report and Integrated Programmatic EIS include:

- Reduction of future hurricane and storm damage created by storm surge;
- Prevention of future saltwater intrusion exacerbated by storm surge associated with Hurricane Katrina;
- Reduction of coastal erosion due to shoreline instability;
- Restoration of ecosystems for preservation of fish and wildlife; and

- Reduction of loss of life and property by moving people out of low-lying, environmentally sensitive areas.

2.3 Study Goals and Objectives

Congress directed the Corps to conduct an analysis and design for comprehensive modifications and improvements in the Mississippi coastal area for the purposes of hurricane damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resources purposes. Coastal Mississippi was the point of impact of the greatest tidal surge that has hit the mainland of the U.S. in its recorded history.

Around the 1950s, Coastal Mississippi had heightened development with both commercial and residential structures. Population began to increase during this period also. This increase continued with the onset of Hurricane Camille and has continued with each hurricane event. It is anticipated to increase following Hurricane Katrina.

With this development came the filling in of various kinds of wetland habitats. Natural ecosystem habitats, such as tidal marsh, freshwater marsh, wet pine savannah, and beaches, were altered, if not, completely destroyed. This development was severely impacted by the storm surge associated with Hurricane Katrina. Unfortunately much of Coastal Mississippi has been completely lost – both environmentally and culturally. The MsCIP effort will formulate alternatives that address Congress directives. In order to fully accomplish Congress directives - hurricane damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resources purposes - the MsCIP efforts were divided between non-structural, structural, and environmental. These three PDTs worked closely to develop alternative(s) that accomplished all directives.

CHAPTER 3. DEVELOPMENT OF ENVIRONMENTAL MEASURES AND ALTERNATIVES

3.1 Environmental Restoration Measures Evaluated

The formulation of measures was based on watershed-scale assessments of hurricane and stormwater damage, saltwater intrusion, preservation of fish and wildlife, coastal erosion, flooding, navigation, and other problems and opportunities, in a collaborative approach involving Federal, state and local agencies, stakeholders, citizen groups, and NGOs. The strategy for analyzing post-storm conditions, both for past and potential future events, was developed by the interagency PDT, and reviewed by ITR Team, with approval by the Corps-HQ.

The interagency PDT is comprised of representatives from the following:

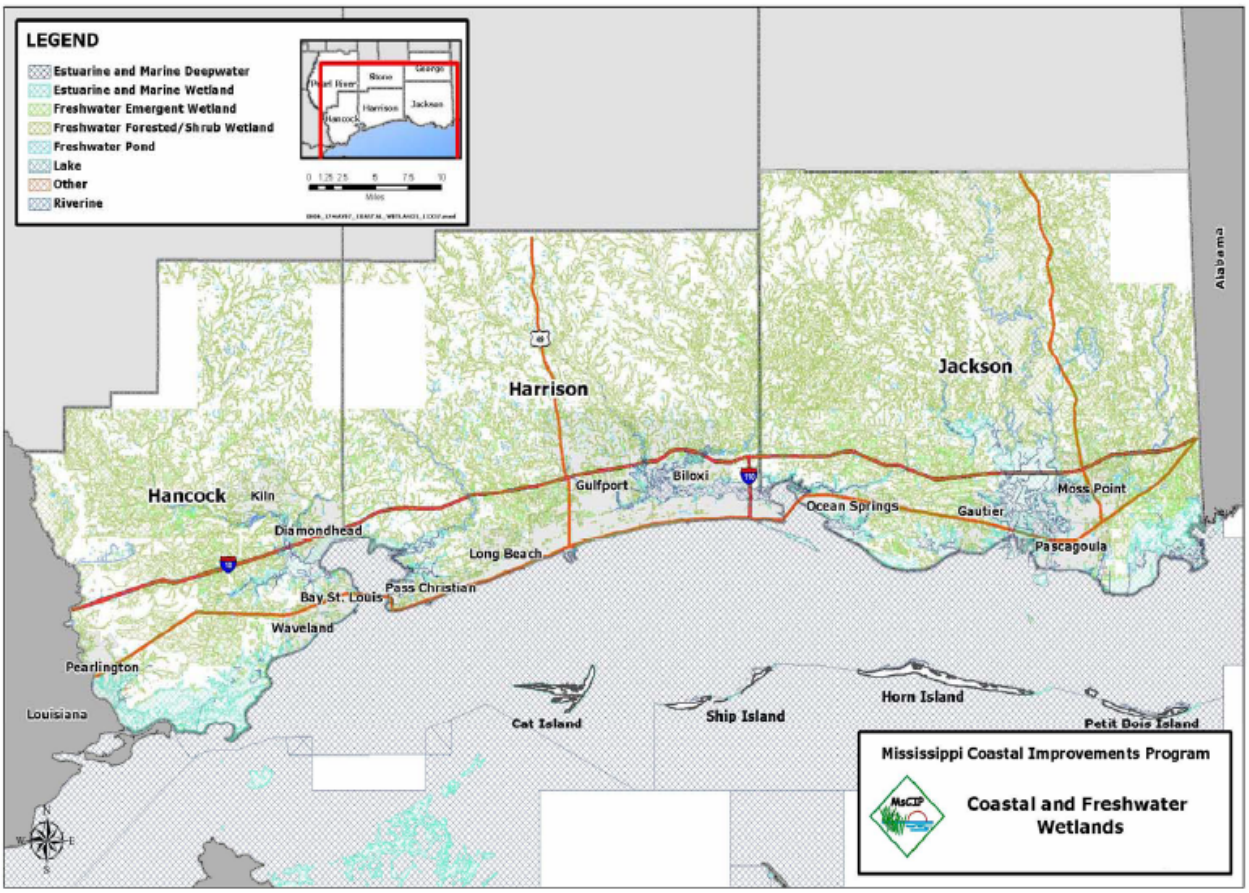
- USEPA
- FEMA
- USFWS
- NPS
- NOAA Fisheries, PRD and HCD
- NWS
- NRCS
- USGS
- MDMR
- MDEQ
- MDOT
- Mississippi SHPO
- Hancock, Harrison and Jackson Counties
- Communities of Bay St. Louis, Biloxi, D'Iberville, Gautier, Gulfport, Long Beach, Moss Point, Ocean Springs, Pascagoula, Pass Christian, and Waveland
- Coastal Restoration Network
- TNC
- Audubon Society
- Sierra Club

In analyzing potential measures, the PDT considered, in all cases in which it would be appropriate, integration of environmental measures within structural and non-structural potential solutions. The following measures have been identified as measures to be examined.

In order to manage all potential measures, the lines of defenses (LOD) concept were developed as a means to effectively address Coastal Mississippi. The LODs moving from offshore, to nearshore, shoreline, and inland, effectively reduce damage potential from large hurricane and storm events. The LOD concept is intended to extend the damage reducing attributes of natural or man-made features and to limit, as far as practicable, the inland reach of destruction. The concept is reasonably flexible and can be tailored to topographic and physical advantage, public preference, and economy.

LOD 1 consists of the four barrier islands that lie several miles to the south. These barrier islands are located along a littoral drift zone that moves sand westward creating three elongated islands and then to the westward most island where littoral currents are not as well defined. LOD 2 consists of essentially all the beaches along coastal Mississippi. Harrison County has the most beachfront with 26 miles extending from Biloxi Bay to St. Louis Bay. Hancock and Jackson County have several miles of beach. The beaches extend along less than half of the Mississippi coastline. Most of the dunes that existed along these beaches were destroyed by Katrina and much of the beach was damaged. LOD 3 consists of raising the roadway or seawall. All of the beaches described as LOD 2 have a roadway landward of the beach. The roads vary from local or county roads to U.S. Highway 90, a four-lane highway that extends across the entire Harrison County coast. The roadways vary in elevation from a few feet to several feet above sea level. All of these roads are evacuation routes and all have been damaged in past hurricanes. This coastal barrier will connect to public right-of-ways that will structurally tie these roadways to other, higher, LODs inland. Also associated with this continuous barrier will be several ring structures that will encircle areas that cannot be included behind the primary line. This will include the cities of Pascagoula, Moss Point, Gautier and Pearlington as well as some large residential developments. LOD 4 is would be the highest line. In order to protect much of the developed areas around Biloxi and St. Louis Bays, this line would be a structural barrier that would also cross the mouth of these bays. These barriers would be to prevent storm surge from moving in through the inlets of the bays. The structural barrier across the bays could be similar to designs used in Europe for storm surge protection. The general alignment of line 4 is envisioned along the path of a railway that crosses the coast of Mississippi. Computer simulations have predicted how far inland storm surge will extend if the worse-case hurricane hits the Mississippi coast. This would consist of LOD 5 and represents a line of safety where homes, facilities or transportation routes north of this line should not be affected by storm surge. This would be an area where hospitals, schools, emergency response and management facilities might be located. Present predictions based on modeling sets this line near elevation 40 feet.

The following environmental measures were evaluated and screened by the MsCIP Environmental PDT based on applicability to the specific problem area. Preliminary measures were assessed by the interagency PDT that included excavating, planting native species, removing exotic species, microtopographic contouring, and restoring of hydrologic connections (Figure 3.1-1). These were all carried further for additional development. The following measures were developed for ecosystem restoration. Several of these measures include integration of non-structural and structural components.



Source: Corps

Figure 3.1-1. Coastal and Freshwater Wetlands

3.1.1 Measures Addressing Saltwater Intrusion

Consists of evaluation of current conditions of saltwater effects on expansive marsh systems located in western and eastern portions of Coastal Mississippi. Diversions of freshwater from existing river systems and other potential measures would be evaluated based on ecosystems needs.

3.1.2 Ecosystem Restoration of Historical Wetlands Previously Developed

Development of an analysis tool – SDSS – by which to prioritize potential environmental restoration and/or homeowners assistance and relocation project areas based on historical conditions, damages from storm surge and coastal flooding, and location to existing natural undisturbed lands (i.e. potentially State of Mississippi or Federal lands).

3.1.3 Barrier Island Restoration

Partnering with the NPS to develop a vision for the barrier islands that would restore the sediment transport and budget system by implementing beach, dune, and littoral system restoration projects, as well as further evaluate the merits of additional restoration of damaged ecosystems including

beach and dune restoration, restoration of salt and freshwater marshes, and revegetation of maritime forests.

3.1.4 SAVs Restoration

Development of a program to determine conditions of SAVs and to determine causes of resource degradation. Identify opportunities to partner with other Federal and state agencies, as well as universities and/or NGOs, to establish research necessary to establish potential solutions and projects.

3.1.5 Incorporation of State of Mississippi Initiative

Continued partnership with MDMR to develop and compliment State of Mississippi projects as opportunities arise.

3.1.6 Restoration of Coastal Forests

Continue partnership with the NPS to further evaluate the feasibility of restoring coastal forests destroyed by the hurricane along the barrier islands. Continue partnership with MDMR to develop and compliment State of Mississippi projects as opportunities arise concerning the mainland of Coastal Mississippi.

3.1.7 Clean-up of Impaired Waterbodies

Determine which waterbodies in Coastal Mississippi were not cleared of deposited sediment and debris as part of the FEMA mission. Establish partnering opportunities with local and state governments to determine increased risks of flooding and develop potential projects that would lessen that risk.

3.1.8 Restoration of degraded coastal wetlands

Continue to assess the degradation of coastal wetlands using the analysis tool – SDSS – in conjunction with the resource agencies to identify additional potential restoration opportunities.

3.1.9 Restoration of Oyster Resources

Continue developing and coordinating with MDMR to implement their restoration of oyster resources wherever feasible. Also incorporate oyster restoration in any applicable proposed projects.

3.1.10 Restoration of Fishing Reefs

Develop a partnership with MDMR to assist in their existing fishing reef program to identify any additional potential locations while also addressing any potential improvements in Mississippi Sound's water quality.

3.1.11 Restoration of Marshes

Development of an analysis tool – SDSS – by which to prioritize potential homeowners assistance and relocation project areas based on historical conditions, damages from storm surge and coastal flooding, and location to existing natural undisturbed lands (i.e. potentially State of Mississippi or Federal lands).

3.2 Development and Evaluation of Mitigation Measures

3.2.1 Potential Mitigation Associate with Non-Structural, Hurricane Storm Damage Measures

Work with the Corps, Non-Structural Team to assess mitigation requirements associated with implementation of the non-structural plans.

3.2.2 Potential Mitigation Associated with Structural, Hurricane Storm Damage Measures (LODs 1-5)

Work with the Corps, Structural Team to assess mitigation requirements associated with implementation of the structural plans.

3.2.3 Potential Mitigation Associated with Structural and Non-Structural Hurricane Storm Damage Measures (LODs 1-5)

Work with both Corps teams to assess mitigation requirements associated with implementation of components of both plans.

3.2.4 Potential Mitigation Associated with Saltwater Intrusion Reduction in Mississippi Sound

Evaluate impacts of diverting freshwater from existing river systems would be evaluated based on ecosystems needs.

3.2.5 Potential Mitigation Associated with Erosion Reduction Measures

Work with both Corps team to assess erosion reduction measures.

CHAPTER 4. PLAN FORMULATION

4.1 Plan Formulation

The development of measures to address ecosystem restoration integrated the input of the multi-disciplinary, and the potential areas as discussed in *Chapter 3*. The multi-disciplinary PDT assessed potential restoration sites in Coastal Mississippi based on the following initial screening criteria:

- Does not require human intervention for recovery
- Does require human intervention for recovery

The multidisciplinary PDT then evaluated sites based on their significance on the following three levels:

- National
- Regional
- Local

The environmental PDT was faced with assessing the three counties in Coastal Mississippi, which consists of hundreds of thousands of acres of uplands, wetlands, urban, coastal forest, etc. This assessment had to be conducted in a consolidated amount of time in order to meet the MsCIP condensed schedule; therefore, the team quickly began compiling various data, such as topographic maps, navigational charts, water quality reports, soil maps, etc, that would be useful in assessing potential restoration efforts. The environmental PDT also had ERDC develop the GIS-based SDSS analysis tool that could effectively assist the team in quickly narrowing down evaluation sites. In addition, the environmental PDT also coordinated closely with both the non-structural and structural PDTs to assess impacts of implementing those measures. The environmental PDT provided ample input to minimize environmental impacts, such as moving the footprint(s) and/or providing natural defenses rather than hardened structures against storm damage.

4.1.1 Goals and Objectives

- Recommend solutions that would assist the people of Coastal Mississippi in their efforts toward recovery of pre-hurricane conditions in the areas of coastal erosion, preservation of fish and wildlife, and prevention of saltwater intrusion
- Recommend measures that would provide for sustainability of the overall natural system
- Recommend measures which integrate ecosystem restoration with storm damage reduction and non-structural plans
- Recommend continued analysis of specific problem areas that require further study to arrive at viable solutions
- Recommend implementable projects directed at recovery of ecological resources along the coast of Mississippi to pre-hurricane conditions, and to examine potential measures that might be implemented to increase sustainability of those resources during future events
- Recommend measures that would provide short-term or long-term recovery of natural resources

- Recommend implementable projects directed at either the stabilization or retreat of saltwater intrusion in the coastal zone exacerbated by the hurricanes, and to examine opportunities for minimization of saltwater intrusion during future events
- Recommend implementable projects directed at recovery of shore erosion protection measures along the coast of Mississippi to their pre-hurricane conditions, and to examine the opportunity for potential increases in the level of protection

4.1.2 Planning Constraints

There are a number of issues that constrain development of certain potential measures that include:

- NPS Policy and Wilderness Areas
- T&E Species and/or Critical Habitat
- State of Mississippi Coastal Zone Management Plan
- State of Mississippi Water Quality standards
- CWA
- NHPA
- CAA
- EFH
- Environmental Justice
- Protection of Children
- CBRA

A detailed discussion of these can be found in the Integrated Comprehensive Main Report/Programmatic EIS.

Managing sediment to benefit a region potentially saves money, allows use of natural processes to solve engineering problems, and improves the ecosystem. As a management method, RSM includes the entire environment, from the watershed to the sea, accounts for the effect of human activities on sediment erosion as well as its transport in streams, lakes, bays, and oceans, and protects and enhances the nation's natural resources while balancing national security and economic needs. RSM is the Corps's standard operating practice for managing sediment on a holistic approach (i.e. regionally) rather than a project specific approach. The Corps recognizes that actions at one specific location have affects regionally. RSM will be considered during evaluation, design, and implementation of potential measures.

The State of Mississippi as part of Gulf of Mexico Alliance has acknowledged that sediment resources are integral to accomplishing many restoration initiatives. It is also recognized that there is a need for a better understanding of regional sediment systems and processes to inform decisions about projects and actions that use or affect sediment resources. Mississippi is actively involved in the development of a Gulf RSM Master Plan as an implementation action for the Gulf Alliance Conservation and Restoration Workgroup with the objective to develop a regional master plan that uses the understanding of sediment dynamics (inputs, outputs, movement) to manage sediment resources towards implementing environmental restoration, conservation, and preservation while reducing coastal erosion, storm damages, and associated costs of sediment management. The regional sediment management plan will also help link sources of sediment with sediment needs,

provide a basis for assessing competing needs for sediment, and foster more cost-effective sediment management.

4.1.3 Public and Agency Involvement

- April 7, 2006 – Over 60 Federal, State and local government agency representatives and other community leaders from business and industry gathered in Biloxi to identify early needs, opportunities and recommendations for the MsCIP process.
- April 10, 11, and 13, 2006 – Public Meetings were held in Harrison, Jackson and Hancock Counties to examine a broad range of potential coastal protection options and solicit public input on designing comprehensive improvements.
- April 18, 2006 – An online agenda of the April 10-13, 2006 public meetings was held for displaced coastal residents or those who could not attend the public meetings.
- April 24 and 25, 2006 – A second Regional Coordination meeting of governmental, business and industry stakeholders was held in Biloxi. The session probed for missing or overlooked ingredients in the near-term planning process.
- May 1, 2, and 4, 2006 – A second round of public workshops was conducted where near-term projects and the screening criteria used to select them were presented.
- May 3, 2006 – A follow-up online workshop was held for displaced coastal residents or those unable to attend public meetings.
- August 21-22, 2006 – A third Regional Coordination Meeting including government partners, business and industry was held in Biloxi. Issue-related subgroups for structural, non-structural, barrier island restoration, and environmental solutions offered specific comments and recommendations to Corps planners and subject matter experts.
- December 19, 2006 – A scoping workshop session was held at MDMR to gather public input for the Integrated Programmatic EIS.
- February 6 and 9, 2007 – Online meetings for structural, nonstructural, environmental, and barrier island working groups took place. Participants had the opportunity to submit comments and be part of a facilitated discussion.
- April 5, 2007 – A public workshop was held to help finalize MsCIP measures for structural, nonstructural, environmental issues, and barrier islands. A 2-part session enabled participants to interact with Corps planners on emerging planning concepts in the first segment and formally comment on the plan during the second part.
- July 9 and 10, 2007 – A Risk Analysis workshop was held at the MDMR to weight the risk impacts to the proposed effort.
- August 13 and 14, 2007 – A follow-up to the Risk Analysis workshop was held at MDMR.
- Public Hearing – To be announced following public release of the Draft Comprehensive Main Report/Draft Integrated Programmatic EIS document.

4.1.4 Plan Formulation Process

The screening of measures discussed above and also in the Integrated MsCIP Comprehensive Report and Programmatic EIS resulted in the following measures being forwarded for potential inclusion in a list of plans for the study area:

- Ecosystem Restoration for preservation of fish and wildlife;
- Freshwater Diversions for prevention of saltwater intrusion;
- Barrier Islands Restoration;
- SAVs Restoration;
- Potential Projects Developed During Interim Report Preparation; and
- Ecosystem Restoration coupled with Storm Damage Reduction through relocations.

The screened list of measures was then combined into a group of well-balanced alternatives that address the suite of problems plaguing Coastal Mississippi. Formulation of these alternatives also incorporated the following complementary measures:

- Integration of projects associated with ongoing recovery efforts;
- Compatibility with other Federal, state, and local programs; and
- Acceptability with the public citizens within the study area.

In addition, the "No-Action" Plan was also developed as a means of comparison to the other alternatives, and as a potentially viable alternative in and of itself.

The plan formulation process began with defining the overall comprehensive natural system and its current state post-hurricane impacts. The MsCIP environmental team compared the post-hurricane conditions to the pre-hurricane conditions. In some cases, ecological contrasts were very great while in other instances not much change had occurred. The environmental team worked with a variety of Federal, state, and local entities to adequately address the magnitude of problems plaguing Coastal Mississippi. Minor problems to complex integrated problems were identified and discussed amongst the team members – structural, environmental, and non-structural. Development of a comprehensive list of problem areas consisted of single or multiple problems associated with a given site that were first identified as having been caused or exacerbated by the hurricane events. These sites were identified with a) coastal erosion; b) damage to fish and wildlife resources, and/or c) saltwater intrusion.

Hurricane-caused problem areas were solicited from, and then discussed, with members of the public, state, local, and other Federal agencies, representatives of industry and commerce, and resource agencies concerned with study area resources, at a series of open meetings previously discussed. The meetings also included a web-cast intended on reaching those that could not physically attend one of the in-field meetings.

Hurricane-caused problems have been investigated in a series of on-going site visits conducted in partnership with local representatives including municipalities, state resource agencies, and Federal partners, to ensure a comprehensive list of the problem areas are developed to address a full range of suitable measures and plans to deal with the identified problems.

4.1.4.1 Screening Criteria

After an initial screening of problem areas to determine their link to the hurricanes, a list of potential problem-solving measures was developed for each problem area. Problem-solving components consists of an array of potential solutions, such as excavating fill at a site, re-planting a destroyed area, restoring tidal flow into an area, or increasing freshwater into an estuarine system. Each problem area was then evaluated in relation to; a) its potential for inclusion as a project tentatively selected for construction; b) its identification as a long-term solution that needs more technical analyses based on the complexity of the system; c) longer term effort; and d) detailed technical

analysis required to adequately address the system. If these criteria could be satisfied, each problem area was then evaluated for their inclusion in the MsCIP Comprehensive Report and Integrated Programmatic EIS. For those projects screened out early during the plan formulation process a section included in this Environmental Appendix entitled Integrated Programmatic EIS – Effected Environment provides the impact analysis for those screened projects.

The list of measures developed for each problem area was more fully developed, and specific measures formulated for each site. These measures were then evaluated and screened once again, according to their continued technical, environmental, and cost-effectiveness feasibility, based on more detailed input from the resource agencies, public and private entities, and technical staff, and their ability to be combined into multi-purpose alternatives, capable of dealing with more than one identified problem at a given site.

The screened list of measures was then combined into a group of well-balanced alternatives, that included both non-structural and if applicable, structural measures that could potentially address the entire suite of problems plaguing an individual site or problem area. Formulation of these alternatives also incorporated the following criteria:

- Does a proposed alternative provide for potential preservation of fish and wildlife and their habitats?
- Does a proposed action or project negatively impact low income or minority populations and/or protection of children?
- Does a proposed alternative provide a potential reduction in coastal erosion?
- Does a proposed alternative provide a potential reduction in the extent or level of saltwater intrusion?
- Does the proposed project fit in, with, or compliment the objectives of the State and/or locals plans and desires for the area?
- Does the proposal contribute to the short-term or long-term recovery of Coastal Mississippi?

Using these questions, as screening criteria in a narrowing of the potential list of measures, the PDT provided for formulation of better project components and alternative plans. This guided the process so that each alternative formulated incorporated measures that would be complimentary while also being mutually exclusive measures that would be evaluated as components of separate alternatives for the following criteria:

- Effectiveness
- Completeness
- Acceptability (Applies to existing Laws and Regulations)
- Efficiency (cost-effectiveness)

The following measures were forwarded for potential inclusion in a list of alternatives for the Coastal Mississippi study area:

- Ecosystem Restoration for Preservation of Fish and Wildlife;
- Freshwater Diversions for prevention of saltwater intrusion;
- Barrier Islands restoration; and
- SAV Restoration

The screened list of measures was then combined into a group of well-balanced alternatives that addresses the entire suite of problems plaguing an individual site or problem area. The following alternatives were then developed and carried forward for further analysis:

1. The No-Action Plan
2. Freshwater Diversions within the Hancock County and Grand Bay Marshes
3. Purchase, removal of structures, and ecosystem restoration within historical wetlands previously developed
4. Restoration of Barrier Island Ecosystems
5. Restoration of SAVs within Mississippi Sound
6. Projects from Interim Report carried for further consideration
7. State Initiative Projects

4.1.4.1.1 Results of Initial Screening Criteria

- Assess barrier island restoration (i.e. entire restoration – including littoral placement, vegetation only, SAV)
- Assess LOD 2 benefits of dunes
- Saltwater Intrusion was assessed through ERDC's water quality models evaluation to assess if a change would occur from freshwater diversion (reference Section 1.1.7)
- Identify environmental restoration in Coastal Mississippi by reducing potential areas through running the GIS-based SDSS analysis tool

4.1.4.1.2 Results of Secondary Screening Criteria

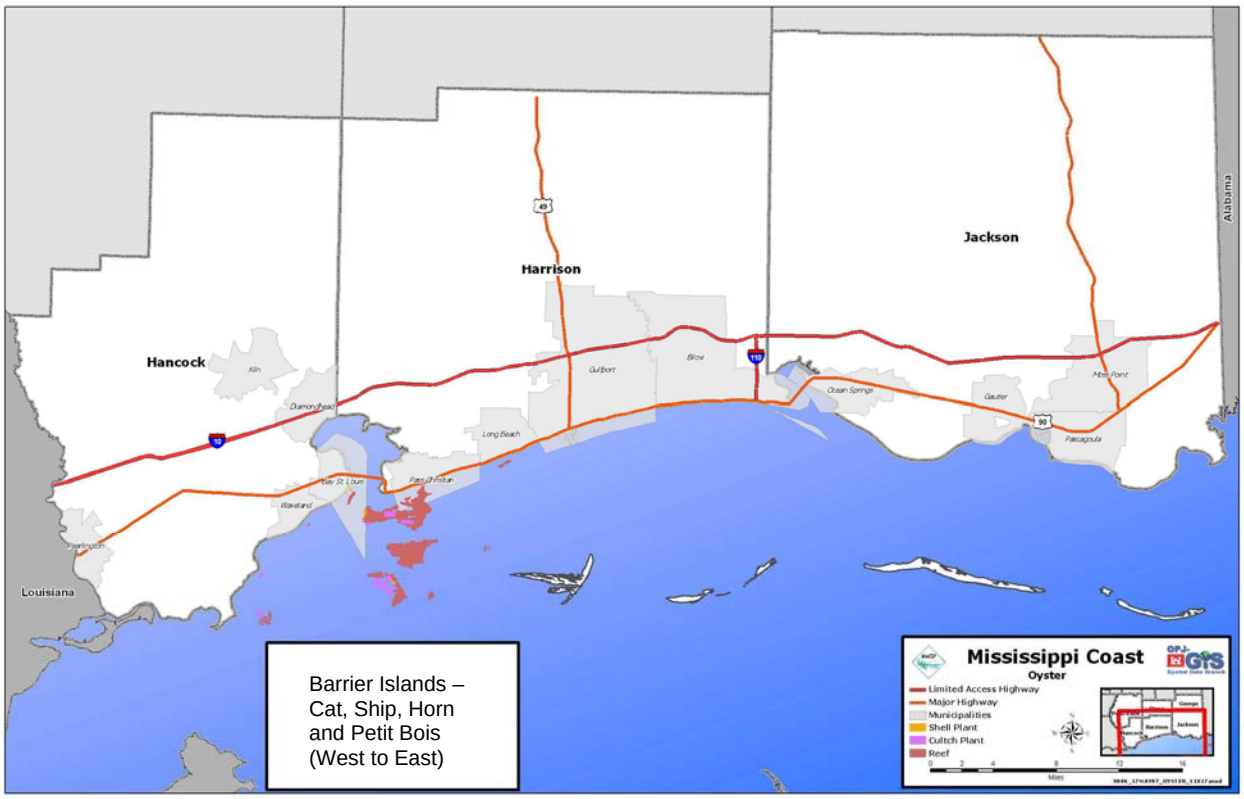
- Barrier Island restoration options would be carried forward for further study
- Water quality model indicated freshwater diversion on the western and eastern portion of the state did change the salinities in Mississippi. Further study is required due to the complex ecosystem.
- Utilized local knowledge and ground-truthing to narrow down potential environmental restoration
- Identified the need for SAV advanced monitoring and mapping needs in Mississippi Sound
- Established a potential partnership with the State of Mississippi Universities and identified a potential pilot project

4.1.5 Environmental Restoration Measures

4.1.5.1 Freshwater Diversion

A freshwater diversion project may serve to enhance the wildlife resources of the area. While there is some disagreement to the benefits of freshwater diversion projects (Turner 2006), further study will assist in determining if such diversions are ecologically feasible in eastern Jackson County, Grand Bay Savannahs and Marshes, and in western Hancock County, Hancock County Marshes. Freshwater diversions enable redistribution of freshwater and much needed sediments to these systems that are experiencing losses and erosion. Hydrodynamic circulation, salinity, and water quality model calibrations have been conducted for Mississippi Sound. Existing or baseline salinity

and water quality distributions were established for March – September 1997 and 1998. Alternative freshwater diversion scenarios were developed and simulated with the calibrated models to examine changes to the baseline salinity and water quality distributions. Freshwater diversion did impact the ecosystem in Jackson and Hancock Counties. Oysters are sensitive to specific ranges of salinity; therefore, freshwater diversions have the potential to either enhance or threaten the resource (Figure 4.1.5.1-1).



Source: MDMR

Figure 4.1.5.1-1. Active Oyster Resources in Mississippi Sound

4.1.5.2 Environmental Restoration of Historical Wetland Sites

The Corps, Mobile District began investigations for identifying potential environmental restoration sites for the purposes of storm-and flood-damage reduction, flood reduction, preservation of fish and wildlife habitat, and removal of habitable structures within high hazard areas. When residential and/or commercial structures and/or land are purchased for the purpose of restoring floodplain areas (i.e. non-structural component), the structures are demolished and the land is no longer available for residential and/or commercial development. Historically, when land is purchased across the U.S., it is left with all or some of the infrastructure at the site rather than restoring it to its historic setting. With the MsCIP environmental plan, land that is purchased (i.e. non-structural component – refer to Non-structural Appendix) would then be restored into functional wetlands. The Hydrogeomorphic (HGM) Approach is a collection of concepts and methods for developing functional indices and subsequently using them to assess the capacity of a wetland to perform functions relative to similar wetlands in a region. The Corps, Mobile District, in cooperation with ERDC, developed a tool to help identify potential restoration sites throughout the study area. A more comprehensive explanation of the SDSS effort used to identify historical wetlands is located in ERDC's *A Wetland Restoration SDSS for the Mississippi Gulf Coast* report (Linn 2007) included in this Environmental Appendix.

Development of a GIS based SDSS tool allowed the Corps, Mobile District, working in cooperation with the USFWS and MDMR, to identify and prioritize potential wetland restoration areas throughout Coastal Mississippi. A subset of potential restoration sites were identified by the SDSS tool and then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS. This interagency team allowed us to both confirm the accuracy of the SDSS results and to collect additional on-site information pertinent to restoration efforts. There are some major benefits in using a GIS-based SDSS approach to wetland restoration. First, it allows for the relatively rapid assessment of the large number of restoration sites across the wide study area. Second, potential sites can be evaluated and restored in a watershed or landscape context, which allows us to comprehensively evaluate the overall natural system. This approach can maximize the benefits of wetland restoration, as opposed to simply restoring wetlands where convenient or where property is available. Essentially use of this SDSS tool allowed the MsCIP environmental team to assess the entire coastline as a holistic natural system; thus, the team was more effectively able to analyze needs in Coastal Mississippi.

The SDSS effort resulted in the following products:

1. A ModelBuilder based SDSS tool, which can be subsequently edited and applied to other areas along Coastal Mississippi in the future as funding becomes available;

2. Maps, such as aerial photography, topographic, soil layers, etc., depicting areas in the study region that have a high probability of being successfully restored into wetland functions that buffer and/or store stormwater, and provide suitable habitat for fish and wildlife;

3. Photograph documentation and data sheets containing information on ground-truthed potential restoration sites.

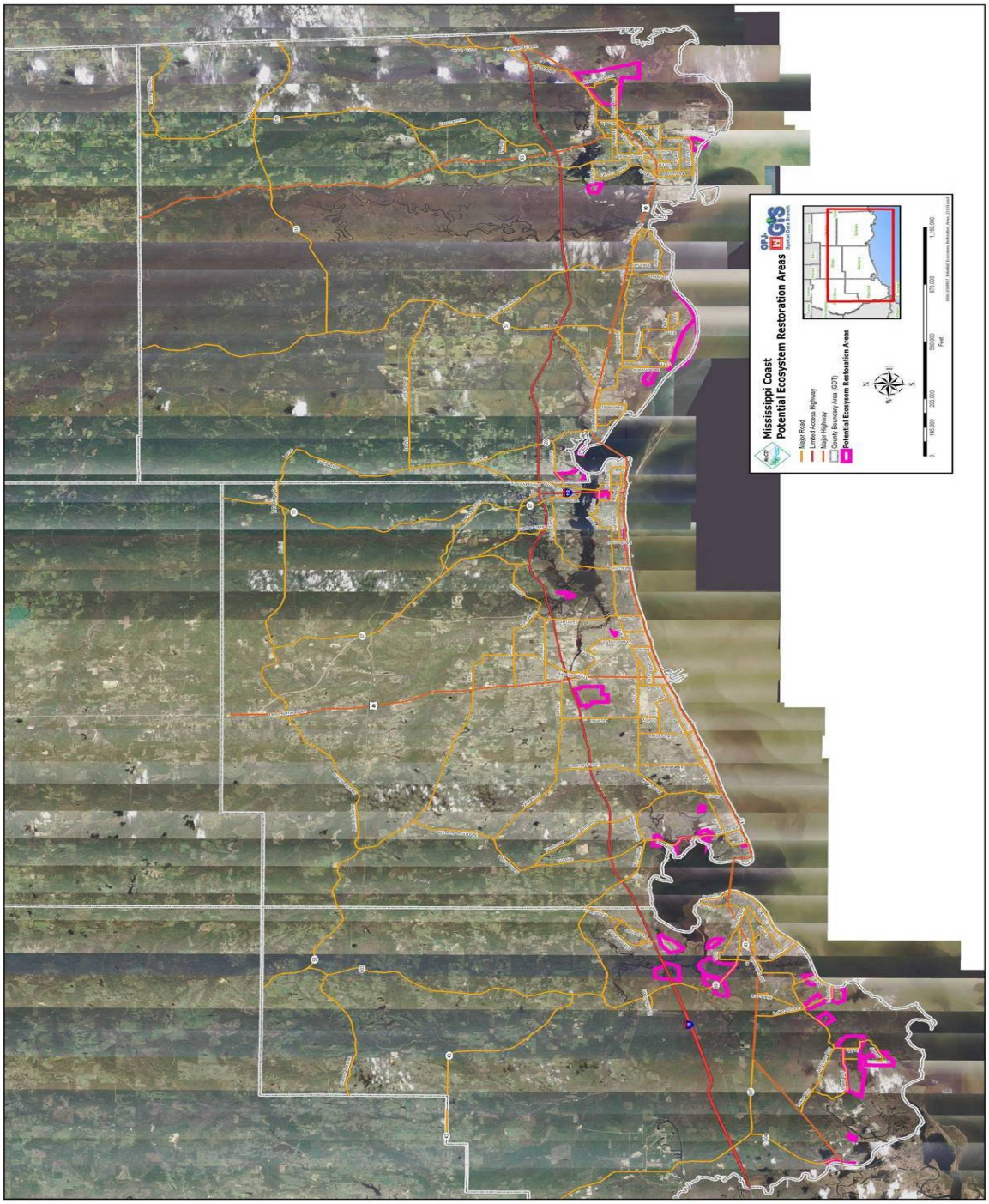
Initial runs of the SDSS tool yielded numerous sites that had to be screened by the Corps, Mobile District, MDMR, and USFWS personnel. The professional team ranked several variables, such as land ownership, proximity to State and other preserved lands, such as the Grand Bay NERR and wildlife management areas, acreage of site, proximity to water, site complexity, potential diversity of natural ecosystem at the site, existing and historical soils, etc., to screen the large list of SDSS sites. The team used these ranked variables for evaluation in order to identify those critical natural systems that would benefit the comprehensive system. Identified environmental restoration sites include a combination of those identified based on the SDSS results, as well as some additional sites (i.e. State Initiatives). These were made using only the non-natural land-use and 100-year flood calculations as the original site selectors (i.e. no damage layers were used), and sites were greater than or equal to 5 acres.

The sites contained the following characteristics:

- Sites were greater than 5 acres in size;
- Sites contained an SDSS Restorability class greater than Low or Medium Low;
- Sites contained an SDSS Habitat class greater than Low or Medium Low; and
- Sites contained an SDSS Storm Surge/Flood Protection class greater than Low.

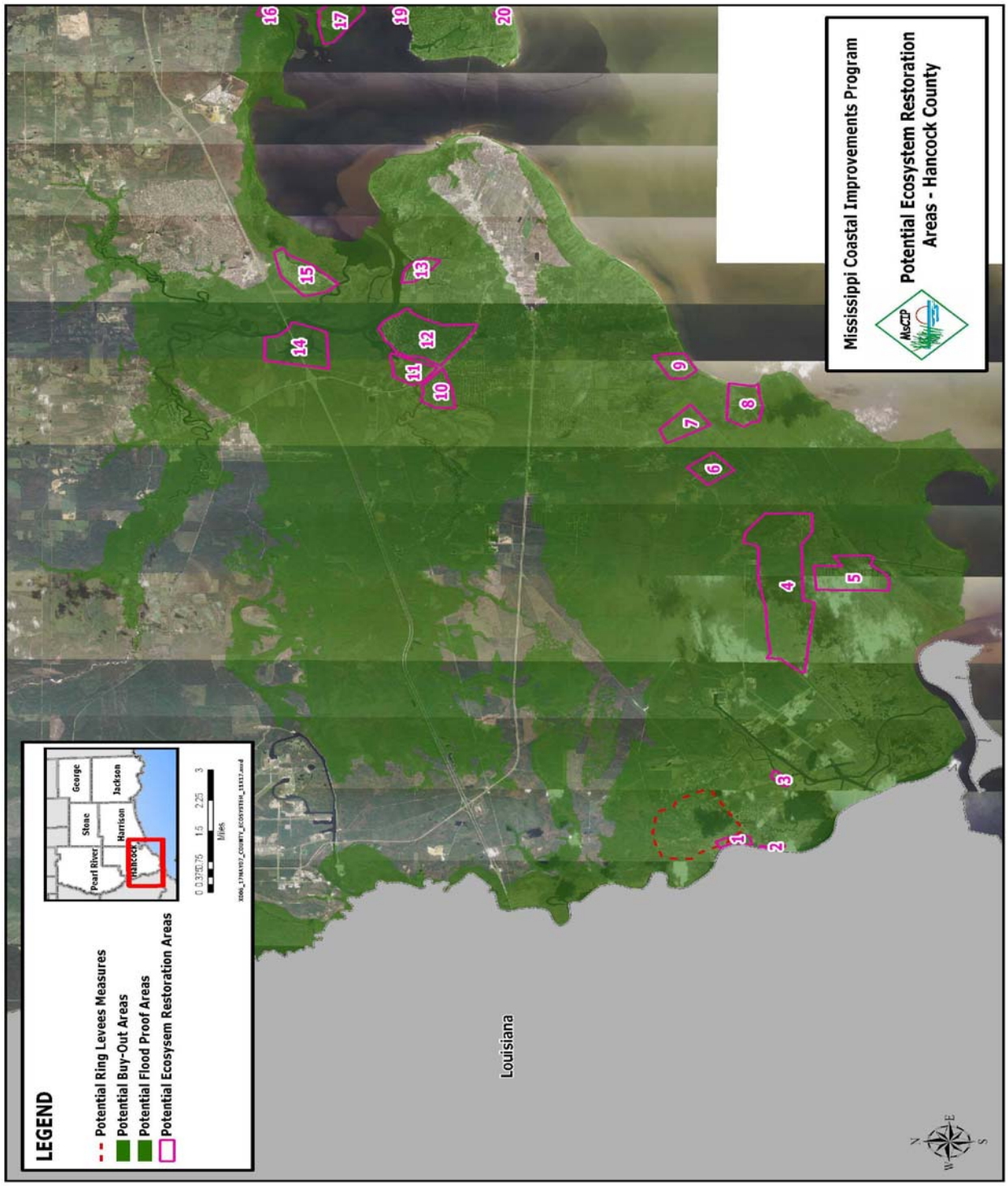
This project has been further coordinated with the ongoing efforts of the MsCIP non-structural flood-proofing committee, and their results were used as the team identified potential restorations sites in Coastal Mississippi. The following selection of 34 restoration sites was based on a combination of results from the SDSS tool and input from MDMR personnel based on local knowledge of the study area and adjacency to existing sensitive protected natural areas (i.e. State and/or Federal lands). Each of the environmental sites were evaluated and screened by using the following criteria:

availability, acceptability, location (i.e. proximity to State of Mississippi owned-lands and greenspace), accessibility, and recreational possibilities. Reference Figures 4.1.5.2-1 to 4.1.5.2-4 and Table 5.1.1.1.1-1 for the specific identified environmental restoration sites.



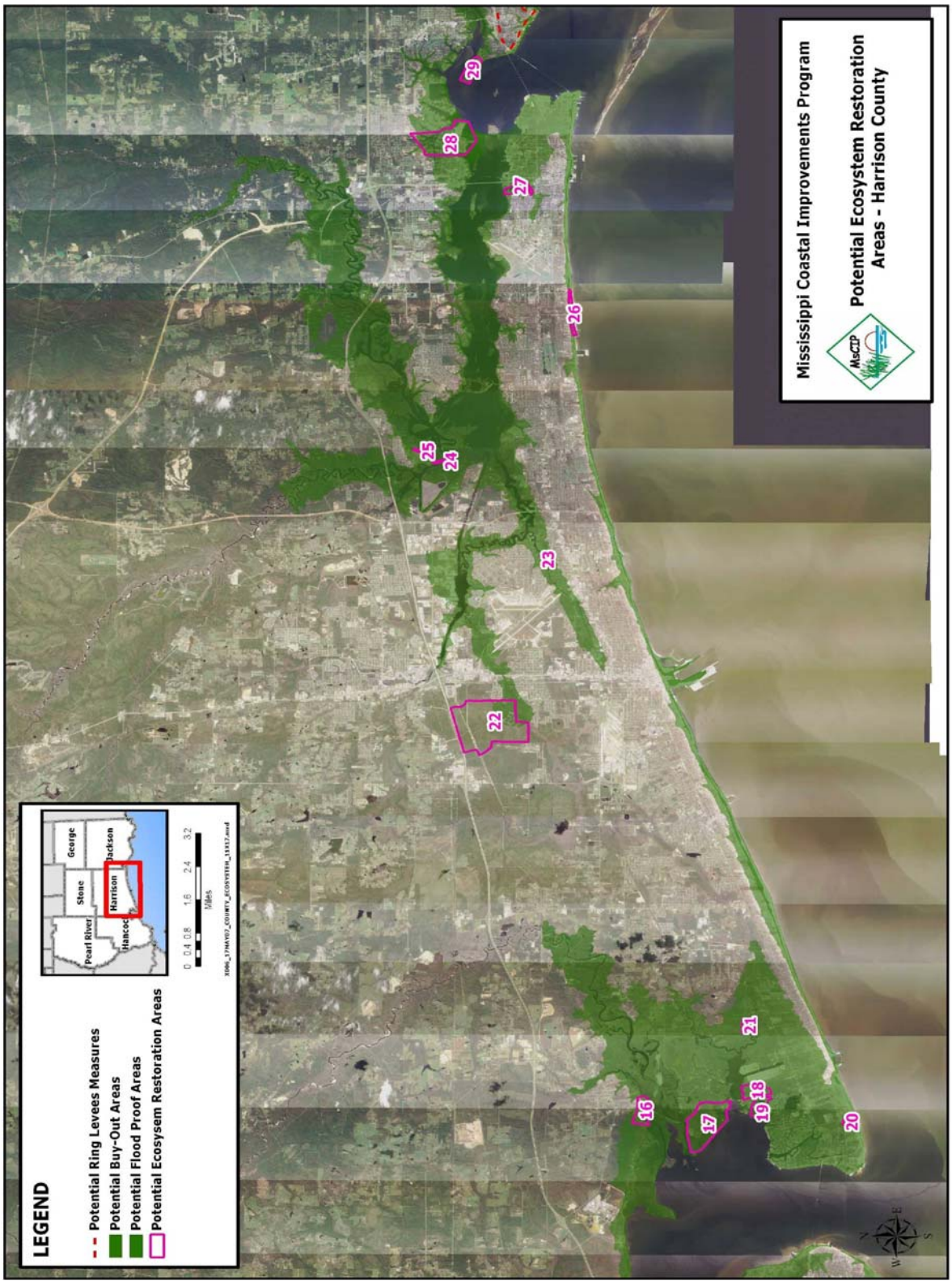
Source: Corps

Figure 4.1.5.2-1. Environmental Restoration of Historical Wetland Sites



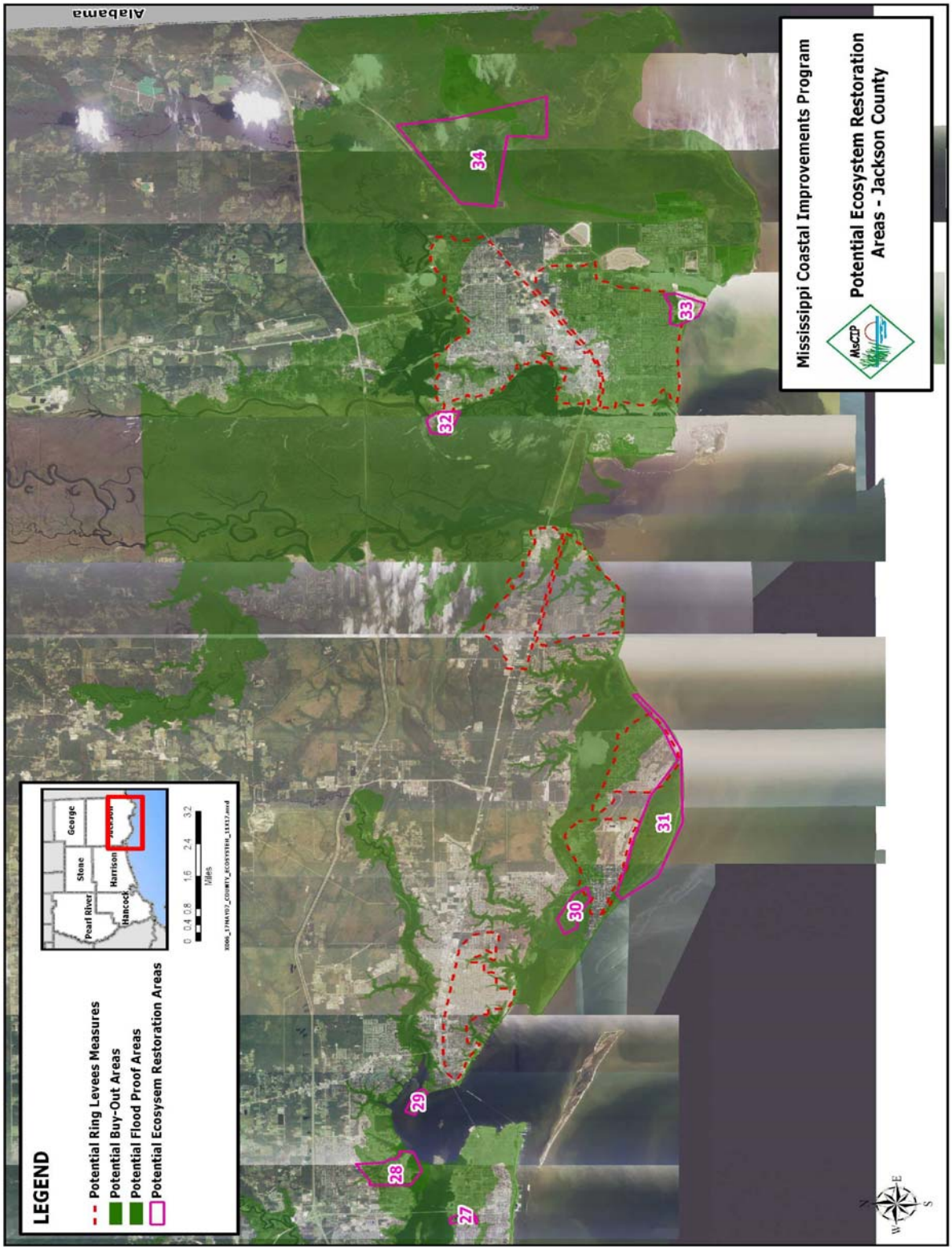
Source: Corps

Figure 4.1.5.2-2. Hancock County Restoration Sites



Source: Corps

Figure 4.1.5.2-3. Harrison County Restoration Sites



Source: Corps

Figure 4.1.5.2-4. Jackson County Restoration Sites

1. Pearlington

- **ACRES:** 76 (State owns 2,200 acres in the Pearlington area)
- **DEMOLITION:** Demolition will be required. Areas found at this site consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet. In order to restore the area to bayhead swamps, excavation will be required to between +3 and +4 feet (i.e. the elevation must be just above the fringing marsh elevation). The slope of the site must be very gradual (i.e. slope should not result in high flow rates.)
- **PLANTING:** Emergent aquatic vegetation would be planted at the site. *Spartina alterniflora* (saltmarsh cordgrass), the low marsh species, would be planted at an elevation ranging from -0.5 to 1-foot. The middle marsh species, *Juncus roemerianus* (black needlerush), would be planted at elevations ranging between 1- and 2-foot while *S. patens* (saltmeadow cordgrass) would be planted above the 2-foot as the high marsh species. Bayhead Swamps trees to be planted consist of *Magnolia virginiana, Nyssa sylvatica*, *Acer rubrum*, and *Taxodium distichum* on a 10- to 30- foot spacing. Bayhead Swamps shrubs to be planted consist of *Persea palustris, Lyonia lucida*, and *Viburnum nudum*. Riverine/levee forests will be planted with *Quercus nigra*, *Celtis laevigata*, *N. aquatica*, *T. distichum*, *A. rubrum*, *Seronea repens*, and *Sabal minor*.

2. Pearlington South

- **ACRES:** 11
- **DEMOLITION:** Demolition will be required. Areas found at this site consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet. In order to restore the area to bayhead swamps, excavation will be required to between +3 and +4 feet (i.e. the elevation must be just above the fringing marsh elevation). The slope of the site must be very gradual (i.e. slope should not result in high flow rates.)
- **PLANTING:** Emergent aquatic vegetation would be planted at the site. *Spartina alterniflora* (saltmarsh cordgrass), the low marsh species, would be planted at an elevation ranging from -0.5 to 1-foot. The middle marsh species, *Juncus roemerianus* (black needlerush), would be planted at elevations ranging between 1- and 2-foot while *S. patens* (saltmeadow cordgrass) would be planted above the 2-foot as the high marsh species. Bayhead Swamps trees to be planted consist of *Magnolia virginiana*, *Nyssa sylvatica*, *Acer rubrum*, and *Taxodium.*

3. Port /West

- **ACRES:** 49
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of high-end residential development and an old golf course. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet.

- **PLANTING:** Emergent aquatic vegetation would be planted at the site. *S. alterniflora,* the low marsh species, would be planted at an elevation ranging from -0.5 to 1-foot. The middle marsh species, *J. roemerianus*, would be planted at elevations ranging between 1- and 2-foot while *S. patens* would be planted above the 2-foot as the high marsh species.

4. Ansley

- **ACRES:** 2,023 (State owns 6,000 acres west of Lakeshore Road)
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet. In order to restore the area to a wet pine savannah habitat, the higher areas will be designated as this type of habitat. These areas have depression areas within them, which will enable water to flow down to the depression areas; thus, holding water.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the *3. Port/West site*. Wet pine savannah habitat will be restored and planted with wet pine flatwoods, such as *Pinus elliottii*, *Morella cerifera*, *Ilex glabra*, *S. patens*, and *Panicum virgatum*.

5. Heron Bay

- **ACRES:** 594 (State owns 6,000 acres west of Lakeshore Road)
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the *3. Port/West site*.

6. Lower Bay Road

- **ACRES:** 226 (State owns 6,000 acres west of Lakeshore Road)
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the *3. Port/West site*.

7. Lakeshore

- **ACRES:** 275
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of commercial development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential and commercial infrastructure and various utilities will be required.

- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the *3. Port/West site*.

8. Bayou Caddy/Lakeshore

- **ACRES:** 362
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of commercial development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential and commercial infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the *3. Port/West site*.

9. Clermont Harbor

- **ACRES:** 209
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the 3. *Port/West site*.

10. Bayou La Croix

- **ACRES:** 259
- **DEMOLITION:** Similar demolition efforts as described in *9. Clermont Harbor* are anticipated to clear the site.
- **EXCAVATION:** Similar excavation efforts as described in *9. Clermont Harbor* are anticipated to prepare the site for planting and restoring of proper hydrology.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the *3. Port/West site*.

11. Admiral Island

- **ACRES:** 245 (State owns 123 acres) (This site is an expansion of the State Initiatives identified in Section 4.1.5.5.)
- **DEMOLITION:** Similar demolition efforts as described in *9. Clermont Harbor* are anticipated to clear the site.
- **EXCAVATION:** Similar excavation efforts as described in *9. Clermont Harbor* are anticipated to prepare the site for planting and restoring of proper hydrology.

- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the *3. Port/West site*.

12. Shoreline Park

- **ACRES:** 889
- **DEMOLITION:** Similar demolition efforts as described in *9. Clermont Harbor* are anticipated to clear the site.
- **EXCAVATION:** Similar excavation efforts as described in *9. Clermont Harbor* are anticipated to prepare the site for planting and restoring of proper hydrology.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the *3. Port/West site*.

13. Chapman Road

- **ACRES:** 146
- **DEMOLITION:** Similar demolition efforts as described in *9. Clermont Harbor* are anticipated to clear the site.
- **EXCAVATION:** Similar excavation efforts as described in *9. Clermont Harbor* are anticipated to prepare the site for planting and restoring of proper hydrology.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the *3. Port/West site*.

14. Jourdan River – Interstate-10 Development

- **ACRES:** 638
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of highend residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** Similar excavation efforts as described in *9. Clermont Harbor* are anticipated to prepare the site for planting and restoring of proper hydrology.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the *3. Port/West site*.

15. Diamondhead

- **ACRES:** 433
- **DEMOLITION:** Similar demolition efforts as described in *9. Clermont Harbor* are anticipated to clear the site.
- **EXCAVATION:** Similar excavation efforts as described in *9. Clermont Harbor* are anticipated to prepare the site for planting and restoring of proper hydrology.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as previously described in the *3. Port/West site*.

Jourdan River Estates

Jourdan River Estates is an existing housing development that received flooding damage. This area has been restored or is in the process of completing repairs to their homes. Very little restoration opportunity exists due to the elevation and small drainage size for this project site. Therefore, it is not being considered any further for environmental restoration opportunities.

16. Delisle

- **ACRES:** 120 (State owns 1,000 acres)
- **DEMOLITION:** Similar demolition efforts as described in *9. Clermont Harbor* are anticipated to clear the site.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet. In order to restore the area to bayhead swamps, excavation will be required to between +3 and +4 feet (i.e. the elevation needs to be just above the fringing marsh). The slope of the site must be very gradual (i.e. the slope should not result in high flow rates.)
- **PLANTING:** Emergent aquatic vegetation would be planted at the site. *S. alterniflora* (saltmarsh cordgrass), the low marsh species, would be planted at an elevation ranging from -0.5 to 1-foot. The middle marsh species, *J. roemerianus* (black needlerush), would be planted at elevations ranging between 1- and 2-foot while *S. patens* (saltmeadow cordgrass) would be planted above the 2-foot as the high marsh species. Bayhead swamps trees to be planted consist of *M. virginiana*, *N. sylvatica*, *A. rubrum*, and *T. distichum* on a 10- to 30-foot spacing. Bayhead Swamps shrubs to be planted consist of *P. palustris*, *L. lucida*, and *V. nudum*.

17. Ellis Property

- **ACRES:** 443 Acres
- **DEMOLITION:** Very minor demolition would be required.
- **EXCAVATION:** Minor excavation would be required.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as described in *16. Delisle*. Preservation with restoration of half tidal marsh and half pine savannah probably more like wet pine flatwoods.

18. Pine Point East

- **ACRES:** 103 (State owns 40-50 tax forfeited lots)
- **DEMOLITION:** Demolition will be required. Residential development exists at this site. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet. In order to restore the area to a wet pine savannah habitat, the higher areas will be designated as wet pine savannah. These areas have depression areas within them which will enable water to flow down to the depression areas; thus, holding water.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site, such as *S. alterniflora*, *J. roemerianus*, and *S. patens*. Wet pine savannah habitat will be restored and planted with wet pine flatwoods, such as *P. elliottii*, *M. cerifera*, *I. glabra*, *S. patens*, and *P. virgatum*.

19. Pine Point West

- **ACRES:** 83 (State owns 40-50 tax forfeited lots)
- **DEMOLITION:** Demolition will be required. Residential development exists at this site. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet. In order to restore the area to a wet pine savannah habitat, the higher areas will be designated as wet pine savannah. These areas have depression areas within them which will enable water to flow down to the depression areas; thus, holding water.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site, such as *S. alterniflora*, *J. roemerianus,* and *S. patens*. Wet pine savannah habitat will be restored and planted with wet pine flatwoods, such as *P. elliottii*, *M. cerifera*, *I. glabra*, *S. patens*, and *P. virgatum*.

20. Pass Christian Beach Front low forested drainage way

- **ACRES:** 21
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet. In order to restore the area to bayhead swamps, excavation will be required to between +3 and +4 feet. The slope of the site must be very gradual.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as described in *13. Delisle.* Bayhead swamps trees to be planted consist of *M. virginiana*, *N. sylvatica*, *A. rubrum*, and *T. distichum* on a 10- to 30-foot spacing. Bayhead Swamps shrubs to be planted consist of *P. palustris*, *L. lucida*, and *V. nudum*.

21. Pass Christian Site – Bayou Portage

- **ACRES:** 43
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet. In order to restore the area to bayhead swamps, excavation will be required to between +3 and +4 feet. The slope of the site must be very gradual.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site as described in 16. Delisle.

22. Turkey Creek

- **ACRES:** 948 (Of this total, 689 acres are being tentatively selected for construction which is discussed in detail in Section 5.1.1.1.2.1.)
- **DEMOLITION:** None
- **EXCAVATION:** In order to restore the area to a wet pine savannah habitat, the higher areas will be designated as wet pine savannah. These areas have depression areas within them, which will enable water to flow down to the depression areas; thus, holding water.

- **PLANTING:** Wet pine savannah habitat will be restored and planted with wet pine flatwoods, such as *P. elliottii*, *M. cerifera*, *I. glabra*, *S. patens*, and *P. virgatum*.

23. Brickyard Bayou

- **ACRES:** 14

- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no anticipated hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.

- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet. In order to restore the area to a Wet Pine Savannah habitat, the higher areas will be designated as Wet Pine Savannah. These areas have depression areas within them which will enable water to flow down to the depression areas; thus, holding water.

- **PLANTING:** Emergent aquatic vegetation would be planted at the site as described in *16. Delisle.* Bayhead swamps trees to be planted consist of *M. virginiana*, *N. sylvatica, A. rubrum*, and *T. distichum* on a 10- to 30-foot spacing. Bayhead swamps shrubs to be planted consist of *P. palustris*, *L. lucida*, and *V. nudum*.

24. Biloxi River – Shorecrest Drive

- **ACRES:** 15

- **DEMOLITION:** Demolition will be required. Areas found in this site consist of only residential development/bulkheads. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.

- **EXCAVATION:** Excavation of old fill material will be required to remove the foreign material.

- **PLANTING:** Plantings will consist of what has been described in *23. Brickyard Bayou at Courthouse Road*. In addition, riverine/levee forests will be planted with *Q. nigra*, *C. laevigata, N. aquatica*, *T. distichum*, *A. rubrum*, *S. repens*, and *S. minor*.

25. Biloxi River – Eagle Point

- **ACRES:** 17

- **DEMOLITION:** Demolition will be required. Areas found in this site consist of only residential development/bulkheads. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.

- **EXCAVATION:** Excavation of old fill material will be required to remove the foreign material.

- **PLANTING:** Plantings will consist of what has been described in *23. Brickyard Bayou at Courthouse Road*. In addition, riverine/levee forests will be planted with *Q. nigra*, *C. laevigata*, *N. aquatica*, *T. distichum*, *A. rubrum*, *S. repens*, and *S. minor*.

26. Biloxi Front Beach – South of Highway 90

- **ACRES:** 40

- **DEMOLITION:** Demolition will be required. Areas consist of only commercial retail outlet development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of commercial infrastructure and various utilities will be required.
- **EXCAVATION:** Excavation of old fill material will be required to remove the foreign material.
- **Fill:** This site is proposed as part of the Interim Report's project and as LOD 2 and 3. This proposed restoration site purchases the remaining parcels that are commercial property located directly on the beach. Dunes will be constructed to provide added protection.
- **PLANTING:** Sea oats will be planted on the dune system.

27. Keegan Bayou

- **ACRES:** 54
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet. In order to restore the area to a wet pine savannah habitat, the higher areas will be designated as wet pine savannah. These areas have depression areas within them, which will enable water to flow down to the depression areas; thus, holding water.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site. Wet Pine Savannah habitat will be restored and planted.

28. St. Martin

- **ACRES:** 467
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential and commercial development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential and commercial infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site.

29. Fort Point

- **ACRES:** 83
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site.

30. Pine Island:

- **ACRES:** 2,531

- **DEMOLITION:** Demolition will be required. Areas found in this area consist of high-end residential development and an old golf course. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site.

31. Belle Fontaine

- **ACRES:** 1,516
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of only residential development/bulkheads. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** Excavation of old fill material will be required to remove the foreign material. In addition, seawalls and bulkheads will be needed to be excavated.
- **FILL:** The beach is developed from sand eroded from the Gulfport Formation, a Pleistocene sand deposit in the center of the area; the sand is spread along the shore by longshore currents driven by wave action. Sandy material will be required to restore the lost beach back to its historic footprint (about 100 to 200 feet seaward). In addition, dunes will be constructed to provide added protection.
- **PLANTING:** Sea oats will be planted on the dune system.

32. Griffin Point

- **ACRES:** 182
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site.

33. Bayou Chico

- **ACRES:** 258
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site.

34. Grand Bay Marsh/Bayou Cumbest

- **ACRES:** 2,666 (Of this total, 148 acres are tentatively selected for construction. A detailed discussion is provided below in Section 5.1.1.1.2.2.)
- **DEMOLITION:** Demolition will be required. Areas found in this area consist of residential development. Material consists of normal construction material and no hazardous/toxic material is anticipated. Removal of residential infrastructure and various utilities will be required.
- **EXCAVATION:** In order to restore the area to emergent tidal marsh, excavation will be required to between -0.5 to +2.0 feet. Higher areas will be restored to wet pine savannah habitat. These areas have depression areas within them, which will enable water to flow down to the depression areas; thus, holding water.
- **PLANTING:** Emergent aquatic vegetation would be planted at the site. Wet pine savannah habitat will be restored and planted with wet pine flatwoods, such as *P. elliottii*, *M. cerifera*, *I. glabra*, *S. patens*, and *P. virgatum*.

Mary Walker Bayou

Mary Walker Bayou area was not considered as a feasible environmental restoration site. Mary Walker Bayou area is located up high on a bluff with only a few businesses in the low area; thus, the site was eliminated from any further study.

Gautier South

There are several drainage areas within the proposed environmental restoration site. This site is located within the City of Gautier and adjacent to the State of Mississippi's Shepard Park. The potential restoration site is located within several residential communities. In evaluating this in greater detail, the team, including MDMR, decided not to carry this proposed potential project any further.

Johnson Bayou Site

This site was eliminated from further consideration by the MsCIP environmental team due to it not being a feasible site for restoration as it was being redeveloped.

Ocean Springs Inner Harbor

In evaluating this potential site, several factors were considered – availability, acceptability, location, and accessibility, to determine if the proposal would be feasible to carry forward in the proposed environmental restoration effort. This site consists of a harbor with predominantly private crafts with residential housing within the area. This site has been mostly restored back to pre-2005 hurricane conditions; therefore, this area is not available as a potential restoration site at this time and would not be acceptable to the citizens of Ocean Springs. This site may be considered in the future as a possible long-term environmental restoration site as the site becomes more feasible.

East Beach – Ocean Springs

East Beach – Ocean Springs is proposed as an Interim Project consisting of beach/dune restoration. Additionally, the East Beach – Ocean Springs site is part of Lines of Defense 2 (beach/dune) and 3 (elevated roadway). This site has also been designated as a non-structural solutions consisting of homeowners assistance and relocation. Restoration of the site would consist of greenspace/recreational site, other upland habitat, and maritime forest habitat, which is a high priority habitat for the USFWS.

4.1.5.3 Restoration of Barrier Island Ecosystems

Barrier islands provide a boundary between the sea water salinity of the open Gulf of Mexico and the brackish water found in Mississippi Sound. Loss of the islands would greatly increase salinity in Mississippi Sound; thus, changing ecological habitats that exist now. This would impact, if not devastate, shellfish and many other forms of marine life. Prior to Hurricane Katrina, the State of Mississippi was working on a coastal storm protection plan and proposition to submit to NPS for consideration that included restoring the barrier islands to the condition that existed prior to Hurricane Camille. While unsubstantiated through scientific study, it was reported that many in Mississippi felt that if the islands had been in the condition that existed prior to Hurricane Camille, there would have been less damage along the coast from Hurricane Katrina. This idea was also included in the Mississippi Governor's Recovery Plan, which called for restoring the islands to a pre-Camille footprint.

Another positive effect that the barrier islands have is to provide a natural offshore breakwater for the large sea waves that are generated from hurricanes. The presence of the islands and the relatively shallow water of the Mississippi Sound between the islands and the mainland prevent the sea waves from maintaining their considerable size as they move towards the mainland. Sea waves, often reported at heights of 40 feet and higher in large storms, would break as they approach the chain of islands. The open water between the islands and the mainland, generally ten miles or more, would have enough fetch for waves to regenerate, but at a much lower height due to the shallower water. The generally accepted relationship between water depth and wave height is that the wave can sustain itself at a height that is one-half the depth of the water.

Sand of sufficient quality and quantity required for this proposed restoration of the barrier islands is not known to occur in close proximity to the islands. Prior studies of the St. Bernard Shoals (USGS personal comm. 2006) indicate that this site is probably the best source of the sand. Vegetation and a dune system would also be incorporated as prescription components as part of any sand placement on the barrier islands in order to further stabilize these restoration projects. The presence of the islands and the relatively shallow water of Mississippi Sound between the islands and the mainland prevent the sea waves from maintaining their considerable size as they move towards the mainland (i.e. a natural breakwater defense). Possible supplement of sand (i.e. from St. Bernard Shoals or an offsite source) in the littoral system is another option that could help restore the islands. This could be accomplished by adding sand in specific locations based on sediment transport modeling. Any improvements to the barrier islands must be closely coordinated with NPS because they are within the NPS boundaries and Petit Bois and Horn Islands are congressionally designated Wilderness Areas.

4.1.5.4 Restoration of SAVs in Mississippi Sound

Continued survival and growth of seagrasses (i.e. SAVs) may be threatened by the cumulative effects of man's activities, in addition to, natural processes in the coastal marine ecosystem. Natural causes of SAV (i.e. *Diplanthera wrightii, Cymodocea manatorum, Thalassia testudinum*, and *Ruppia maritime*) decline, such as disease, storm events, salinity fluctuation, and hypoxic events, coupled with declining water quality caused by anthropogenic eutrophication currently threaten the health of many SAV systems (Montague and Ley 1993, Durako and Kuss 1994, Olesen and Sand-Jensen 1994, Zieman et al 1994, Kock and Beer 1996). These habitats provide vital refuges, feeding, resting, staging, and spawning grounds for a variety of species found in Mississippi Sound and also in the Gulf of Mexico. Past studies throughout the years have attributed anywhere from 50% to 90% of all marine species to utilize this vital habitat at some point in their life state. Opportunities exist to partner with Federal, state, and local resource agencies as well as NGOs. Extensive coordination with the NPS, responsible for managing and operating the Gulf Islands National Seashore, would be required for areas of potential restoration within park boundaries. Involvement of local colleges and

universities with ongoing research programs would also help to identify and pinpoint specific problems for development of potential solutions.

4.1.5.5 State Initiative Projects

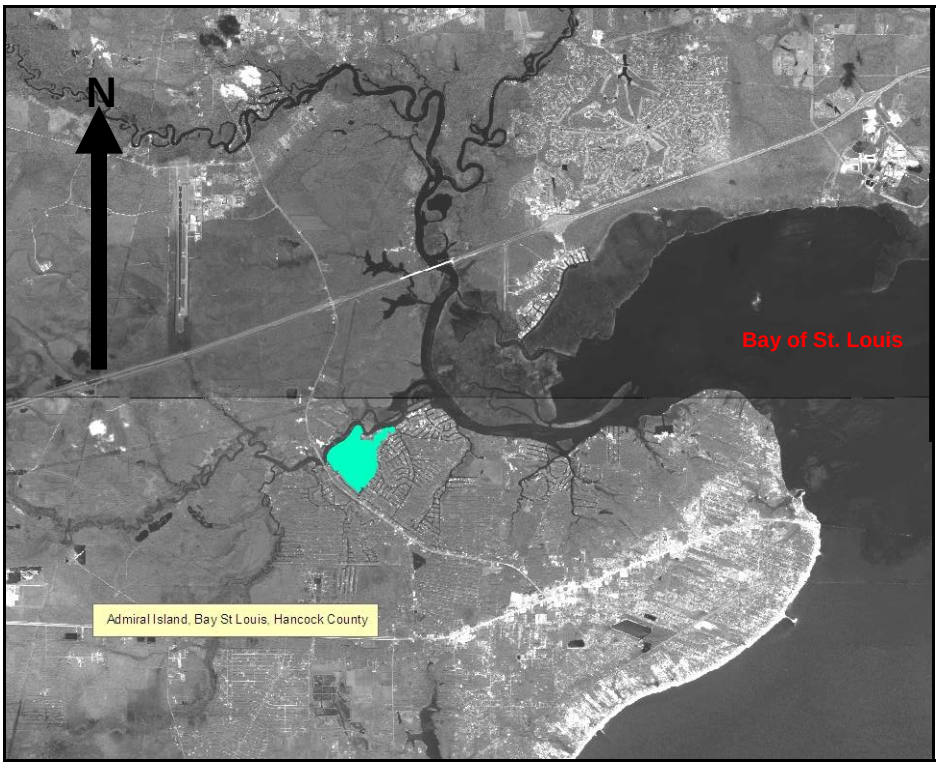
The Governor of the State of Mississippi's *Seven-Point Strategy* for rebuilding coastal resources of the State is anticipated to be an on-going effort over the next 10 to 15 years. The strategy is summarized as follows:

- Implementation of breakwater structures for surge protection (natural surge diffusers, breakwaters, jetties seawalls, etc.);
- Deer Island restoration to pre-1900 footprint with fortification of the south side;
- Barrier Island restoration to pre-Camille conditions;
- Restoration of 10,000 acres of coastal marshes, beaches, and forests;
- Restoration of historical water flow to Coastal Mississippi watersheds to provide water quality and quantity critical to estuarine and marine habitats, including efforts to divert freshwater from Louisiana into the Biloxi marshes;
- Restoration of submerged aquatic vegetation in Mississippi Sound; and the
- Restoration and enhancement of reef systems in Mississippi waters and adjacent Federal waters (i.e. oysters, nearshore low-profile reefs, and offshore artificial reefs).

MDMR has identified the following 11 restoration sites. These are being included in the ecological approach detailed in this Environmental Appendix and also in the MsCIP Comprehensive Main Report/Integrated Programmatic EIS.

Hancock County:

- **SITE:** Admiral Island, Hancock County
- **DESCRIPTION:** 123 acres total – 62 marsh and 61 forested scrub shrub
- **CONDITION:** Admiral Island has extensive debris fields washed in from Bayou Lacroix during Hurricane Katrina (Figure 4.1.5.5-1 and Figure 4.1.5.5-2). Approximately 10 acres are covered in a mat of crushed houses, boats, and other debris. Mechanized removal of these debris fields via the central road on Admiral Island will be necessary before prescribed burning takes place. Foot reconnaissance will be necessary to gather plastic and other potentially hazardous burnable materials on the remaining acreage before conducting a prescribed burn.



Source: MDMR

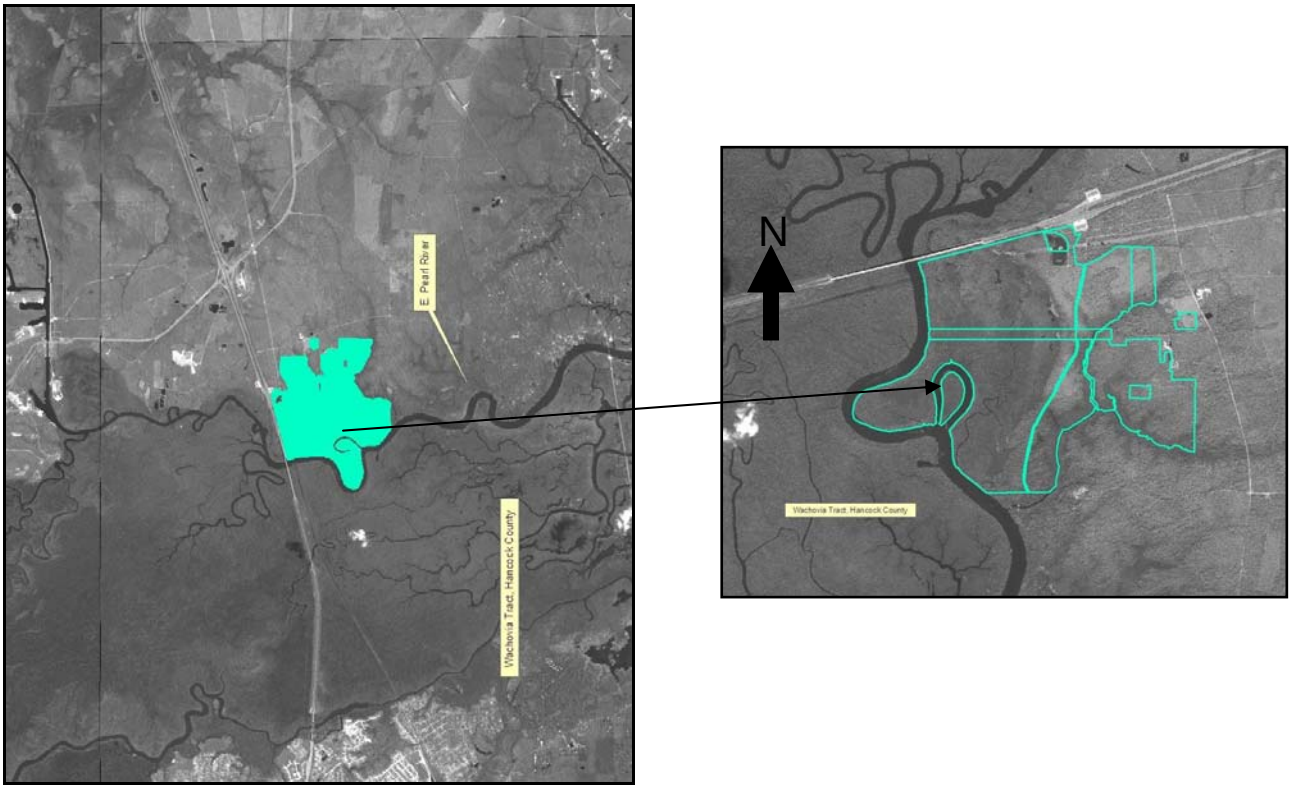
Figure 4.1.5.5-1. Admiral Island, Hancock County State Initiative Projects



Source: MDMR

Figure 4.1.5.5-2. Admiral Island, Hancock County State Initiative Projects

- **PLANTING:** Chinese tallow trees have heavily infested the property and mature trees were significantly damaged by Hurricane Katrina. However, new seedlings are property wide and are forming virtual carpets in some areas. Treatment needs to begin this year while the other vegetation is dead. It is easy to move through and makes it much easier to distinguish growing "tallows". Treatment would be even easier if a prescribed burn can be conducted first.
- **SITE:** Wachovia, Hancock County
- **DESCRIPTION:** 1,200 acres total – 800 marsh, 200 forested, 200 savannah
- **CONDITION:** Wachovia has significant marsh debris and scour from storm surge. However, the scoured areas appear to be forming high quality open-water habitat evident by a high level of dragon fly activity and breeding. The scours are several feet deep and would require an invasive operation to be filled and replanted (Figure 4.1.5.5-3). The debris is predominantly natural material, mostly the marsh "rolled up" from the scoured areas.



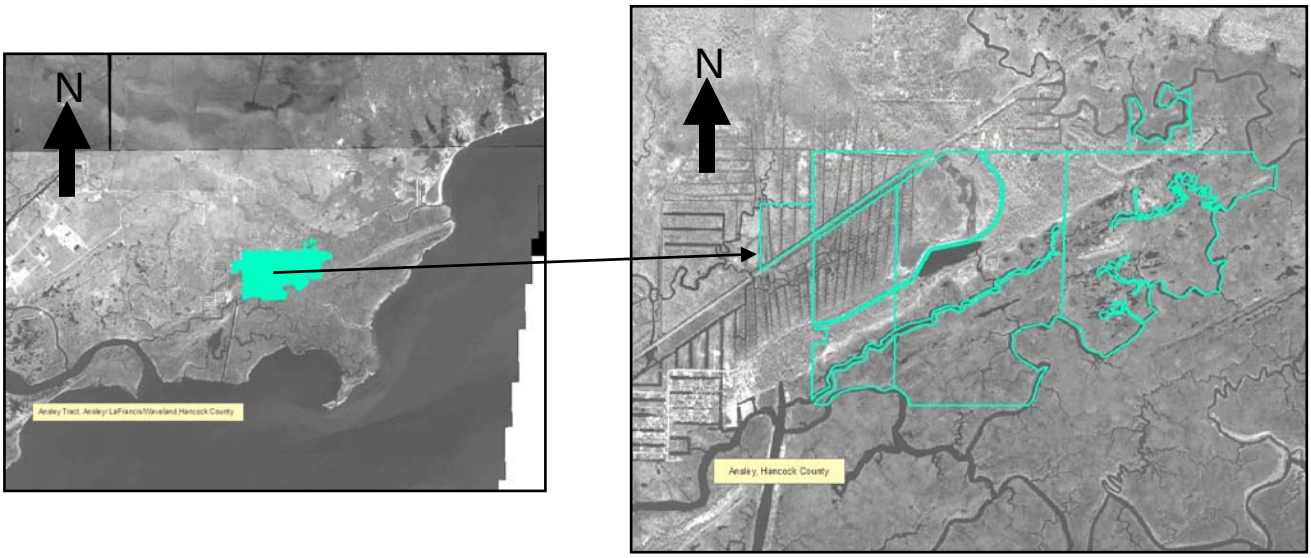
Source: MDMR

Figure 4.1.5.5-3. Wachovia, Hancock County State Initiative Project

Much of the remainder of the tract is forest and savannah, which has suffered wind damage in the form of downed trees and vegetation. This has increased fuel loads and complicated access across the property. This is significant because the fuel loads at Wachovia were already high. The tract is very much in need of prescribed burning, particularly areas that were planted with longleaf pine several years back. The tract is immediately south of Interstate-10 so special considerations will be necessary to facilitate a safe and effective burn. Invasive species, particularly Chinese tallow, are present site wide and will require special attention in the post Katrina environment.

- **SITE:** Ansley, Hancock County

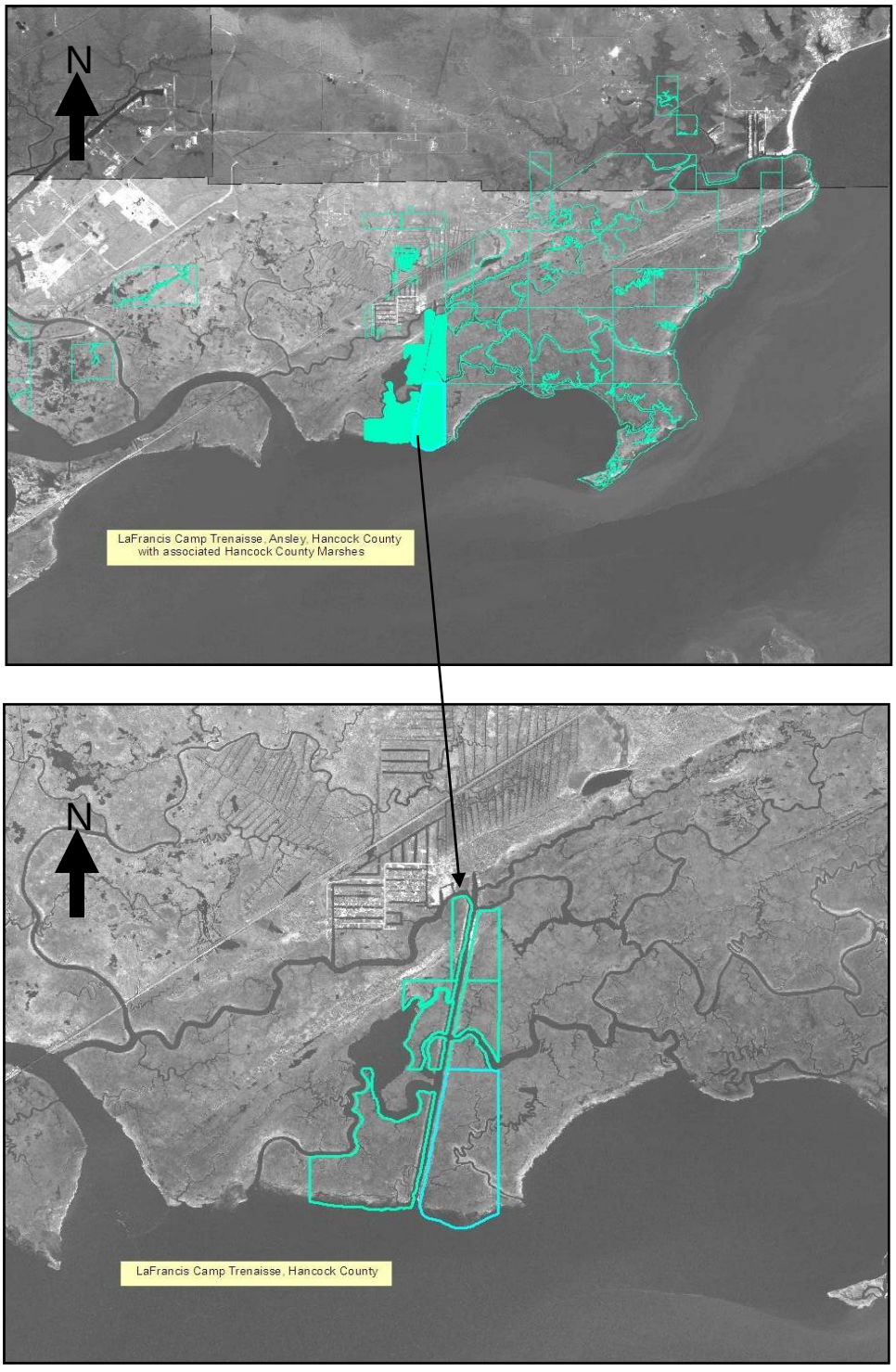
- **DESCRIPTION:** 900 acres total – 800 marsh, 100 forested
- **CONDITION:** The site is primarily marsh, which has experienced limited scouring (Figure 4.1.5.5-4). The recovery from scouring will require further monitoring and assessment. There are significant debris fields within the marsh that extend into the forested areas. Pine timber fared relatively well but hardwoods were heavily damaged. There are significant invasive infestations, primarily Chinese tallow tree. Extensive mosquito ditching disrupts hydrology and creates vectors for invasive species.



Source: MDMR

Figure 4.1.5.5-4. Ansley, Hancock County State Initiative Project

- **SITE:** LaFrancis Camp Trenaisse, Hancock County
- **DESCRIPTION:** 45 acres total – all open water
- **CONDITION:** This "trenaisse" (canal) may simply be the right of way of the underlying gas pipeline that has been progressively widened by small boat traffic and tidal flow (Figure 4.1.5.5-5). Regardless, it intersects two bayous and has significantly reduced their flow and sediment carrying capacity, resulting in a loss of navigability. It is also likely that this canal serves as a direct conduit for storm surge into the LaFrancis/ Heron bay / Ansley community. It is recommended that this channel be closed and restored to its original marsh cover. It is also recommended that the north most bayou (Campbell's Inside Bayou) be dredged to the west if necessary to reestablish navigation to the LaFrancis marina and associated community.
- **SITE:** Gulf Islands National Seashore in Mississippi: Petit Bois, Horn, Ship and Cat Islands in Jackson, Harrison and Hancock Counties
- **DESCRIPTION:** 7,000 acres total
- **CONDITION:** Hurricane Katrina and other recent storms have over washed all barrier islands in the Northern Gulf causing severe erosion, severely damaging or destroying facilities and resources, depositing massive amounts of debris, degrading habitats, and setting the stage for rampant infestations of noxious, invasive plant and animal species. The following proposal is based directly on a post-storm needs assessment prepared by Gulf Islands National Seashore science and management staff.

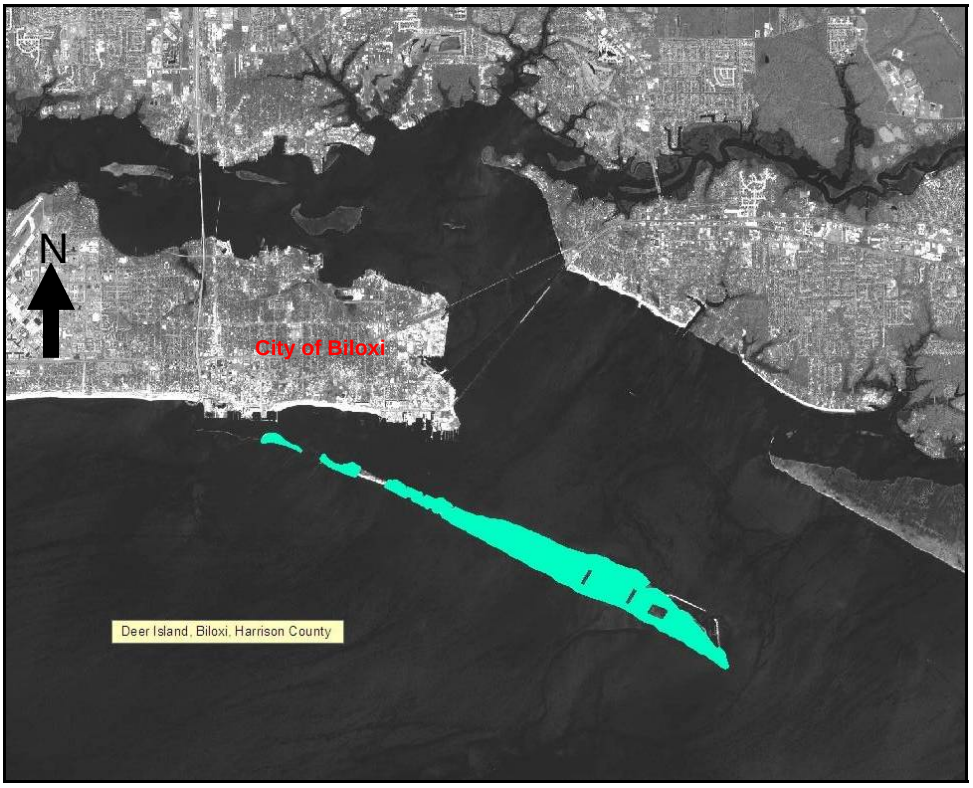


Source: MDMR

Figure 4.1.5.5-5. LaFrancis Camp Trenaisse, Hancock County State Initiative Project

- **SITE:** Deer Island, Harrison County
- **DESCRIPTION:** 450 acres total, 200 marsh, 250 forested

- **CONDITION:** During Katrina, Deer Island lost little actual land area but a significant amount of sand beach and dunes at higher elevations (Figure 4.1.5.5-6). Related to this, a large number of slash pine trees were killed with mortalities approaching 100% near the east end. These trees will need to be replaced to maintain soil stability and avoid more catastrophic erosion in the future. Planting with additional storm hardy tree species, such as live oak should be examined. Advanced, high yield nursery trees would be ideal for this purpose.



Source: MDMR

Figure 4.1.5.5-6. Deer Island, Harrison County State Initiative Project

The stability of current and future created marsh on Deer Island may also be improved. The existing marsh creation project survived relatively well and indicates that marsh creation should be expanded to help provide additional erosion protection and estuarine habitat. However, the very fine grain material used for substrate needs to be augmented with coarser grain sandy sediments to improve consolidation and resistance to erosion. Rip-rap breakwaters could be augmented and protected by adding shell and soil then planting with storm tolerant plants, such as live oaks.

Remaining natural marshes on Deer Island have some invasive species issues, primarily torpedo grass. Chinese tallow trees occur at the site but not as severe infestations and appear to have been stressed by Katrina so the time to treat is now. As with most of the other Coastal Preserve projects, prescribed fire is an important consideration for both for ecological and management related financial reasons.

- **SITE:** DuPont, Harrison County
- **DESCRIPTION:** 650 acres total – 170 marsh, 480 forested

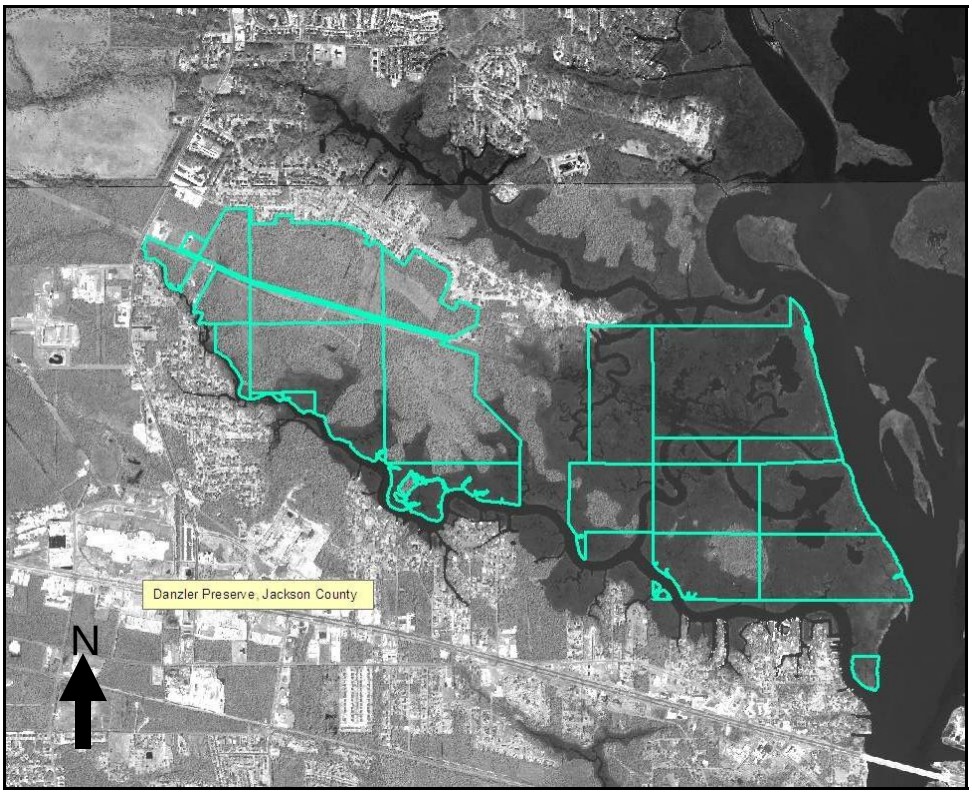
- **CONDITION:** The site is dominated by a 20- to 40-year rough (unburned vegetation) (Figure 4.1.5.5-7). Hurricane Katrina placed many acres of debris into the marshes and forest and downed a very high percentage of hardwoods on the property. There are massive debris fields that will require implementation of clearing and prescribed burns.



Source: MDMR

Figure 4.1.5.5-7. DuPont, Harrison County State Initiative Project

- **SITE:** Danzler, Jackson County
- **DESCRIPTION:** 900 acres total – 500 marsh, 385 forested
- **CONDITION:** The Danzler property was further from Katrina's core and suffered less direct wind and tidal surge damage than many of the other Coastal Preserves (Figure 4.1.5.5-8). However, serious long term consequences are anticipated due to the distribution of Chinese tallow tree propagules across the site. The effort to regain control of Chinese tallow site wide and clean up residual storm debris will be greatly aided by first conducting Comprehensive prescribed burns. Restoring access lost due to storm downfall can be accomplished as part of the preparation for prescribed burning.



Source: MDMR

Figure 4.1.5.5-8. Danzler, Jackson County State Initiative Project

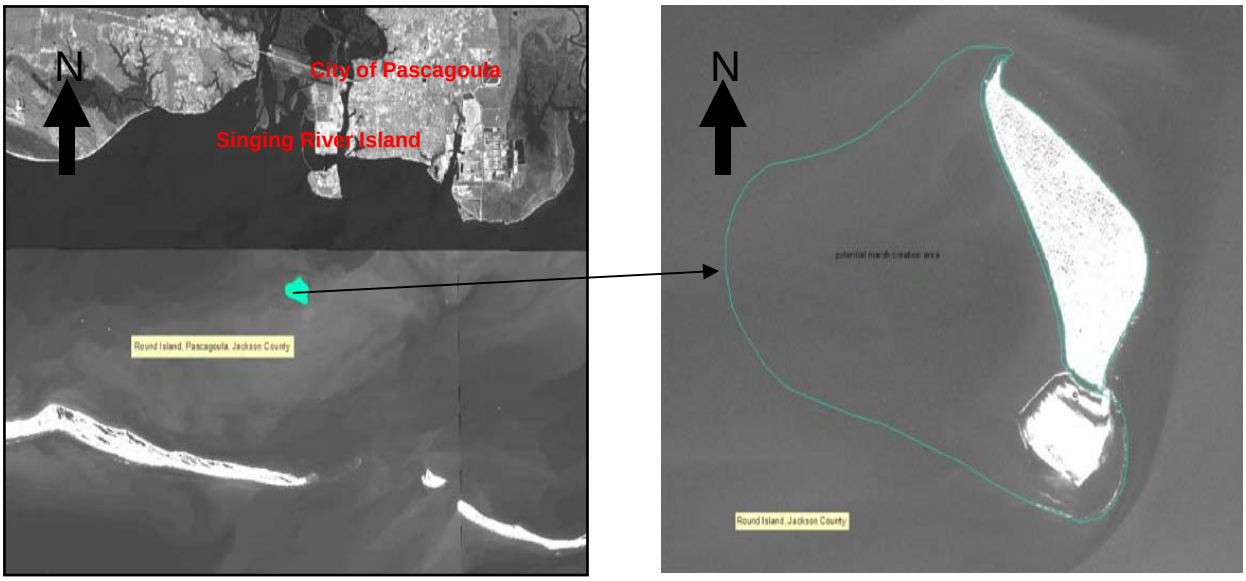
- **SITE:** Pascagoula River Marsh, Jackson County
- **DESCRIPTION:** This preserve consists of 11,150 acres that includes essentially all marsh associated with the mouth of the Pascagoula River. This drainage consist primary of tidal oligohaline marshes which give way to tidal freshwater marshes and tidal Bald Cypress forests and woodlands.
- **CONDITION:** Katrina didn't significantly impact the integrity of the Pascagoula marsh system, but left it exposed to an explosion of invasion exotic species (Figure 4.1.5.5-9). Gaps left by vegetation lost and disturbances in hydrology regimes will increase the recruitment and growth of such species. The two species that are of the greatest concern are *Salvinia molesta* (Giant Salvinia) and *Sapium sebiferum* (Chinese tallow) can truly be considered noxious. Also disturbed areas often support dense, nearly monospecific colonies of *Phragmites australis* common reed which is becoming a greater threat to native species population. Control measures are recommended.



Source: MDMR

Figure 4.1.5.5-9. Pascagoula River Marsh, Jackson County State Initiative Project

- **SITE:** Round Island, Jackson County
- **DESCRIPTION:** 65 acres total, predominantly forested
- **CONDITION:** Round Island has eroded extensively in the past decade (Figure 4.1.5.5-10). Hurricanes George, Dennis, Ivan, Katrina, and numerous tropical storms have all taken their toll. The Island needs basic management to deal with post-storm conditions. Prescribed burning is needed to reduce fuel loads, improve access, and restore ecological integrity. Invasive species control is required primarily for Chinese tallow trees. Limited planting of new trees will be conducted to improve stand quality and diversity to help insure long-term stability of the remaining original island.

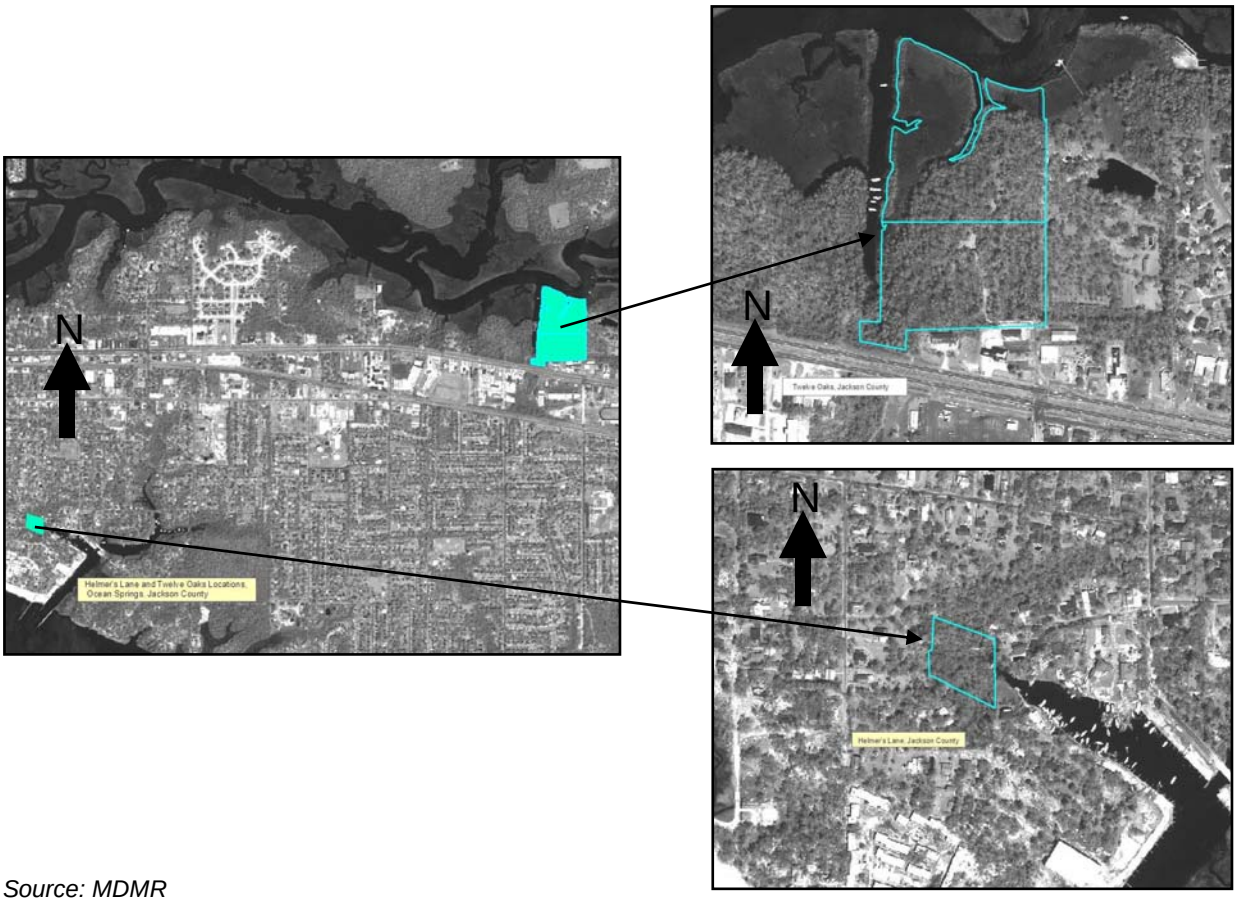


Source: MDMR

Figure 4.1.5.5-10. Round Island, Jackson County State Initiative Project

Round Island also represents an excellent opportunity to restore and create marsh and other estuarine systems. It is proposed that marsh be created on the west side, protected from the prevailing long shore current. In turn the island would be protected on its east and south by a vegetated breakwater (i.e. essentially an artificial chenier). Marsh would also be created on the lee side of the breakwater to the south.

- **SITE:** Twelve Oaks and Helmer's Lane, Jackson County
- **DESCRIPTION:** 30 forested
- **CONDITION:** These properties are in the Coastal Preserve boundary and are partially owned by the Land Trust for the Mississippi Coastal Plain (Figure 4.1.5.5-11). Both tract suffered significant blow down and Helmer's received a massive amount of debris from the Ocean Spring's Harbor, which has been largely removed by volunteers. Funding is requested to help remove dangerous snagged trees, some of the heavy downed timber, treat noxious invasive weeds and reforest as needed.



Source: MDMR

Figure 4.1.5.5-11. Twelve Oaks and Helmer's Lane, Jackson County State Initiative Project

4.1.6 Projects from Interim Report carried for further Consideration

Table 4.1.6-1.
180 Projects – Environmental

Name	PRIME_AUTH	SEC_AUTH	TERT_AUTH	Problem_ID	Addressed By:
Coastal Mississippi Artificial Reef Project for Remediation of 2005 Hurricane Damage	Other			Hurricane Storm Damage & Reduction (HSDR), Sub-surface Erosion, Fish & Wildlife Habitat Degradation.	MDMR
Restore more natural freshwater flows by closing the MRGO	Ecosystem Restoration (ER)				Corps, New Orleans
Restore grassbeds in MS Sound	HSDR	ER			MsCIP Comprehensive - SAV Restoration
Replace structures with marshes.	ER	Flood Damage Reduction (FDR)			MsCIP Comprehensive - SDSS/Non-structural
Provide 100 acres of oyster reef restoration	ER	HSDR			MsCIP Interim & Comprehensive - Partnership with MDMR
Provide an incentive for replacing failing septic systems in rural areas to improve water quality along bayous and bays.	Other				USEPA
Add wetlands along main drainage systems in each location to increase capacity of the systems during rainfall and surge flooding events.	ER	FDR			MsCIP Comprehensive - SDSS
Consider brown water system to minimize demand on ground and surface waters and limit saltwater intrusion.	Other				USEPA
Consider all archaeological sites in planning process Many significant coastal sites are eroding and need to be preserved.	HSDR				MsCIP Comprehensive - Programmatic EIS

Table 4.1.6-1.
180 Projects – Environmental (continued)

Name	PRIME_AUTH	SEC_AUTH	TERT_AUTH	Problem_ID	Addressed By:
Marsh Restoration where Feasible This can be done in conjunction with private and government dredging projects	ER	HSDR	FDR		MsCIP Comprehensive - SDSS & Barrier Islands
Partnership Efforts with Louisiana to Marsh Island Areas	OTHER				LaCPR Comprehensive
Barrier Islands - Restoration (to a natural setting)	ER	HSDR			MsCIP Comprehensive - SDSS & Barrier Islands
Allow nature to dictate wetlands vs. beach to a greater degree	FDR	EC			MsCIP Comprehensive - SDSS
Hancock County Comprehensive HSDR - Ecosystem Restoration	HSDR	ER		HSDR and Erosion of beach, seawall, and road raising and/or repair; sand placement, dune restoration; potential 5-8 miler reach.	MsCIP Interim & Comprehensive
Jackson Wetland Restoration	ER	HSDR		HSDR, Erosion to drainage outfalls and interior drainage facilities.	MsCIP Interim
St. Louis Bay Comprehensive ER	ER	HSDR		HSDR, Erosion, Fish & Wildlife Habitat Degradation.	MsCIP Comprehensive - Future Studies
Lakeshore Beach ER	ER	HSDR		HSDR, Erosion, Fish & Wildlife Habitat Degradation.	Environmental Concerns - Potential SAVs
Biloxi Marshes Comprehensive ER	ER	HSDR	FDR	HSDR, Fish & Wildlife Habitat Degradation, Silt Deposition, Saltwater Intrusion.	MsCIP Comprehensive - Freshwater Diversion/Future Studies
Clermont Lake ER	ER	FDR	HSDR	HSDR, Erosion, Fish & Wildlife Habitat Degradation, Saltwater Intrusion and/or contamination.	MsCIP Comprehensive - SDSS
Magnolia Branch ER	HSDR	ER		Use conservation easements to restore magnolia branch.	MsCIP - SDSS

Table 4.1.6-1.
180 Projects – Environmental (continued)

Name	PRIME_AUTH	SEC_AUTH	TERT_AUTH	Problem_ID	Addressed By:
Jordan River Shores ER. Home owner assistance and relocation, return hydrology, begin mitigation, prohibit new/more development	FDR	ER		Return hydrology, begin mitigation, prohibit new/more development.	MsCIP Comprehensive - Non-Structural/SDSS
Pearlington ER – Home owner assistance and relocation and return hydrology	FDR	ER		Homeowners assistance and relocation project and return hydrology.	MsCIP Comprehensive - Non-Structural/SDSS
Shoreline Park Home owner assistance and relocation	FDR	ER		See Shoreline Park Home owner assistance and relocation.	MsCIP Comprehensive - Non-Structural/SDSS
Restore all Hancock (all coastal MS) marshes damaged by storm	HSDR	ER			MsCIP Comprehensive - Freshwater Diversion/Non-Structural/SDSS
Restore Hancock County Beaches to Pre-Katrina conditions	HSDR	ER			MsCIP Interim
Widen Hancock County Beaches, jump-start dunes	HSDR	ER			MsCIP Interim
Preserve Bayou Caddy Area	ER				MsCIP Interim
Protect Hancock County wetlands from filling for development	FDR	ER			MsCIP Comprehensive - SDSS
Turkey Creek Watershed Improvements	FDR	HSDR		HSD exacerbation to existing drainage systems.	MsCIP Comprehensive - Non-Structural/SDSS/ Future Studies
Tchoutacabuffa River Flood Damage and Watershed Improvement	FDR	ER		HSD to existing development, marsh damage due to surge.	MsCIP Comprehensive - Future Studies
Biloxi Back Bay Watershed Management and Ecosystem Restoration	ER	FDR		HSD, Erosion, FW Habitat Degradation, Saltwater Intrusion and/or contamination.	MsCIP Comprehensive - Future Studies
Courthouse Road Wetlands Ecosystem Restoration and Preservation	ER	FDR		HSD, Erosion, FW Habitat Degradation.	MsCIP Interim
Deer Island Ecosystem Restoration	ER	HSDR		HSD, Erosion, FW Habitat Degradation.	Section 528 Construction General & FCCE Funds

Table 4.1.6-1.
180 Projects – Environmental (continued)

Name	PRIME_AUTH	SEC_AUTH	TERT_AUTH	Problem_ID	Addressed By:
DÆIberville Wetlands Ecosystem Restoration	ER	HSDR		HSD, Erosion, FW Habitat Degradation.	MsCIP Comprehensive - Non-Structural/SDSS
Acquire wildlife corridors in lands that repeatedly flood	FDR	ER		Acquire and set aside green corridors in areas that have flooded often, such as Turkey Creek in Harrison, Bay Side Park). The Land Trust would hold land in perpetuity.	MsCIP Comprehensive - Non-Structural/SDSS
Develop Concrete Staging Center in Industrial Canal. Develop Harrison county industrial canal artificial reef staging area to stockpile concrete debris for oyster reef and other useful projects.	OTHER			Develop Harrison county industrial canal artificial reef staging area to stockpile concrete debris for oyster reef and other useful projects.	MDMR and MsCIP Comprehensive - Partnership with State
Restore or enhance Mississippi oyster reefs.	HSDR	ER		90-95% of the reefs were destroyed by Katrina. MS had around 12,000 areas of productive reefs prior to Katrina.	MDMR and MsCIP Comprehensive - Partnership with State
Utilize HW 90 bridge as artificial reef material	OTHER			Utilizing Highway 90 Bridge as Artificial Reef Material	MDMR Completed
Wiers (low level dams) within estuaries to control water flow	OTHER				MsCIP Comprehensive - Freshwater Diversion
Purchase riparian buffers, wetland areas.	FDR	ER			MsCIP Comprehensive - Non-Structural/SDSS
Reconsider dioxin cleanup on navy base post Katrina.	OTHER				USEPA
Reduce toxic exposure which exacerbates storm damage - Dioxin, Creosote, Titanium Dioxide, Gypsum.	OTHER				USEPA
Turkey Creek watershed Greenway	ER				MsCIP Comprehensive - Future Studies

Table 4.1.6-1.
180 Projects – Environmental (continued)

Name	PRIME_AUTH	SEC_AUTH	TERT_AUTH	Problem_ID	Addressed By:
Forrest Height Levee :- Restore; Vegetate with native species; Footbridges; Nature trail atop	HSDR	FDR			MsCIP Comprehensive
Turkey Creek: Mt. Pleasant UME Audubon site 41, Tidal Creek restoration of flood plain.	FDR	ER		Tidal Creek restoration of floodplain.	MsCIP Comprehensive - Future Studies
Possibly add height to the existing beach elevation and redevelop lost dune vegetation.	HSDR	ER			MsCIP Interim & Comprehensive
Front Beach Boulevard ER and Erosion Control	HSDR	ER			MsCIP Comprehensive - Non-Structural/SDSS
Front Beach Road Wetlands	ER	HSDR			MsCIP Comprehensive - Non-Structural/SDSS
East Beach Road ER	ER	HSDR			MsCIP Comprehensive - Non-Structural/SDSS
Belle Fontaine Marsh	HSDR	ER			MsCIP Comprehensive - Non-Structural/SDSS
Biloxi Back Bay	FDR	ER	HSDR		MsCIP Comprehensive - Future Studies
Davis Bayou ER	ER	HSDR			MsCIP Comprehensive - Future Studies
Jackson County Marsh Outlet ER	HSDR	ER	FDR	HSD and sediment infilling of existing drainageways and drains.	MsCIP Comprehensive - Non-Structural/SDSS
Gautier Hurricane Storm Damage Reduction and Ecosystem Restoration/Ladnir Rd	HSDR			HSD, Erosion, Storm-caused failure of bulkhead, road damage, severance of evacuation route, threats to bridge.	MsCIP Interim & Comprehensive - Non-Structural/SDSS
Pascagoula beaches, offshore breakwater/dunes/reefs/marshes to dissipate wave energy	HSDR	ER		HSD and sediment infilling of existing drainageways and drains.	MsCIP Interim

Table 4.1.6-1.
180 Projects – Environmental (continued)

Name	PRIME_AUTH	SEC_AUTH	TERT_AUTH	Problem_ID	Addressed By:
Restore natural drainage ways upper Bayou Castelle (vic Fishhawk Rd, Meadow Dale Dr., Longwood Dr, and Bayou Castelle Dr)	FDR	HSDR		Restore natural drainage ways upper Bayou Castelle (vic Fishhawk Rd, Meadow Dale Dr., Longwood Dr, and Bayou Castelle Dr).	MsCIP Comprehensive - Non-Structural/SDSS
Robert Hiram Bridge (Gautier) Hurricane evacuation route. Wetlands restoration, drainage	HSDR	FDR	ER	Hurricane evacuation route. Wetlands restoration drainage.	MsCIP Comprehensive - Non-Structural/SDSS
Graveline Road Bridge at Shepard St Park (County)	HSDR	FDR	ER	Hurricane evacuation route. Wetlands restoration drainage.	MsCIP Comprehensive - Non-Structural/SDSS
W River Delta restoration. Bulkhead western channel. Beneficial use. Wave protection for subdivisions.	HSDR	ER		Bulkhead western channel. Beneficial use. Wave protection for subdivisions.	MsCIP Comprehensive - Freshwater Diversion
Bennett Bayou tidal marsh restoration	HSDR	ER		Provide wetland function in a highly visible project area for public education and promote the Gov's Restoration Initiative.	MsCIP Comprehensive - Non-Structural/SDSS
Pascagoula Beach Restoration. Dunes, grasses, trees, with intermittent pockets of sand beach	HSDR	ER		HSD, Erosion, Bridge abutment damage.	MsCIP Interim
Ebb and flow of Intracoastal veins from the MS Sound to rebuild property with the erosion in the bayous near potential project #66.	HSDR	FDR			MsCIP Comprehensive
Cedar Point/West River-Restore beaches, sand, work, sediment management in this area	HSDR				MsCIP Comprehensive
ER along Hwy 90, Jackson County	ER	HSDR			MsCIP Comprehensive - Non-Structural/SDSS

Table 4.1.6-1.
180 Projects – Environmental (continued)

Name	PRIME_AUTH	SEC_AUTH	TERT_AUTH	Problem_ID	Addressed By:
Improve the Jackson-county seawall. Provide additional county-wide seawall construction, boardwalks, beach construction, marsh construction, or a combination of these elements	HSDR	ER			Duplicate
Rebuild and enlarge Marsh Island	ER	HSDR			Corps, New Orleans
Divert water from Escatawpa River into Bayou Cumbest to restore freshwater flow to the bayou and improve water quality.	ER				MsCIP Comprehensive - Freshwater Diversion
Pascagoula brown water system study	OTHER			Brown water system study.	USEPA
Pascagoula Beach Blvd. Restoration (Boardwalk, beach, and marsh addition along Pascagoula front beach)	HSDR	ER		Boardwalk, beach, and marsh addition along Pascagoula front beach.	MsCIP Interim/FEMA/City of Pascagoula

4.1.7 Mitigation Measures

The Council of Environmental Quality's (CEQ) Regulations for Implementing the Procedural Provisions of National Environmental Protection Act (NEPA) [40 Code of Federal Register (CFR) 1500-1508] clarify the requirements by defining direct effects, indirect effects, and cumulative effects.

- **Direct Effects.** Those effects caused by the action and occurring at the same time and place. [40 CFR 1508.8].
- **Indirect Effects.** Those effects caused by the action and occurring later in time or farther removed in distance, but still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems. [40 CFR 1508.8].
- **Cumulative Impacts.** Those impacts on the environment, which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. [40 CFR 1508.7].

Implementation of structural plans identified in the Engineering Appendix would require placement of fill in wetlands, including open-water habitats, in Coastal Mississippi. These structural plans involve direct, indirect and cumulative impacts, such as the filling in of wetlands and loss of wetlands in the future. A more detailed discussion of these impacts can be found in the MsCIP Comprehensive Report and Integrated Programmatic EIS and also in the Engineering Appendix. Overall, structural measures have been developed in ways that avoid or minimize wetland impacts. The Environmental PDT worked closely with the Engineering PDT to ensure that levee alignments went through land that would result in the least impact. This has resulted in several alternative alignments of structural components; however, there are still some wetland impacts anticipated.

The direct loss of wetlands by structural measures would be mitigated in order to ensure no net loss occurs in Coastal Mississippi. The Environmental PDT utilized as a guide the current mitigation bank ratio policies currently implemented in Coastal Mississippi as an early surrogate to preliminarily assess mitigation costs. Mitigation for impacts to wetlands would be accomplished by creation of tidal and non-tidal wetlands throughout the three coastal drainage basins. Should any of these structural plan elements be tentatively selected for construction and/or additional study, the actual development of the mitigation plan and associated costs would be developed at that time.

LOD 3 (i.e. elevation of the existing roadway and seawall along the mainland shoreline) would result in the loss of 2.6 acres of tidal wetlands and 13.1 acres of non-tidal wetlands. There are no alternative designs due to the technical feasibility.

LOD 3 (i.e. ring levees around coastal communities) would result in the loss of up to 81.4 acres of tidal wetlands and up to 182.8 acres of non-tidal wetlands. Several optional layouts have been considered, which would result in less wetland acreage impacts. The Forrest Heights Levee project located in the City of Gulfport, Harrison County is tentatively selected for construction. Under this 21-foot alternative, there is an expected loss of 3.6 acres of wetland vegetation impacted by construction of the levee. Although native vegetation under the levee footprint would be lost, the levee itself would be vegetated with non-native species for stabilization of the structure. Alternative alignments results in impacts being reduced to approximately 12 acres of tidal wetlands and 67 acres non-tidal wetlands. LOD 4 (i.e. inland barrier and surge gates) would result in the loss of up to

138.1 acres of tidal wetlands and up to 287.4 acres of non-tidal wetlands. The alternate ring levee alignment can be found in the Engineering Appendix.

The surge gates crossing Bay of St. Louis would result in the loss of approximately 35 acres of waterbottoms. Detailed discussion regarding the design, location, and operations and maintenance of these structures are discussed in the Engineering Appendix. Mitigation would be accomplished by the creation of 175 acres of tidal fringe wetlands throughout the Bay of St. Louis vicinity. An alternative ring levee around Bay St. Louis would impact up to 1.4 acres tidal wetlands and up to 54.6 acres non-tidal wetlands. An alternate alignment of the inland barrier in the western portion of Harrison County along Menge Avenue would reduce impacts to waterbottoms. Implementation of this alternative alignment would impact up to 33 acres of non-tidal wetlands. By implementation of these two alternate alignments, the need for a surge gate crossing the Bay of St. Louis would be eliminated.

The surge gates crossing of Biloxi Bay would result in the loss of 27 acres of waterbottoms. Mitigation would be accomplished by creation of 135 acres of tidal fringe wetlands throughout Biloxi Bay vicinity. No alternatives have been developed.

Further development of alterative alignments are being currently refined in order to reduce potential impacts and to include all necessary structural components. An example of this is the construction of a ring levee around Bay St. Louis and an alternate alignment along Menge Avenue (i.e. LOD 4), which would eliminate the surge gate crossing the Bay of St. Louis. This is an ongoing formulation process in order to determine the best possible alignments.

4.2 Tentatively Selected Plans

The environmental component of the MsCIP Comprehensive Report and Integrated Programmatic EIS consists of the construction of environmental restoration projects that would ensure preservation of fish and wildlife, prevent saltwater intrusion, and provide stabilization of shorelines, in order, to reduce or eliminate coastal erosion and restore lost fish and wildlife habitat. These potential environmental restoration projects would restore low-lying areas; thus, reducing future storm damages to Coastal Mississippi. Residents and structures (i.e. commercial and residential) would be moved from these areas. In addition, the restoration of historic environmental settings would provide a natural buffer to future storm damages while also benefiting fish and wildlife.

Potential projects include freshwater diversion projects into Western Hancock County Marshes that have severely degraded over the years due to levee systems in eastern Louisiana and along the Pearl River, causing a decline in oyster resources.

Restoration of lost ecosystem functions where restoration needs are immediate due to unchecked wetland deterioration. As Coastal Mississippi residents are rebuilding much needed housing, there is an increase in developmental pressures on these valuable ecosystems due to housing shortages. The Environmental Tentatively Selected Plan would allow for restoration of storm damaged habitats and coastal systems and would prevent further destruction of these vital habitats. Wetlands in Coastal Mississippi can be restored to a sustainable level, one that coexists with human uses and communities.

Restoring critical landforms, barrier island shorelines, historical hydrologic patterns, and the sediment transport and budget system are crucial in order to sustain ecological and geomorphological function in perpetuity. The Environmental Tentatively Selected Plan has an emphasized interagency cooperation as dedicated staff members include representatives from the Corps, Mobile District, USFWS, and NPS. Additionally, we have collaborated with other resource agencies that include USEPA, USGS, NRCS, NOAA Fisheries (PRD & HCD), MDEQ, and MDMR.

The Environmental Tentatively Selected Plan partners with the State and recommends for construction of state recommended initiative projects that allow for recovery of badly damaged ecosystems. Additional collaboration has and will continue to occur with NGOs, including TNC, Gulf Restoration Network, The Sierra Club, The Audubon Society, etc., in addition to Mississippi academic coastal engineers and biologists, such as USM, Gulf Coast Research Lab, and MSU, in order to accomplish widespread support for this environmental effort. A strong public involvement campaign has been used to ensure contributions have been submitted by local constituencies and stakeholders in order to create strong buy-in on potential restoration projects.

CHAPTER 5. TENTATIVELY SELECTED PLANS

The results of the alternative development, comparison, modification, screening, and selection process indicated that the recommended approach presented the most cost-effective solution, and was clearly the best-balanced plan where all factors were taken into consideration. All tentatively selected plans on ecosystem restoration have incorporated adaptive management capabilities, where needed.

The **Tentatively Selected Environmental Plans for Coastal Mississippi** consists of the following:

5.1 Ecosystem restoration of historical wetlands previously developed

5.1.1 Plan Formulation

The Corps, Mobile District began investigations for identifying potential environmental restoration sites for the purposes of storm and flood damage reduction, flood reduction, preservation of fish and wildlife habitat, and removal of habitable structures within high hazard areas. When residential and/or commercial structures and/or land are purchased for the purpose of restoring floodplain areas (i.e. non-structural component), the structures are demolished and the land is no longer available for residential and/or commercial development. Historically, when land is purchased across the U.S., it is left with all or some of the infrastructure at the site rather than restoring it to its historic setting. With the MsCIP environmental plan, land that is purchased (i.e. non-structural component – refer to Non-structural Appendix) would then be restored into historical functional wetlands. The Corps, Mobile District, in cooperation with ERDC, developed a tool to help identify potential restoration sites throughout the study area.

Development of a GIS based SDSS tool allowed the Corps, Mobile District, working in cooperation with the USFWS and MDMR, to identify and prioritize potential wetland restoration areas throughout Coastal Mississippi (Lin 2007). A detailed discussion of this GIS based SDSS tool is included in this Environmental Appendix. A subset of potential restoration sites were identified by the SDSS tool and then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS. This interagency team allowed us to both confirm the accuracy of the SDSS results and to collect additional on-site information pertinent to restoration efforts. There are some major benefits in using a GIS-based SDSS approach to wetland restoration. First, it allows for the relatively rapid assessment of the large number of restoration sites across the wide study area. Second, potential sites can be evaluated and restored in a watershed or landscape context, which allows us to comprehensively evaluate the overall natural system. This approach can maximize the benefits of wetland restoration, as opposed to simply restoring wetlands where convenient or where property is available. Essentially use of this SDSS tool allowed the MsCIP environmental team to assess the entire coastline as a holistic natural system; thus, the team was more effectively able to analyze needs in Coastal Mississippi.

The SDSS effort resulted in the following products:

1. ModelBuilder based SDSS tool, which can be subsequently edited and applied to other areas along Coastal Mississippi in the future as funding becomes available;

2. Maps, such as aerial photography, topographic, soil layers, etc., depicting areas in the study region that have a high probability of being successfully restored into wetland functions that buffer and/or store stormwater, and provide suitable habitat for fish and wildlife; and

3. Photograph documentation and data sheets containing information on ground-truthed potential restoration sites.

This project has been further coordinated with the ongoing efforts of the MsCIP non-structural flood-proofing committee, and their results were used as the team identified potential restorations sites in Coastal Mississippi. The selection of 34 restoration sites, identified in Section *4.1.5.2 Environmental Restoration of Historical Wetland Sites*, was based on a combination of results from the SDSS tool and input from MDMR personnel based on local knowledge of the study area and adjacency to existing sensitive protected natural areas (i.e. State and/or Federal lands). A summary discussion of this effort follows.

5.1.1.1 SDSS

The SDSS tool evaluated potential wetland restoration sites that had been initially selected based on having a non-natural land cover (i.e. urban, deforested, and agricultural land cover, based on MDMR 2001 land cover GIS layer) and were located in the 100-year floodplain (Lin 2007). Numerous potential environmental restorations sites were initially identified. This initial group of sites was narrowed down based on the results of the SDSS. Sites with the following characteristics were screened out:

- < 5 acres in size
- Restorability class of Low or Medium Low
- Habitat class of Low or Medium Low
- Storm Surge/Flood Protection class of Low

5.1.1.1.1 Environmental Restoration Sites

Screening yielded numerous sites that were then reviewed by the Corps, Mobile District, MDMR, and USFWS personnel and based on this input the tentatively selected sites identified as Phase I as Turkey Creek, Bayou Cumbest, Admiral Island, Dantzler and Franklin Creek (discussed in the following sections in detail) and the other 38 final restoration sites identified as Phase II (shown in Table 5.1.1.1.1-1) were selected. These final environmental restoration sites include a combination of those identified based on the SDSS results, as well as some additional sites (i.e. State Initiatives). These were made using only the non-natural land-use and 100-year flood calculations as the original site selectors (i.e. no damage layers were used), and sites were greater than or equal to 5 acres.

Table 5.1.1.1.1-1.
Environmental Restoration Sites in Coastal Mississippi

Site	Restoration Acres	Environmental Habitat Setting	Cost
(1) Pearlington, Hancock	76 acres (State owns 2,200 acres in the Pearlington area)	Emergent aquatic vegetation Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$ 30,200,000
(2) Pearlington South, Hancock	11 acres	Emergent aquatic vegetation Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$ 23,400,000
(3) Port /West, Hancock	49 acres	Emergent aquatic vegetation	$ 19,800,000
(4) Ansley, Hancock	2,023 acres (State owns 6,000 acres west of Lakeshore Road)	Emergent aquatic vegetation Wet pine savannah	$ 482,100,000
(5) Heron Bay	594 acres	Emergent aquatic vegetation	$ 192,100,000
(6) Lower Bay	226 acres	Emergent aquatic vegetation	$53,000,000
(7) Lakeshore, Hancock	275 acres	Emergent aquatic vegetation	$ 69,200,000
(8) Bayou Caddy/Lakeshore, Hancock	362 acres	Emergent aquatic vegetation	$ 113,400,000
(9) Clermont Harbor, Hancock	209 acres	Emergent aquatic vegetation	$ 208,300,000
(10) Bayou La Croix, Hancock	259 acres	Emergent aquatic vegetation	$ 207,100,000
(11) Shoreline Park, Hancock	889 acres	Emergent aquatic vegetation	$ 1,259,200,000
(12) Chapman Road, Hancock	146 acres	Emergent aquatic vegetation	$ 174,100,000
(13) Jourdan River – Interstate 10 Development, Hancock	638 acres	Emergent aquatic vegetation	$ 155,900,000
(14) Diamondhead, Hancock	433 acres	Emergent aquatic vegetation	$ 267,700,000
(15) Delisle, Harrison	120 acres (State owns 1,000 acres)	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs	$ 41,900,000
(16) Ellis Property, Harrison	443 acres	Emergent aquatic vegetation Pine savannah - wet pine flatwoods.	$ 60,300,000
(17) Pine Point East, Harrison	103 acres (State owns 40-50 tax forfeited lots)	Emergent aquatic vegetation Wet pine savannah habitat	$ 47,500,000

Table 5.1.1.1.1-1.
Environmental Restoration Sites in Coastal Mississippi (continued)

Site	Restoration Acres	Environmental Habitat Setting	Cost
(18) Pine Point West, Harrison	83 acres (State owns 40-50 tax forfeited lots)	Emergent aquatic vegetation Wet pine savannah habitat	$ 36,700,000
(19) Pass Christian Beach Front, Harrison	21 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs	$ 10,700,000
(20) Pass Christian Site – Bayou Portage, Harrison	43 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs	$ 27,800,000
(21) Brickyard Bayou, Harrison	14 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs	$ 7,000,000
(22) Biloxi River – Shorecrest, Harrison	15 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs Riverine/levee forests	$ 12,500,000
(23) Biloxi River – Eagle Point, Harrison	17 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs Riverine/levee forests	$ 17,400,000
(24) Biloxi Front Beach - South of Highway 90, Harrison	40 acres	Dune System	$ 60,500,000
(25) Keegan Bayou, Harrison	54 acres	Emergent aquatic vegetation Wet Pine Savannah habitat	$ 31,500,000
(26) St. Martin, Jackson	467 acres	Emergent aquatic vegetation	$ 147,500,000
(27) Fort Point, Jackson	83 acres	Emergent aquatic vegetation	$ 29,400,000
(28) Pine Island, Jackson	237 acres	Emergent aquatic vegetation	$ 518,600,000
(29) Belle Fontaine, Jackson	1,516 acres	Dune System	$ 373,700,000
(30) Griffin Point, Jackson	182 acres	Emergent aquatic vegetation	$ 70,900,000
(31) Bayou Chico, Jackson	258 acres	Emergent aquatic vegetation	$ 82,900,000
(32) Grand Bay/Bayou Cumbest, Jackson	2,666 acres	Emergent aquatic vegetation	$ 621,400,000
(33) Wachovia, Hancock	1,200 acres total – 800 marsh, 200 forested, 200 savannah	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$ 2,830,000
(34) Ansley, Hancock	900 acres – 800 marsh, 100 forested	Emergent aquatic vegetation, Wet pine savannah	$ 2,420,000
(35) LaFrancis Camp Trenaisse, Hancock	45 acres total – all open water	Open Water	$ 8,770,000
(36) DuPont, Harrison	650 acres – 170 marsh, 480 forested	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$ 4,500,000
(37) Dantzler, Jackson (Alternate)	900 acres – 500 marsh, 385 forested	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$ 6,597,000
(38) Pascagoula River Marsh, Jackson	11,150 acres	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests	$ 2,230,000

Table 5.1.1.1.1-1.
Environmental Restoration Sites in Coastal Mississippi (continued)

Site	Restoration Acres	Environmental Habitat Setting	Cost
	27,397 acres	**Grand Total**	**$ 5,481,047,000**

Source: MsCIP Environmental Team

The MsCIP environmental team then re-evaluated potential environmental restoration sites to see if there were any additional potential sites based on local knowledge of the coast. Existing wetlands targeted by MDMR for improvements, rather than restoration, were quickly identified by the team members. Because these sites are classified as having a natural land cover, they were not included in the initial selection of potential sites evaluated by the SDSS. Sites targeted by MDMR for restoration to upland habitat were also identified as potential restoration. Since the SDSS tool was evaluating sites based on wetland restoration potential, these sites were screened out for having a *Restorability class of Low or Medium Low*. Therefore, the local knowledge assisted in identifying and including these sites in the list.

For example, Shoreline Park was screened out after the SDSS evaluation because it had a *Medium Low restorability classification*. This Medium Low score was a result of large portions of Shoreline Park having been mapped in the state's soil survey as essentially a *spoil/fill* category, which is classified as non-hydric. However, it is known that historically the Shoreline Park area contained hydric soils, which could easily be restored through the removal of the existing fill and spoil. Therefore, this restoration site was then reinstated.

5.1.1.1.2 Initial Projects – Two Environmental Restoration Sites

Two potential restoration sites were chosen as *Phase I initial projects* to be carried forward in the environmental component of the MsCIP Comprehensive Plan. The potential restoration sites are located throughout the study area. One of the sites consists of restoring emergent tidal marsh and scrub/shrub habitat and the other site restores wet pine savannah habitat. The two sites allow the Corps, Mobile District to demonstrate the planning process involved in developing environmental restoration measures, development of alternatives, and selection of a cost-effective restoration plan (refer to the Economic Appendix for a detailed cost-effective discussion) for each potential environmental restoration site. This short-term effort was classified by the PDT as Phase I of a two phased approach, which allows for short-term and long-term comprehensive efforts. Phase II includes environmental restoration projects that require a longer timeframe to complete. If selected for further study, all 38 potential sites would go through a similar planning and evaluation process under the Phase II – Longer Term Comprehensive effort. Table 5.1.1.1.2-1 demonstrates how the identified environmental restoration projects allow the Environmental and overall MsCIP PDTs to achieve the overall project goals and objectives.

Table 5.1.1.1.2-1.
MsCIP Comprehensive Approach

Proposed Restoration Project	Portion of the Ecotone to be Addressed	Ecological/Societal Functions to be Addressed	Comprehensive Plan Objectives to be Addressed
Freshwater Diversion, Escatawpa River, MS	Littoral areas, emergent wetland areas	Enhanced oyster production, enchanced productivity of brackish marshes	3, 4, 5, 6
Other Coastal Wetland and Forest Restoration	Emergent Tidal Marsh Scrub/Shrub	Enhanced productivity of emergent tidal wetland, habitat enhancement, relocation of human development out of the coastal ecotone for public safety	1, 2, 3, 5, 6
Levee Projects – Belle Fontaine, Gulf Park Estates, Pascagoula/Moss Point, Pearlington, Gautier, Ocean Springs, Bay St. Louis	Reduces flooding	Adds protection to human development out of the coastal ecotone for public safety zone	1, 2, 6
Long-term High Hazard Area Risk Reduction Plan	Restore natural flooding buffer	Restore natural buffer zone, relocation of human development out of the coastal ecotone for public safety	1, 2, 6
Freshwater Diversion of the Mississippi River	Littoral areas, emergent wetland areas	Enhanced oyster production, enchanced productivity of brackish marshes	3, 4, 5, 6
High Hazard Area Risk Reduction Plan	Emergent tidal marsh, forested wetlands	Enhanced productivity of wetlands and forested wetlands in order to restore natural buffer zone	1, 2, 6
Moss Point Municipal Relocation Component	Restore natural flooding buffer	Restore natural buffer zone, relocation of human development out of the coastal ecotone for public safety	1, 2, 6
Waveland Floodproofing	Restore natural flooding buffer	Restore natural buffer, relocation of human development out of the coastal ecotone for public safety zone	1, 2, 6
Forest Heights Hurricane and Storm Damage Reduction Component	Reduces flooding	Adds protection to human development out of the coastal ecotone for public safety zone	1, 2, 6
Turkey Creek Ecosystem Restoration	Wet Pine Savannah Wetlands	Enhanced productivity of wetlands Removes structures from project area	1, 2, 3, 6
Dantzler Restoration Area Ansley	Wet Pine Savannah Wetlands	Enhanced productivity of wetlands	1, 3, 6
Franklin Creek Ecosystem Restoration	Wet Pine Savannah Wetlands	Moves Residents out of Harms Way (MsCIP Interim Project) Enhanced productivity of wetlands	1, 2, 3, 5, 6

Table 5.1.1.1.2-1.
MsCIP Comprehensive Approach (continued)

Proposed Restoration Project	Portion of the Ecotone to be Addressed	Ecological/Societal Functions to be Addressed	Comprehensive Plan Objectives to be Addressed
Bayou Cumbest Ecosystem Restoration Pearlington, Pearlington South, Port/West, Chapman Road, Diamondhead, Delisle, Ellis Property, Brickyard Bayou, Biloxi River – Shorecrest , Biloxi River – Eagle, Jourdan River – I-10 Development, Pine Island, Fort Point, St. Martin, Keegan Bayou	Emergent Tidal Marsh Scrub/Shrub	Enhanced productivity of emergent tidal wetland, habitat enhancement, relocation of human development out of the coastal ecotone for public safety	1, 2, 3, 5, 6
Admiral Island Ecosystem Restoration Lakeshore, Bayou Caddy/Lakeshore, Clermont Harbor Bayou La Croix, Shoreline Park, Pine Point East, Pine Point West, Pass Christian Site – Bayou Portage	Emergent Tidal Marsh Scrub/Shrub	Enhanced productivity of emergent tidal wetland, habitat enhancement, relocation of human development out of the coastal ecotone for public safety	1, 2, 3, 5, 6
SAV Pilot Project at Bayou Cumbest	SAV – *Ruppia maritime*	Enhance fishery production	3, 6
Beach and Dune Ecosystem Restoration	Coastal Dune Habitat	Buffer mainland from storm surge and waves energy	1, 2, 3, 5, 6
Barrier Island Restoration Biloxi Front Beach – South of Highway 90	Littoral zones, beach, dunes, emergent tidal marsh	Buffer mainland from storm surge and waves energy, enhanced productivity of emergent tidal marsh, enhance productivity of SAVs in littoral areas, enhance fisheries production	1, 2, 3, 4, 5, 6
Deer Island Ecosystem Restoration	Coastal Forests, Emergent Tidal Marsh	Enhanced productivity of wetlands	1, 2, 3, 5, 6

Footnote: Objectives - Green – Tentatively Selected Elements, Purple – Site Specific Elements, Orange – System Wide Elements. 1. Reduce loss of life caused by hurricane and storm surge by 100%; 2. Reduce damages caused by hurricane and storm surge by $150M-$200M annually; 3.Restore 10,000 acres of fish and wildlife habitat including coastal forests, coastal wetlands, wet pine savannah, submerged aquatic seagrasses, oyster reefs, and beaches and dunes by the year 2040; 4. Manage seasonal salinities within the western Mississippi Sound, such that optimal conditions for oyster growth (surrogate for other aquatic resources, 15 ppt during summer months) are achieved on an annual basis by 2015; 5. Reduce erosion to barrier islands, mainland, and interior bay shorelines by 50%; 6. Create opportunities for collaboration with local, state, and Federal agencies to facilitate implementation of programs and activities that maximize the use of resources in achieving the comprehensive goal.

Part of the reason these two sites were selected for the initial projects is because published HGM Functional Assessment models (Shafer et al, 2007; Rheinhardet et al 2002) exist for the regional wetland classes being restored at these sites (different HGM models exist for different regional wetland subclasses across the country), and thus could be used to measure restoration benefits. HGM models evaluate functions that are specific to a particular regional subclass by mathematically combining variable data (such as vegetation, soil, landscape, or hydrologic indicators) that have been scaled, based on a set of reference wetlands, to a value between 0.0 and 1.0, in order to obtain an index score for each function that is also between 0.0 and 1.0. Functional units are calculated by multiplying each functional index score by the total number of acres of the site. An example assessment HGM table is shown below in Table 5.1.1.1.2-2. For the two initial project sites, the functional units calculated for each function were combined so that a single functional unit benefit number was reported for each plan.

Table 5.1.1.1.2-2.
Cover Classes and Midpoint Values for Each Class

Cover Class %	Class Midpoint %	Cover Value
0	0.0	0.000
0-5	2.5	0.025
5-25	15.0	0.150
25-50	37.5	0.375
50	50.0	0.500
50-75	62.5	0.625
75-95	85.0	0.850
95-100	97.5	0.975
100	100.0	1.000
>100	100.0	1.000

Note: These midpoint values are used to estimate cover in plots. First determine if cover is more, less, or equal to 50%, If cover is >50%, decide if cover ismore or less than 75%. If >75%, decide if cover is more or less than 95%. If cover is <95%, then cover is 75-95% with a midpoint of 85% (0.85).

Because HGM functional assessments allow for restoration benefits to be evaluated in terms of functional unit gains or losses, rather than simply in acres, an advantage to using this method is that both the quality and quantity of wetland being affected are measured. Furthermore, since the variables used in the assessment are often ones that can be manipulated through restoration activities, the HGM assessment can determine the functional unit benefits for specific restoration measures.

It should also be noted several of the variables used in both HGM models require field data collection in order to accurately calculate their value pre-restoration. Because of current project time constraints, field data collection was unable to be conducted. However, the environmental team selected these sites due to their high familiarity with them which would allow effective and accurate assessment. Therefore, in order to estimate functional unit benefits, values for these variables were developed using past local field knowledge, aerial photography, soil surveys, and other readily available information on the region in general. Prior to any actual restoration activities, the necessary field work could be conducted in order to obtain a more accurate measure of pre-restoration site conditions and, subsequently, the functional unit benefits resulting from restoration.

The following plans are being considered for being tentatively selective as part of the overall MsCIP Comprehensive Report/Integrated Programmatic EIS. This effort serves as a Phase I initial project that will be enhanced by the tentatively selected Phase II longer term comprehensive effort. The

MsCIP environmental PDT has identified potential environmental restoration projects specified in Table 5.1.1.1.1-1 that would be studied further and restored under this tentatively selected longer term effort.

5.1.1.1.2.1 Turkey Creek, Harrison County

This project site is located north of Gulfport, Mississippi, adjacent to U.S. Highway 49, a major north-west thoroughfare, and within the impaired Turkey Creek watershed. The area is becoming increasingly urbanized and development pressures are resulting in increased wetland degradation and loss by the direct filling. The project site is comprised of 689 acres south of the existing railway located on top of an elevated berm. Approximately 190 acres are located north of the railway and functions separately. The site is primarily comprised of a degraded pine savannah wetland. Several miles of ditches have been excavated throughout the site. Additionally the elevated railway berm fragments the wetland habitat and substantially alters the hydrology of the wetlands located to the north. Several plans were evaluated in order to determine the most cost-effective plan for restoration.

The Turkey Creek site had an HGM assessment performed in 2000, using the *Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains* (Rheinhardt et al 2002). Results from this earlier assessment are being used to establish baseline (current) conditions at the site. The site has been divided into 8 separate assessment areas (Figure 5.1.1.1.2.1-1), as there were different baseline conditions for each area. The same HGM model is also being used to measure functional unit benefits at the site resulting from different restoration plans.

Objectives:

1. Restore native vegetation.
2. Restore natural hydrology.
3. Restore fish and wildlife habitat.
4. Provide storm water storage protection.

Assumptions:

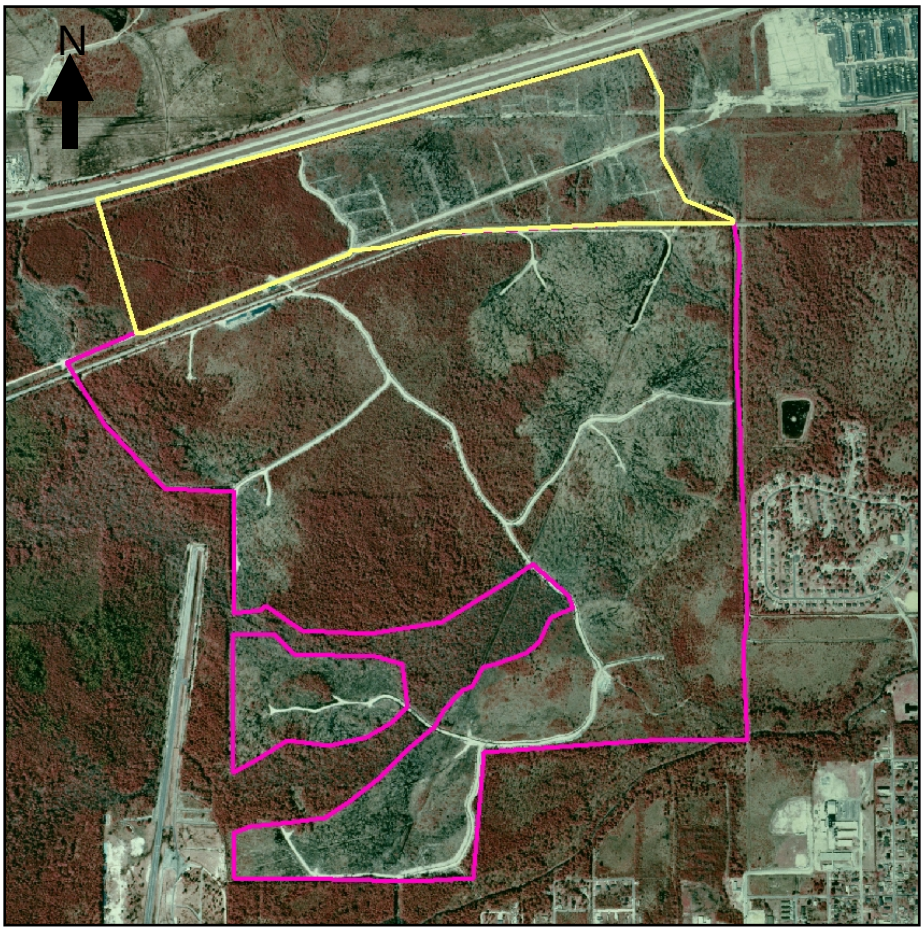
1. Mandatory homeowners assistance and relocation effort.

Measures:

Listed below are the proposed restoration measures and their expected effect on variables used in the HGM model.

1. Filling in ditches (Mandatory to achieve overall restoration project).

   This measure affects the “Outflow of Water” variable, which measures the removal of water by ditches or drains. The variable score would increase from 0.0 to 1.0 under this measure.



Source: Corps

Figure 5.1.1.1.2.1-1. Turkey Creek Restoration Site, Broken into Assessment Areas North (yellow border) and South (pink border) of the Railroad

2. Maintain vegetation (Mandatory to achieve overall restoration project).

Alternatives:

a) Burn (3-year cycle).

b) Mow (annual).

This measure affects the “area of contiguous fire-maintained landscape”, as well as all plant related variables used in the model. It is assumed that these variables will recover to a score of 1.0 under the burn alternative. Under the mowing alternative, the “area of contiguous fire-maintained” landscape variable will score a 0.0 but the plant related variables will still score a 1.0, similar to burning.

3. Excavate and remove existing roadbeds and any additional fill (Mandatory to achieve overall restoration project).

This measure affects the “surface water storage” variable, which measures the presence of excavation or fill at the site. This variable score would increase from 0.0 to 1.0 in areas with existing roadbeds/fill.

A combination of the measures resulted in the following plan combinations listed in Table 5.1.1.1.2.1-1:

Table 5.1.1.1.2.1-1.
Turkey Creek Restoration Measures

Plans 1-2.	Restoring areas north and south of railroad Plan 1. 1, 2a, 3	Plan 2. 1, 2b, 3
Plans 3-4.	Restoring just areas south of railroad Plan 3. 1, 2a, 3	Plan 4. 1, 2b, 3
Plans 5-6.	Restoring just areas north of railroad Plan 5. 1, 2a, 3	Plan 6. 1, 2b, 3

Table 5.1.1.1.2.1-2 shows the total functional units of the site under each plan, and the Average Annual Functional Unit (AAFU) benefit. It is assumed here that functional units will remain the same under existing conditions and the no-action plan. To calculate the AAFU, it is assumed all benefits are immediately accrued following plan implementation, and that the benefits are sustainable over the life of the project. Therefore, the AAFU was simply calculated as the difference between the total functional units for the restoration plan the total functional units for the no-action plan.

Table 5.1.1.1.2.1-2.
Summary of Functional Unit Benefits From Various Restoration Plans

Site	Restoration Acres	Plan	Total Functional Units	Average Annual Functional Unit Benefit
Turkey Creek	879	Existing Condition (plans 1-2)	1,222	-
Turkey Creek	689	Existing Condition (plans 3-4)	1,012	-
Turkey Creek	190	Existing Condition (plans 5-6)	210	-
Turkey Creek	879	No-action plan (plans 1-2)	1,222	0
Turkey Creek	689	No-action plan (plans 3-4)	1,012	0
Turkey Creek	190	No-action plan (plans 5-6)	210	0
Turkey Creek	879	plan 1	3,268	2,046
Turkey Creek	879	plan 2	2,574	1,352
Turkey Creek	689	plan 3	2,577	1,565
Turkey Creek	689	plan 4	2,037	815
Turkey Creek	190	plan 5	691	481
Turkey Creek	190	plan 6	537	327

(1) AAFU's are based on a 50-year period of analysis.
(2) See economic appendix for cost-effective analysis.

5.1.1.1.2.1.1 Plan Selection

These management measures were combined to create six plans that were analyzed to determine the cost-effectiveness of each. Economically ineffective plans are identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the six plans analyzed, three plans were eliminated because they produced less benefit at greater cost than a subsequent plan. Of the three remaining plans, one proved to be more cost-effective and consists of restoration of 689 acres south of the railway by restoration maintained by burning.

The tentatively selected plan requires filling ditches, maintaining vegetation growth by burning and mowing the project area in the initial year of construction as well as maintaining it by burning every

three years over the life of the project, and excavating and removing existing roadbeds and any additional fill.

5..1.1.1.2.1.2 Benefits

In order to restore this area to a wet pine savannah habitat, the higher areas will be designated as wet pine savannah. These areas have depression areas within them which will enable water to flow down to the depression areas; thus, holding water. The wet pine savannah habitat will be restored with wet pine flatwoods, such as *Pinus elliotti, Morella cerifera, Ilex glabra, Spartina patens, and Panicum virgatum*.

Many species of wildlife are indigenous to the wet pine savannah habitat. Understory plant communities may contain wiregrass, sedges, orchids, American Chaffseed and rough-leaved loosestrife. Insectivorous plants that may be found include pitcher plants, bladderworts, venus flytrap, and sundews. Rare, T&E birds that may occur in these areas include Henslow's sparrow, Bachman's sparrow, red-cockaded woodpecker, and Mississippi Sandhill Crane. This ecosystem may also benefit the Mississippi Gopher frog and in drier areas along ridges, the black pine snake and the gopher tortoise.

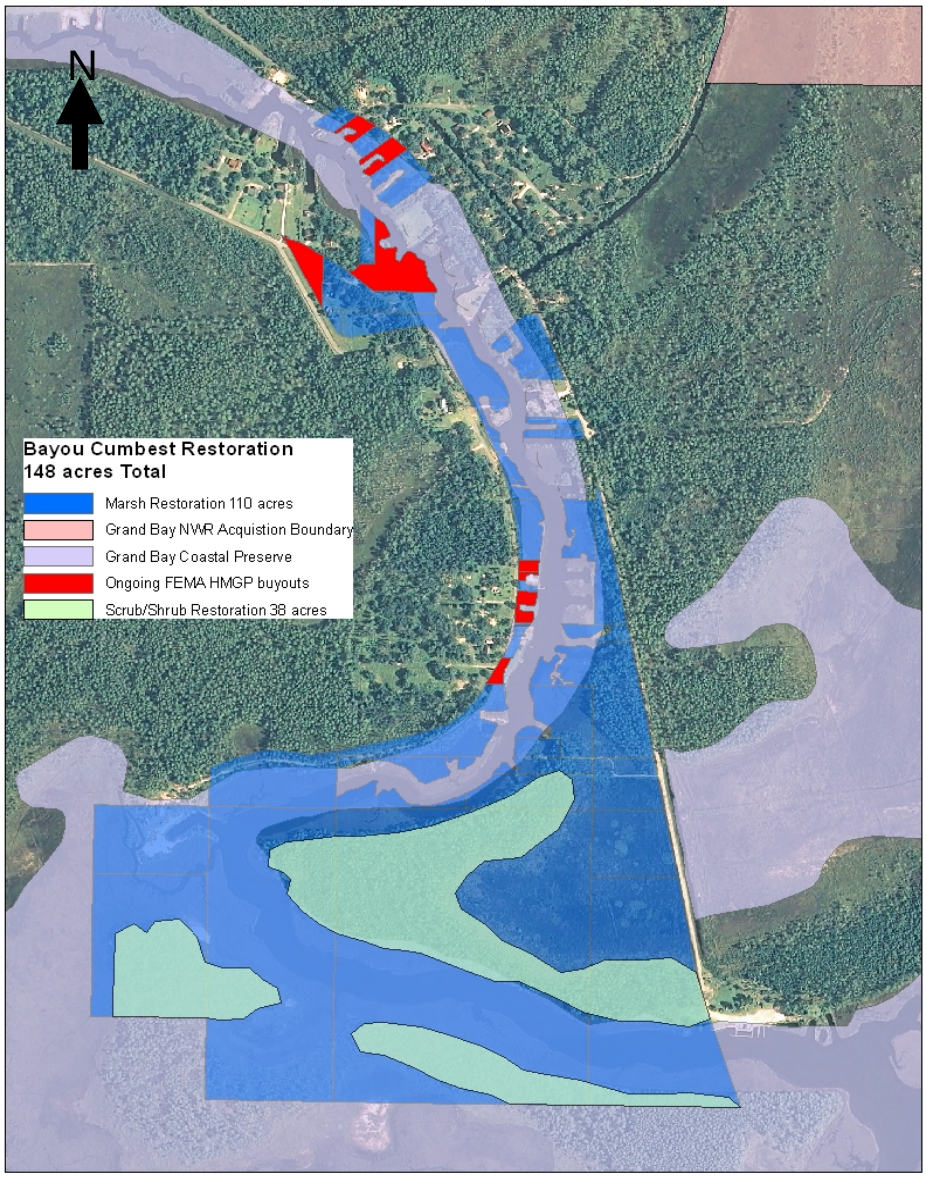
Benefits are measured in terms of AAFU. The HGM approach was used to assess wetland function. Results from this assessment were used to establish baseline (current) conditions and, ultimately, to measure the functional unit benefits resulting from different restoration plans. Table 5.1.1.1.2.1.2-1 shows the total functional units under the tentatively selected plan and the AAFU net benefit. It is assumed that functional units will remain the same under existing conditions and the no action plan. The AAFU net benefit was calculated as the difference between the total functional units for the ecosystem restoration plan and the total functional units for the no action plan. An essential component necessary when selecting the tentatively selected plan at Turkey Creek was the need for burning. Burning allows the wet pine savannah environment to continue naturally as a functioning system. Although mowing does effectively keep understory plants from over colonizing the area, it does not simulate the natural conditions (i.e. seed germination, heating the pine bark, etc.) Therefore, the environmental PDT ranked the burning measure higher than that of the mowing. This resulted in Plan 2 being eliminated due to its mowing component. When evaluating between Plan 1 and 3, the AAFU units were very different. The acreages were also very different due to Plan 1 including both the north and south parcels while Plan 3 included only the south parcel. The team noted that the man-made barrier within the project site produced hydrology constraints. Dominant flora species in wet pine savannah habitats are dependent upon burning; thus, the MsCIP environmental team selected the following plan knowing that most of these plant species would colonize the area upon establishment of routine burning and hydrology. The Environmental PDT then noted that the desired environmental restoration outputs (i.e. a functioning wet pine savannah) could be achieved by selecting Plan 3 which would also provide a cost-effective plan.

Table 5.1.1.1.2.1.2-1.
Summary of Benefits

Plan	Plan Description	Total Functional Units	AAFU Net Benefit
Existing Condition	Existing Condition	1,012	-
No Action	No Action	1,012	0
Tentatively Selected Plan – Plan 3	689 Acre Restoration Fill Ditches Remove Structures Excavate Fill Burn Every Three Years	2,577	1,565

5.1.1.1.2.2 Bayou Cumbest, Jackson County

The project site is located in the extreme southeastern portion of Jackson County adjacent to Bayou Cumbest and Mississippi Sound. The Bayou Cumbest restoration area (Figure 5.1.1.1.2.2-1) contains approximately 148 acres to be restored consisting of 110 acres of emergent tidal marsh and 38 acres of scrub/shrub wetland habitat. Existing scrub shrub vegetation at the site supports natural propagation through removal of exotic species that currently outcompete native vegetation. The area also consists of existing tidal marsh as well as filled and developed areas. Due to the severity of Hurricane Katrina, most of the residential development was severely damaged or destroyed. The site has low elevations and since most residential structures have been destroyed, an opportunity exists to excavate the old fill material and restore the once existent marsh. For increased habitat diversity, the team proposed to leave some of the higher elevations as is and plant shrub/scrub species in order to enhance ecological benefits at the restoration site.



Source: USFWS

Figure 5.1.1.1.2.2-1. Bayou Cumbest Restoration Site

Objectives:

1. Restore marsh to historical (pre-development ~1950's) conditions.
2. Provide storm surge protection.
3. Restore native tidal wetland plant community.
4. Provide fish and tidal wildlife habitat.
5. Prevent saltwater intrusion.

Assumptions:

1. Mandatory property purchase.
2. 100% removal of existing structures.

Measures:

1. Excavation of old fill material (includes 90-95% removal of existing exotic species in excavated areas). (Mandatory to achieve overall restoration in all plans)

   This measure, in conjunction with measure 3, affects the hydrologic regime variable, which under existing conditions receives a score 0.50, on the assumption that approximately half the site has been filled above the normal tidal flooding zone. This measure by itself would raise the hydrologic regime variable to a 0.75.

2. 100% removal of exotics from non-excavated areas and maintain removal of exotic species, such as Chinese Tallow, Phragmites, Cogon Grass, in all areas over project lifetime. (Mandatory in all plans).

   This measure affects the "percent cover by invasive or exotic species" variable, and would raise the variable score to 1.0 under all plans.

3. Filling in 100% of existing artificial ditches/channels.

   If this measure is performed in addition to the mandatory measure 1, the hydrologic regime variable score would increase to 1.0 as there would be no more hydrologic alterations to the site.

4. Native Vegetation Planting.

   Alternatives:

   a) 0.5 meter spacing

   b) 1 meter spacing

   c) 2 meter spacing

This measure affects the "percent cover by woody plant species", "wildlife habitat diversity", "vegetation height", "wetland indicator status" and "mean percent cover emergent plant species" variables. The relevant vegetation variables are assumed to reach their highest potential score at year 5 under 0.5 meter spacing, year 7 with 1.0 meter spacing, and year 10 with 2.0 meter spacing, and then sustained at that level for the 50 -year project life, Variable subindex scores are treated as increasing linearly from their value under the no-action plan up to their highest potential value obtained at year 5, 7, or 10, depending on the planting spacing, and then remaining constant thereafter.

A combination of the measures resulted in the following plan combinations listed in Table 5.1.1.1.2.2-1:

Table 5.1.1.1.2.2-1.
Bayou Cumbest Restoration Measures

Plan 1. 1,2,3,4a	Plan 2. 1,2,3,4b	Plan 3. 1,2,3,4c
Plan 4. 1,2,4a	Plan 5. 1,2,4b	Plan 6. 1,2,4c

Table 5.1.1.1.2.2-2 shows the AAFU benefit under each plan.

Table 5.1.1.1.2.2-2.
Summary of AAFU Benefits From Various Restoration Plans

Site	Restoration Acres	Plan	AAFU Benefit[1]
Bayou Cumbest	110	No-action plan	0
Bayou Cumbest	110	plan 1	191
Bayou Cumbest	110	plan 2	188
Bayou Cumbest	110	plan 3	184
Bayou Cumbest	110	plan 4	172
Bayou Cumbest	110	plan 5	169
Bayou Cumbest	110	plan 6	164

(1) AAFU's are based on a 50-year period of analysis.
(2) See economic appendix for cost-effective analysis.

5.1.1.1.2.2.1 Plan Selection

These management measures were combined to create six plans that were analyzed to determine the cost-effectiveness of each. Economically ineffective plans are identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the six plans analyzed, two plans were eliminated because they produced less benefit at greater cost than a subsequent plan.

The tentatively selected plan will restore 110 acres of emergent marsh and 38 acres of scrub shrub habitat. Existing scrub shrub vegetation at the site supports natural propagation with exotic species management. The tentatively selected plan consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas, filling existing artificial ditches, and planting native vegetation, such as *Spartina alterniflora* (Smooth Cordgrass) at the seaward edge of marsh; *Juncus roemerianus* (Black Needle Rush) at a slightly higher elevation; and *Spartina patens* (Saltmeadow Cordgrass) at a slightly higher elevation at a density of 1 meter. For those higher elevation areas identified in Figure 5.1.1.1.2.2-1, exotics would be removed and replanted with scrub/shrub species in order to enhance habitat diversity at the restoration site.

5.1.1.1.2.2.2 Benefits

Benefits are measured in terms of AAFU. The HGM approach was used to assess wetland function. A HGM assessment was performed. Results from this assessment were used to establish baseline (current) conditions and, ultimately, to measure the functional unit benefits resulting from different restoration plans. Table 5.1.1.1.2.2.2-1 shows the total functional units under each implemented plan and the AAFU net benefit. To calculate the AAFU net benefit, it is assumed that benefits will be maximized at year 5 with 0.5 meter spacing of vegetation, at year 7 with 1.0 meter spacing of

vegetation, and at year 10 with 2.0 meter spacing of vegetation. These benefits are estimated to be sustainable over the life of the project. Net AAFU benefits are calculated as the difference between the total functional units for the ecosystem restoration plan and the total functional units for the no action plan.

The environmental MsCIP team selected the 1.0 meter spacing based on professional experience by the Corps, universities, NGOs, State, and other Federal agencies with restoration of emergent marsh habitats. Past experience in Coastal Mississippi has proven that spacings, elevation, and hydrology are the three key essential components to obtain a successful emergent marsh site. The three spacing scenarios (i.e. 0.5, 1.0, 2.0 meters) have been used at a local Coastal Mississippi project (i.e. Deer Island, Harrison County). Upon assessing the propagation of those different spacings, the environmental PDT determined that although the 0.5 meter spacing is the desired planting technique, the overall goal of the restoration project can be achieved by spacing the tidal emergent plants out to 1.0 meters per plant. The 2.0 meter spacing was determined to leave the site too vulnerable to storms and/or hurricanes; thus, this spacing technique proofed to be rather risky. Marsh restoration along Coastal Mississippi will provide nursery habitat for various vertebrates and invertebrates while also providing a natural storm protection buffer from future storms. Therefore, the environmental PDT tentatively selected Plan 2 because it provides both the optimal elevation and hydrology requirements while also providing suitable spacings for the tidal marsh plants that will allow the plants the ability to quickly colonize the site.

Table 5.1.1.1.2.2.2-1.
Summary of Benefits

Plan	Plan Description	AAFU Units	Net AAFU Units
Existing Condition	Existing Condition	1,052	-
No Action	No Action	1,052	0
Tentatively Selected Plan 2	Excavate Fill Remove Exotics Fill Ditches Plant at Density 1.0m	1240	188

5.2 Freshwater Diversions

5.2.1 Plan Formulation

Several projects are presently being considered to divert freshwater from the Mississippi River or other sources as a mechanism to promote reversing a historic increase in salinity in the Mississippi Sound/Biloxi marshes area in order to support fresher marshes and oyster reef health and productivity thus enhancing both their economic value and the ecological services they provide.

Oysters not only support a commercial fishery but interact directly with local hydrodynamic conditions, affecting currents, flow conditions, and sedimentation patterns (Lenihan 1999). They filter large amounts of phytoplankton and detritus exerting a powerful influence on water quality, phytoplankton productivity, and nutrient cycling of estuaries (Dame 1996). Oyster reefs provide habitat for a wide range of other invertebrates present either on the oyster shell itself or in the interstices between shells. Oyster reefs also support numerous resident, transient, and juvenile fish and decapod species and may provide a refuge from predation and poor water quality conditions.

Oysters are sensitive to specific ranges of salinity; therefore, freshwater diversions have the potential to either enhance or threaten the resource. For instance, where the average salinity exceeds 15 ppt oysters often experience increased predation rates by oyster drills whereas young oysters are more susceptible to certain diseases at salinities greater than 9 ppt (Cake 1983; Chatry et al. 1983). Similarly, salinities averaging below 7.5 ppt can inhibit oyster growth and sexual maturation while salinities that persist for extended periods of time below 2 ppt can result in direct mortality (Sellers and Stanley 1984). The relationship between oyster productivity and river flow is a complex one and there does not appear to be a close link between oyster harvests and freshwater inflow (Turner 2006).

Alternately, the water diverted from riverine sources not only has lower salinity, but it usually carries more sediment and nutrients. Diversions may result in areas of excess nutrients and thus cause algal blooms, lower light attenuation and other signs of eutrophication.

Therefore, any proposed diversion project needs to be carefully evaluated in order to insure the maximum probability that proper habitat and water quality conditions are met. Because of the potentially large number of projects that might require evaluation, it is essential that a screening tool be developed to cost effectively identify those proposals which warrant the level of detailed study required to make informed decisions. It is essential that proposals that have no likelihood of success are eliminated early in the evaluation process in order to maximize the effectiveness, eliminated negative impacts from poorly designed projects, and reduce costs of evaluating the remaining candidates.

In an effort to initiate the proper evaluation of freshwater diversions, a water quality model, which is based on the CE-QUAL-ICM water quality model code, is coupled to output from a three-dimensional hydrodynamic model of the region, which is based on the CH3D hydrodynamic model (Dorth et al 2007). The version of CH3D with sigma coordinate in the vertical dimension is being used. The model grid extends seaward beyond the Chandeleur Island and includes Mobile Bay, Lake Borge, Lake Pontchartrain, the Inner Harbor Navigation Channel of New Orleans and the Mississippi river Gulf Outlet Channel. Predicted water quality constituents, including nutrients, phytoplankton, dissolved oxygen, temperature, salinity, and underwater light intensity, were evaluated for several scenarios and compared to modeled existing baseline conditions to assess relative changes.

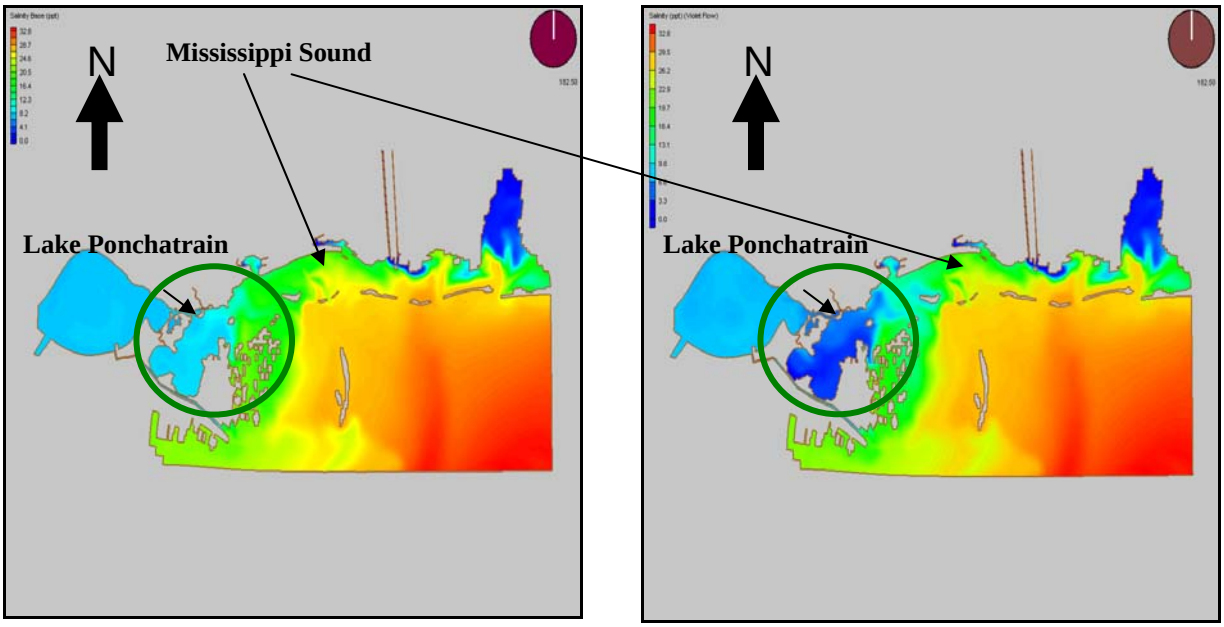
The water quality model was applied for three alternative scenarios: (1) diversion of freshwater flow from the Mississippi River at Bonnet Carre' spillway, (2) diversion of freshwater flow from the Mississippi River at Violet Marsh, and (3) diversion of all of the Escatawpa River flow into Grand Bay. The Bonnet Carre' diversion varied by month while the Violet Marsh diversion was a constant flow of 7,500 ft^3/s. The Escatawpa diversion is the flow that occurred in the Escatawpa River during 1998, and those values were varied daily in the model. The water quality model was applied for the period April through September 1998 using the same inputs as the final calibration run except for different hydrodynamics and different boundary conditions for the diverted flow and associated concentrations of the flow. The hydrologic model was run with the same conditions as used for the base conditions used in the water quality model calibrations for 1998 except that the additional freshwater flows were introduced.

In an effort to apply this water quality data to ecological issues, MsCIP and ERDC convened a panel of representatives from TNC, MDMR, USM at the Gulf Coast Research Laboratory. The aim of the panel is to suggest simplistic ecological models that can be incorporated with projections from the combined hydrodynamic and water quality models to identify simulations which might result in an improvement in oyster habitat quality. The panel has identified several key attributes that need to be incorporated into the evaluation of freshwater diversion options. The first is that salinities average as closely as possible to the optimal range for oyster health and productivity. This is clearly of critical

importance since the primary purpose for contemplating freshwater diversions is to improve habitat conditions for oysters. Second, a diversion should not result in extended periods of low salinity resulting in mortality or poor growth and reproduction. This consideration is particularly critical during times of high river flow or other extreme conditions. Third, a diversion should not unduly influence habitat conditions for other critical resources. Diversions that result in favorable conditions for oyster health may not be conducive to other equally important resources. For instance, most seagrasses do poorly at salinities less than 20 ppt. A diversion that results in excellent conditions over the prime commercial beds but drives salinities below 20 ppt in the seagrass elsewhere would not be acceptable. Other important habitat requirements that should also be considered for seagrass health include light availability and nutrient concentrations. These ecological concerns associated with water diversions, in addition to potential impacts on important fisheries species of those areas, require conservative actions and more study of potential impacts (positive and negative) of such practices for the long-term sustainability of nearshore and estuarine resources.

As an example, the results from a simulated diversion of 7,500 ft^3/s of Mississippi River water near Violet, Louisiana are presented in Figure 5.2.1-1. The results suggest that 180 days after initiation of the diversion salinities were lowered in western Mississippi Sound. Dortch et al. (2007) sufficiently warrant additional examination. However, at present, absolute salinity values predicted by the model poorly match calibration data. Further refinement of the models should correct this limitation and must be made to allow the usefulness of the model results for estimating potential beneficial or deleterious effects on oysters and other coastal resources.

Results also showed that diversion through the Bonnet Carre and through the Escatawpa/Grand Bay system have the potential to significantly influence coastal salinities.



Base Conditions **With Diversion**

Source: Corps

Figure 5.2.1-1. Projected Salinity Values 180 Days after Initiation of a Diversion of 7,500 cfs of Mississippi River Water at Violet, LA Simulated Diversion of Mississippi River into Lake Borgne Near Violet, Louisiana

Ongoing and future studies can be used to refine the hydrodynamic and water quality model and tighten the calibrations. This will allow for better integrating the water quality results to ecological

concepts. Also, this preliminary effort just developed information for some possible discharge scenarios in order to do a sensitivity analysis as to whether diversion could potentially affect the areas of concern. These efforts showed the potential for freshening the systems. Future studies and model runs will need to be performed to test precise operational discharge plans and seasonal influences.

5.2.1.1 Grand Bay Savannahs and Marshes

Historically, the estuarine marsh within the Grand Bay NERR represented the former deltaic ecosystems of the Pascagoula and Escatawpa Rivers in eastern Jackson County. The outlets of these rivers have shifted westward over time, severely limiting the inflow of freshwater, nutrients, and sediments into the Bayou Cumbest area of the reserve.

Currently, it is speculated that much of the freshwater entering the Grand Bay NERR estuary is from surface runoff through Bayou Heron and Bayou Heron, within the Bangs Lake Hydraulic Unit, measuring approximately 21,374 acres. Human disturbances to the area have also altered historic sheet flow and surface water flows into the area, as well as the natural migration of the Pascagoula and Escatawpa Rivers. A freshwater diversion project in the area, if feasible, may serve to enhance the wildlife resources of the area. The need for freshwater diversion at the Grand Bay savannahs and marshes would help restore the predominant wet pine savannah habitat. Shoreline erosion along the Grand Bay area (i.e. loss of the Grand Batture Islands) has also contributed to the increased salinity in the area.

The proposed project will seek to develop a refined hydrodynamic model for the area, inputting biological, water quality, and physical data into the model to evaluate a variety of freshwater diversion scenarios. This work represents a critical first step in the final assessment of potential water diversion projects for this area. Community information will be solicited and a public workshop will be held to share the results.

5.2.2.2 Hancock County Marshes

Diversion of Mississippi River freshwater and/or sediments in the vicinity of Violet, Louisiana has been strongly considered because of a number of positive factors. These include proximity of the river to target coastal wetlands restoration areas, strong public support, and high confidence in potential environmental benefits. The Violet Diversion Project is under consideration by the MsCIP (Corps, Mobile District) and Corps, New Orleans District as a freshwater diversion project that could potentially have a positive impact to the Hancock County Marshes. Preliminary results from modeling a simulated diversion of 7,500 ft^3/s of Mississippi River water near Violet, Louisiana, suggest that after 180 days of initiation of the diversion, salinities were lowered in Western Mississippi Sound sufficiently to warrant additional examination (Dortch et al 2007). Further refinement of the models should address current limitations and must be made to estimate potential beneficial or deleterious effects on oysters, seagrasses, marsh systems, and other coastal resources. Although the idea is viable, at this point, additional information is needed to determine current problems within Hancock County Marshes and potential impacts to existing coastal resources as well as navigational impacts.

5.2.2 Tentatively Selected Plan

Due to the time constraint of this MsCIP Comprehensive Report/Integrated Programmatic EIS, the MsCIP team was only able to qualitatively determine that freshwater input into the systems does change the overall environment. It is known that these systems have been altered and/or starved by lack of freshwater inflow. An integrated environmental web exists in these rivers and also in

Mississippi Sound, which needs to be fully identified, in order, to completely understand various effects that could possibly occur.

The MsCIP environmental team recommends additional study, such as water quality and quantity, of this freshwater diversion plan (i.e. Hancock County Marshes and Grand Bay Savannahs and Marshes) as part of the MsCIP Comprehensive Report/Integrated Programmatic EIS. This study is necessary to assess the quantitative amount of freshwater flows required to positively impact each ecosystem.

In a collaborative effort, the MsCIP Environmental PDT closely worked with the Louisiana Coastal Protection and Restoration PDT to coordinate efforts. This close coordination allowed both the States of Mississippi and Louisiana to accomplish its respective goal of increasing sedimentation and freshwater via diverting water from the Mississippi River. Congress recently passed a law authorizing water resources projects and investigations throughout the U.S. WRDA of 2007 recommended a freshwater diversion project at Violet, Louisiana. The project is authorized to produce the same benefits for the Biloxi Marshes and Mississippi Sound as an earlier project (1988) at the Bonnet Carre Spillway in Louisiana. As authorized this effort would be designed and built by the Corps in partnership with the States of Mississippi and Louisiana.

The Louisiana Coastal Protection and Restoration and MsCIP PDTs will accomplish the following:

- Investigation of hurricane protection and coastal restoration for south Louisiana lead by the Corps, New Orleans and Mobile Districts in cooperation with the States of Louisiana and Mississippi.
- Evaluates four options for freshwater diversion at Violet for enhancement and preservation of wetlands in eastern St. Bernard Parish, Louisiana. Recommend construction of a freshwater diversion at Violet for salinity reduction in Mississippi Sound to improve oyster bed habitat.
- Flow rate alternatives range from 250 ft^3/s to 50,000 ft^3/s and estimated construction costs range from $1 million to $279 million.
- The Louisiana Coastal Mississippi Protection and Restoration and MsCIP final technical reports are due in December 2007 but it will not contain a construction tentatively selected plan for any of these alternatives.

5.3 Beach and Dune Restoration – LOD-2

5.3.1 Plan Formulation

Essentially all the beaches along Coastal Mississippi are man-made. Harrison County has the most beachfront with a 26-mile stretch extending from Biloxi Bay to St. Louis Bay. This beach is the longest man-made beach in the U.S. Hancock County has several miles of beach while Jackson County only has a small beach located in the Cities of Pascagoula and Ocean Springs. In total, the beaches extend along less than half of the Mississippi coastline.

Most of the dunes that previously existed along these beaches were destroyed by Hurricane Katrina and much of the beach was damaged. Many Federal, state, and local entities raised environmental concerns regarding the various Mississippi beaches as part of the 180 projects previously discussed. In some areas, such as in the City of Pascagoula, the beach was completely gone. Reconstruction of the dunes, where beaches exist, will provide a reduction of damaging wave action from smaller storms (i.e. normal summer storms, tropical storms, and/or lower energy hurricanes).

A project to restore the beaches in Harrison County has been funded and is underway as part of the Flood Control and Coastal Emergencies (FCCE). Other projects to construct dunes to a height of 5-foot in Harrison County and to 2-foot in Hancock and Jackson County were proposed as part of the MsCIP Interim Report. That dune restoration project has since been funded and the Corps, Mobile District is underway preparing the plans and specifications.

The beaches, situated immediately seaward of developed areas, provide an excellent location where elevated dunes could be constructed to provide some additional protection against smaller hurricanes. Furthermore, the seaward side of the dunes also provides excellent feeding grounds at the nearshore and intertidal shore areas for various birds, crabs, and other fauna. The MsCIP environmental and engineering PDTs cooperatively assessed various dune elevations. The teams quickly designated this component of the plan as LOD 2. The engineering team evaluated the structural benefits while the environmental team evaluated habitat benefits to the Coastal Mississippi ecosystem.

Original concepts were to look at crest elevations of +10.0 feet and +15.0 feet as options for all dunes. Further discussions made it clear that the top elevation of the dunes needed to be below the elevation of the adjoining roadway. This was to help mitigate the migration of the sand onto the roadway as aeolian (wind blown) deposits. It was decided to correlate the top of the dune to an elevation that would be +1-foot lower than the adjacent road that would be included in LOD-3. LOD-3 elevated roadway elevations of +11.0 feet were selected for Jackson and Hancock Counties and +16.0 feet for Harrison County. These decisions for LOD-3 then dictated dune crest elevations of +10.0 feet for Jackson and Hancock Counties and +15.0 feet for Harrison County. Supplemental information can be found in the Barrier Island Appendix.

Dunes are consistent with public preference for a more natural appearing defense mechanism rather than a hardened structure. Construction of dunes will include planting vegetation, such as sea oats (*Uniola paniculata*), and sand fencing to help stabilize the dunes (Figures 5.3.1-1 and 5.3.1-2). Sand dunes are naturally occurring dynamic coastal features, which are formed by the accumulation of wind blown sand. Sand is naturally carried along the beach by the wind. Sand fences help facilitate the building of sand dunes by trapping and collecting this wind driven sand. Sand fences are usually made of wood or biodegradable material. Without dune vegetation, sand dunes become unstable; thus, the MsCIP environmental team tentatively selected planting dune vegetation. Dune plants tolerate harsh beach conditions including wind, salt spray, storms, scarce nutrients, limited freshwater, and intense sunlight and heat. The plants and/or seedlings provide feeding sources to a variety of animals while also providing nesting and roosting habitat.

These dunes would be a sacrificial barrier, but could also be important by providing additional protection for the toe of the existing roadway, especially in an elevated seawall or roadway configuration as LOD-3. Placement of the dunes directly against a raised seawall or roadway would also serve aesthetically to mask the appearance of a structural barrier. Thus, adding to the public acceptance and/or appeal of this other proposal.



Source: Corps

Figure 5.3.1-1. Examples of Sand Fence Patterns



Source: Corps

Figure 5.3.1-2. Dune Vegetation with Sand Fencing

While the measure described above joins LOD-2 with the adjoining roadway (i.e. LOD-3), consideration could be given to having a stand-alone LOD-2 dune system that is on the existing beach, but separated from the road. The quantity of sand for an option, such as this, would increase since the northern slope of the dune is adjacent to the roadway. The grade elevation would go down to about +5.0 feet and not abut against the roadway. By doing so, the top elevation of the dune could vary and be above the roadway as necessary. This may increase the need for maintaining the sand in the designated dune alignment since it would be expected that the sand dune would tend to migrate under the prevailing wind direction. This option was not fully designed as many unanswered questions remain that may have to be simulated with models. This includes the width of the dune crest and the width of the beach berm that might be required in front of the dune. This option would also block any view of the water from the existing roadway in most areas, replacing the view with a dune scene including plantings of sea oats or other beach type vegetation.

5.3.2 Tentatively Selected Plan

A dune system, 60-foot wide and 2-foot high, planted with sea oats along the mainland coast is tentatively selected for construction. Sand fencing would be used to stabilize the dune feature. A detailed description is conducted in the Engineering Appendix.

5.4 Barrier Island Restoration

5.4.1 Plan Formulation

A significant environmental impact from the barrier islands continuing to diminish is the increase in Mississippi Sound's salinity. Under current conditions, the islands provide a boundary between the sea water salinity [~33 ppt] of the open Gulf of Mexico and the brackish water found in the Sound. Salinity in the Sound during low flow periods range from 10 ppt to 30 ppt. Highest salinities occur just south of Pascagoula and Gulfport and the lowest salinities in the Lake Borgne-Pearl River area. Loss of the islands would allow the salinity to greatly increase changing the ecological habitats that now exist. This would impact, if not devastate, shellfish and many other forms of marine life. Oysters currently found in concentrated Mississippi Sound areas would possibly cease to exist.

The degradation of the Chandeleur Islands in southeastern Louisiana allows us to anticipate potential environmental changes. Initial assessments are showing SAVs diminishing, marsh erosion rates accelerating, and wave energy along the mainland having no natural barrier. Like Cat Island on the Mississippi barrier islands, the Chandeleur Islands are a remnant of a delta lobe from the Mississippi River where wave action created a beach that remained as an island after sea level rise and erosion removed the land mass between the island and the mainland.

5.4.1.1 Entire Restoration

Prior to Hurricane Katrina, the State of Mississippi was working on a coastal storm protection plan and proposition to submit to NPS for consideration that included restoring the barrier islands to the condition that existed prior to Hurricane Camille. Soon after Hurricane Katrina, it was reported that many in Mississippi felt that if the islands had been in the condition that existed prior to Hurricane Camille, there would have been less damage along the coast from Hurricane Katrina. This idea was also included in the Mississippi Governor's Recovery Plan, which called for restoring the islands to a pre-Camille footprint. In addition, this restoration concept was raised in the initial 180 projects previously discussed. This concept was included in the hurricane protection study as LOD-1, which is discussed more fully in the Engineering Appendix.

Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. This area is the most protected from the restored islands and this protection may result in only up to a 10% reduction in storm surge. The effect of this protection diminishes rapidly to the west from Jackson County. A detailed discussion of this modeling effort can be found in the Engineering Appendix.

The post-Hurricane Katrina condition can be considered a baseline condition for the modeling and the pre-Camille condition would be an improved condition (Table 5.4.1.1-1). The pre-Camille footprint of the islands was obtained from historical records and an assumption was made as to a top of dune elevation of +20 feet. [It should be noted that some of the islands have migrated to the west and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations.] Restoration of Ship Island in a pre-Camille configuration includes closing the post-Hurricane Katrina, 4-mile long breach between East and West Ship Islands to a 2,000-foot width and with 20-foot high dunes, along with some rebuilding of the other islands to a larger land area. This option will only include new land mass that is being added to the islands by bringing sand dredged from an offshore location. Sand of sufficient quality in the quantities required for this type of project is not known to occur in close proximity to the islands. Prior studies of the St. Bernard Shoals (Oral Communication, USGS 2006) are probably the best source of the sand. Additional studies and sampling will be required to ensure the source. The shaping of the sand into

beaches, dunes, and marsh areas will not affect the existing islands other than that narrow strip of land that will form the Gulf Island National Seashore boundary between the existing island and the new land mass.

A detailed discussion of the St. Bernard Shoals can be found in the Engineering Appendix. The average water depth over the shoals is 60 feet, which puts the sand within reach of a hopper type dredge; however, the water depth near the islands is too shallow for the draft of hopper dredge that would be used in this type of operation. In order to accomplish this, a basin would be dredged near each of the islands to discharge the sand being transported from the borrow area. Using this procedure, the hopper dredge could enter the basin and bottom dump the sand near the islands. This would be much faster than pumping off the sand. Doing this would also allow the basin to be placed outside of the NPS's National Seashore boundary. As the basin is filled, a suction dredge would be mobilized to the site and the sand could be moved to the area where it is needed to create additional land mass. As the sand was placed on the new land mass, it would be sculpted into dunes and swales, which would vary from sea level up to heights of approximately 20 feet. As the new land mass is added to the existing islands, portions of the new island will be planted with various type of vegetation to provide habitat and to aid against erosion. Vegetation would increase stabilization of the dune systems. The percentage of maritime forest varied among the islands from 1% up to 23%. For the new land mass of the islands additions, it was decided to use a quantity of 20% percent of the land mass for planting the trees consisting of longleaf pine. The lower elevations of the new land mass would be planted with emerging marsh species that would cover 38% of the area. Dunes planted with sea oats would make up 2% of the area and the beach areas would be left as open berms.

Table 5.4.1.1-1.
The Amount of Land Mass Lost from Each of the Mississippi Barrier Islands from Pre-Camille Conditions to Post-Katrina Conditions

Island	Pre-Camille (acres)	Post-Katrina (acres)	Land Loss (acres)
Cat	2,344	1,957	387
Ship	1,172	631 (East and West)	541
Horn	3,612	3,077	535
Petit Bois	1,329	1,098	231

The difference in the land mass over this period was then converted to an acreage that it would take to restore the size of the footprint. The width of the islands was maintained with the additional land mass being added as length. Each of the surface areas was converted to a quantity by using an average water depth of 7 feet and raising the sand up to elevation of +10.0. It was assumed that approximately 25% loss of the material would occur during the process of placement.

5.4.1.2 Breakwater Construction to Restore the Barrier Islands

One positive affect the islands have is to provide a natural offshore breakwater for the large sea waves that are generated from hurricanes. The presence of the islands and the relatively shallow water of Mississippi Sound between the islands and the mainland prevent sea waves from maintaining their considerable size as they move towards the mainland. Sea waves, often reported at heights of 40 feet and higher in large storms, would break as they approach the chain of islands. The open-water between the islands and the mainland, generally ten miles or more, would have enough fetch for waves to regenerate, but at a much lower height due to the shallower water. The generally accepted relationship between water depth and wave height is that the wave can sustain itself at a height that is one-half the depth of the water. Construction of breakwaters to restore the

barrier island system was found technically unfeasible due to it not providing enough protection to the islands and the mainland of Coastal Mississippi.

5.4.1.3 Littoral Supplement to the Barrier Islands

With the consideration that the barrier islands lands administered by the NPS and the core preservation and protection mission and management policies applicable to the agency, any proposed improvements would be required to be subjected to additional environmental impact analysis and compliance. Additionally, Petit Bois and Horn Islands are congressionally designated Wilderness areas, an added layer of resource protection requiring proposed management actions be subjected to review according to the Wilderness Management Act. One other consideration to help restore the islands including restoration of the sediment transport and budget system they are dependent upon, is to supplement the sand in the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. The source of these sands may be from inland sources and/or from offshore borrow areas. A detailed discussion pertaining to the sources of sand (i.e. inland and offshore) can be found in the Engineering Appendix. This would not directly affect the present-day islands; however, on a long-term basis, supplement of the littoral zone could continue the sustainability of this important barrier island system and ultimately protect Mississippi Sound and its very productive fisheries.

The construction of inland waterways in Alabama and Mississippi has resulted in continuing maintenance dredging to maintain the channel depths and alignments. This dredged material is now accumulated in numerous disposal areas along the banks of the river. Dredging of some of the areas along the river has produced large quantities of sand that have potential use for replenishment of littoral zones, such as are found along the Mississippi barrier islands.

An inventory of current disposal sites indicates that approximately 30,000,000 cubic yards of sand is available. Only disposal sites that contain a minimum of 100,000 cubic yards of sand were included in the inventory. Of interest to this study are disposal sites that are located along the Black Warrior–Tombigbee River system and the Tennessee–Tombigbee Waterway. The cost to store this type of dredged material is high and it has recently been estimated that removing the sand from the existing disposal areas would save the Government over $100,000,000 at today's cost.

Sand from the river was typically a finer grain size than that of the beach sand. It was also noted that the beach sand was more rounded than the river sand. All of the river sand had a brown tint described as "very pale brown" or "light yellow brown." Adding this sand into the littoral zone may diminish the differences between the natural sand in the system and the river sand that would be added. By spreading the sand over large areas to a small thickness, approximately 1-foot, it is anticipated that the natural sediment transport process would blend the two sands together. The transport process would also tend to remove any staining from the sand grains and help to round the individual particles through abrasion. Further evaluation, modeling, and study would be required in cooperation with the NPS before this riverine source could be sanctioned as a viable alternative to increase volumes of beach compatible (grain size, color, and texture) sand within the barrier island system.

The entire process would consist of loading the sand onto river barges at various disposal areas, moving the barges downriver, and into Mississippi Sound via tugboat tows, unloading the barges with a "hydraulic unloader", and spreading the sand with a "spreader barge." The process would require a continuous supply of loaded barges as the unloader only needs about an hour to remove the sand from a typical river barge. Staging this process from within Mississippi Sound would also help with down time due to weather that would be more affected on the south side of the islands. Preliminary analysis has indicated the St. Bernard Shoals source is likely compatible (grain size, color, and texture) with existing beach sand on the Mississippi barrier islands.

Another consideration to help restore the islands is to supplement the sand in the littoral system with sand obtained from offshore borrow areas. Like the upland source, this could be accomplished by adding sand in specific locations based on sediment transport modeling. The sand that could be used in this option may come from the same offshore borrow area as the St. Bernard Shoals located about 45 miles south of the barrier islands.

5.4.1.4 Reshaping the Islands

Another option with the least impact on the existing post-Hurricane Katrina barrier islands would be to re-establish the vegetation that was destroyed. This option could involve restoration of the existing islands through adding sand dunes on the beaches along with planted vegetation (i.e. *U. paniculata*), planting of marshes (i.e. *S. alterniflora, J. roemerianus*, and *S. patens*) and maritime forests (i.e. *P. elliottii engelm*, *S. repens, S. minor*, etc.), and planting seagrasses (i.e. *D. wrightii, C. manatorum, T. testudinum*, and *R. maritime*) in the nearshore areas of the islands.

Historically, large areas of seagrasses existed north of the islands. Much of this seagrasses is now gone and the loss of these areas have been mapped. Replanting the grass will aid in establishing valuable habitat that is part of the ecological system that has been destroyed near the islands. Foremost, the vegetation would restore the island's natural setting, which allows for the diverse array of flora and fauna to persist. This plan would not involve adding any land mass to the islands other than the possibility of adding to the dune system. Vegetation would aid in reducing erosion from wind; thus helping in maintaining the stability of the islands. The vegetation would also aid in preventing erosion in the event that the islands get overtopped by storm surge in a large hurricane. Sources of this sand could be from the beach area behind the dunes or from sources off the island.

5.4.1.4.1 Two-Foot Dune System

The dune would be shaped from sand that would be removed from the surface between the constructed dune and the edge of the vegetation north of the dune. The dune would have a height of 2-foot, with a 1-foot vertical to 3-foot horizontal slopes and a crest width of 6 feet. The dune would be continuous for the length of the gulf-side, south beach. The construction of a small 2-foot high dune on the islands' south beach could be accomplished by utilizing the existing sand on the beach berm. The sand could be scraped from the beach surface between the dune line and the vegetation that grows inland. This small dune would be used as a planting platform for establishing sea oats that have been destroyed by the recent hurricanes. While this small dune would provide very little damage reduction for the island, it would build with time as wind driven deposits of sand become trapped by the vegetation and increase the size of the dune.

5.4.1.4.2 Six-Foot Dune System

This proposal is similar to above except that it would consist of a 6-foot dune rather than a 2-foot dune. The sand that could be used may come from the same offshore borrow area as the St. Bernard Shoals located about 45 miles south of the barrier islands. In order to accomplish this restoration effort, sand would be moved from a hopper dredge to a staging area on the beach, then the sand would again be moved to the area of placement along the beach.

5.4.2 Tentatively Selected Plan

Further study is required to adequately address comprehensive barrier island restoration due to their complex ecosystem and impacts on the environment. Options of littoral zone placement and filling of the Ship Island breach (i.e. comprehensive barrier island restoration) are being tentatively selected for construction through the need for additional detailed analysis. The MsCIP PDT will closely coordinate those efforts in cooperation with the NPS, USGS, and the State of Mississippi.

A detailed study analyzing sand movement throughout the coast of Mississippi littoral drift is ongoing by ERDC. Results from this assessment will be used to develop these two options more fully. The MsCIP environmental PDT anticipates detail analysis/study of this sand movement will be needed at Ship Island in order to restore the breached area. Other specific areas (i.e. littoral zone placement sites) will also be identified during the developments. Additional study is required in order to supplement the comprehensive restoration of barrier islands with littoral zone sand placement and to fill Ship Island's breach.

The Corps, Mobile District applied the Functional Habitat Index (FHI) tool for the tentatively selected plan - placement of sand in the littoral zone and filling in Ship Island breach - in order to quantify the environmental outputs generated from various measures/alternatives. Potential benefits associated with restored habitat types were assessed using past scientific studies and direct field experience. This environmental output unit (i.e. number) generated from the FHI tables was used to assess the cost-effectiveness of various ecosystem restoration at the barrier islands. An environmental output unit quantifies the expected improvements in target functions as related to project objectives. Tables 5.4.2-1 and 5.4.2-2 provide the FHI benefits that would be achieved by implementation of this proposed construction compared to the no action.

Table 5.4.2-1.
Comprehensive Barrier Island Restoration – Littoral Zone Placement & Fill of Breach Between West & East Ship Islands

	Habitat Units									
Assessment Variables	*Shorebirds*	*Waterfowl*	*Migratory Birds*	*Raptors*	*Beach Fauna*	*Dune Flora and Fauna*	*Oysters*	*Estuarine Fish*	*T&E Species*	*FHI Unit*
Island Persistence	10	8	10	8	10	10	10	10	10	86
Shoreline Stabilization	10	8	8	8	10	10	10	6	10	80
Reproduction Habitat	10	0	0	0	8	10	10	10	10	58
Feeding Habitat	10	6	10	8	8	10	10	10	10	82
Roosting Habitat	10	6	8	6	10	10	10	10	10	80
Wintering Habitat	10	6	8	6	10	10	10	10	10	80
Dune Habitat	10	10	10	10	10	10	10	10	10	90
Beach Habitat	10	10	10	10	10	10	10	10	10	90
Water Column Habitat	8	8	8	8	8	8	10	10	10	78
Water-Land Interface Habitat	10	10	10	10	10	10	10	10	10	90
Fishery Habitat	10	10	10	10	10	10	10	10	10	90
Oyster Habitat	6	6	6	6	6	8	10	8	8	64
									TOTAL FHI	**968**

Table 5.4.2-2.
No Action

Habitat Units										
Assessment Variables	*Shore birds*	*Waterfowl*	*Migratory Birds*	*Raptors*	*Beach Fauna*	*Dune Flora and Fauna*	*Oysters*	*Estuarine Fish*	*T&E Species*	*FHI Unit*
Island Persistence	0	0	0	0	0	0	0	0	0	0
Shoreline Stabilization	0	0	0	0	0	0	0	0	0	0
Reproduction Habitat	0	0	0	0	0	0	0	0	0	0
Feeding Habitat	0	0	0	0	0	0	0	0	0	0
Roosting Habitat	0	0	0	0	0	0	0	0	0	0
Wintering Habitat	0	0	0	0	0	0	0	0	0	0
Dune Habitat	0	0	0	0	0	0	0	0	0	0
Beach Habitat	0	0	0	0	0	0	0	0	0	0
Water Column Habitat	2	2	2	2	2	2	2	2	2	18
Water-Land Interface Habitat	0	0	0	0	0	0	0	0	0	0
Fishery Habitat	2	2	2	2	2	2	2	2	2	18
Oyster Habitat	2	2	2	2	2	2	2	2	2	18
									TOTAL FHI	**54**

For similar projects (i.e. Deer Island - Section 204: Beneficial Use of Dredged Material, Mississippi and Deadman's Islands, Florida - Section 206: Aquatic Ecosystem Restoration Project), multi-disciplinary teams of biologists, scientists, ecologists, engineers, hydrologists, and planners were formed to assess what functions a particular project could potentially provide. Functions are defined as specific habitat and environmental features that would benefit from the tentatively selected project. A variety of functions are generated by a proposed alternative. During past FHI table development with the multi-disciplinary teams, it was determined best to group fauna generally rather than specifically identifying each species that would potentially use, or benefit from, the restored project area. If specifically listed, the team was concerned that the FHI table could quickly become unmanageable.

Functional production was quantified as an output that the fauna could potentially use. Functions evaluated in the matrix included substrates, habitat types, stabilization, and vegetation. The output was identified between a scaling of 1 and 10 – 10 being the highest benefit. The "No Action" still has

a FHI score even though there is no work proposed for the area. The barrier islands provide a function to the resources *currently* even though no action is being proposed; however, this benefit is considerably reduced over time. Specifically speaking, re-establishing the barrier islands via filling the breach and littoral sand placement has a *benefit* to shorebirds because they use the shoreline for feeding, nesting, and roosting. Many of these shoreline birds would cease to be on the island without it. The FHI tables quantify expected biological output by linking biophysical benefits (termed functions) to specific restoration activities. The term biophysical, in this case, refers to the living and non-living components and processes of the ecosphere. The functions identify aspects of the project beneficial to the overall habitat quality. Adding all of these outputs together from the table provides a FHI score.

5.5 Restoration of SAVs

SAV benefits an array of ecosystems in Mississippi including the following:

- Primary production (food for other animals);
- Improves water quality;
- Storm protection (dampens waves, currents, and storm surge);
- Value to commercial and recreational fisheries by providing;
- Protection to juveniles from predators;
- Nursery habitat;
- Foraging habitat;
- Nutrient cycling (estimated to be $7,700 per acre per year in 1996);
- Sediment filtration and trapping (offset sea-level rise);
- Oxygen production;
- Organic-matter production and export (provides materials used in other habitats, such as adjacent wetlands and marsh, offsets sea-level rise);
- Prevents/reduces erosion; and
- Increased species diversity (in both the sediments and SAV beds).

Table 5.5-1 provides the fish species collected in SAV beds at Grand Bay NERR from April 2005 through February 2006.

Table 5.5-1.
Fish Species Collected at Grand Bay NERR SAV beds

Scientific Name	Common Name
Anchoa mitchilli	Bay anchovy
Bairdiella chrysoura	Silver perch (drum family)
Brevoortia patronus	Gulf menhaden
Citharichthys spilopterus	Bay whiff (flounder)
Ctenogobius boleosoma	Darter goby
Cynoscion nebulosus	Spotted seatrout
Eucinostomus argenteus	Spot-fin mojarra
Lagodon rhomboides	Pinfish

Leiostomus xanthurus	Spot

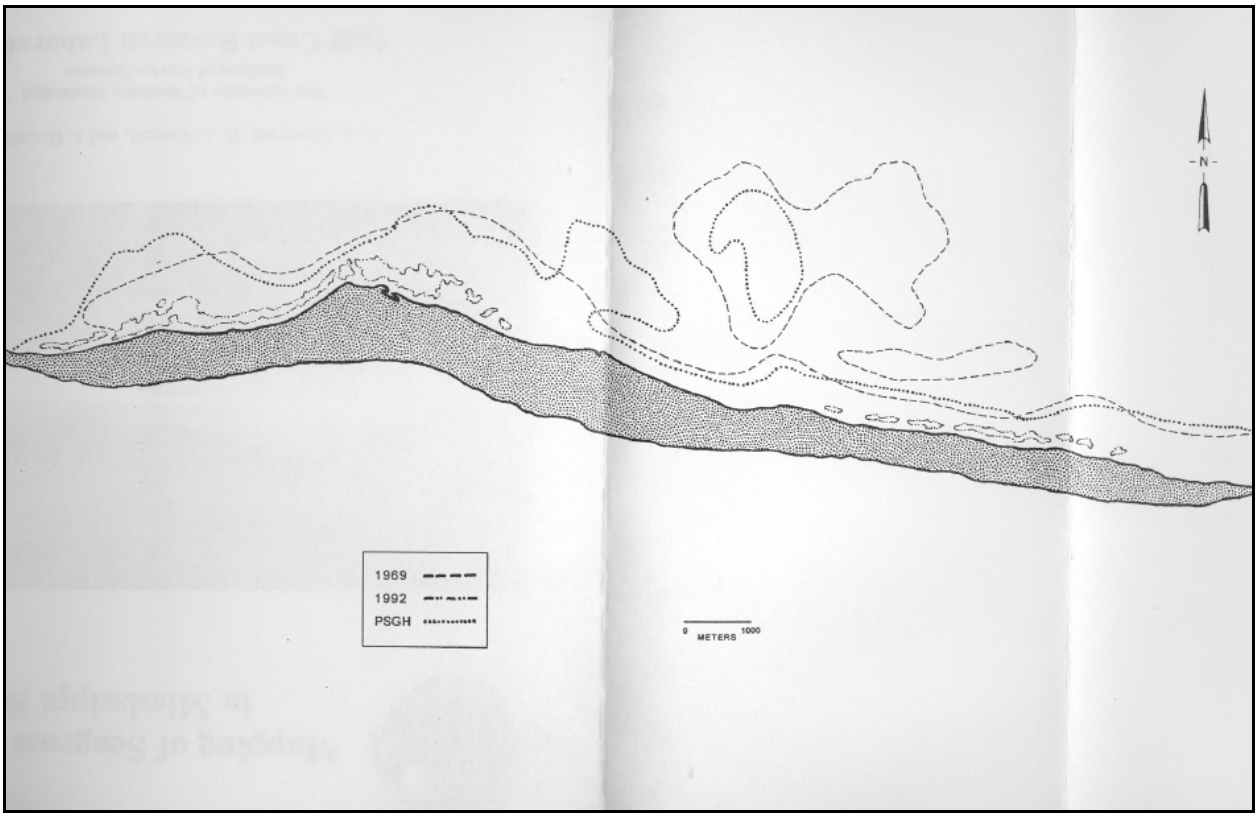
Table 5.5-1.
Fish Species Collected at Grand Bay NERR SAV beds (continued)

Scientific Name	Common Name
Lucania parva	Rainwater killifish
Lutjanus grisues	Grey snapper (mangrove snapper)
Menidia beryllina	Inland silverside
Mugil cephalus	Striped mullet
Oligoplites saurus	Leatherjack
Sphoeroides parvus	Least puffer
Sphyraena guachancho	Guaguanche (barracuda family)
Sygnathus louisianae	Chain pipefish
Sygnathus scovelli	Gulf pipefish
Symphurus plagiusa	Black cheeked toungefish (flounder-like)
Synodus foetens	Inshore lizardfish
Archosargus probatacephalus	Sheepshead
Mycteroperca microlepis	Gag grouper
Chasmodes saburrae	Florida blenny
Orthopristis chrysoptera	Pigfish

In addition, the SAV beds support shrimp and blue crabs, both of which have value as commercial and recreational fisheries.

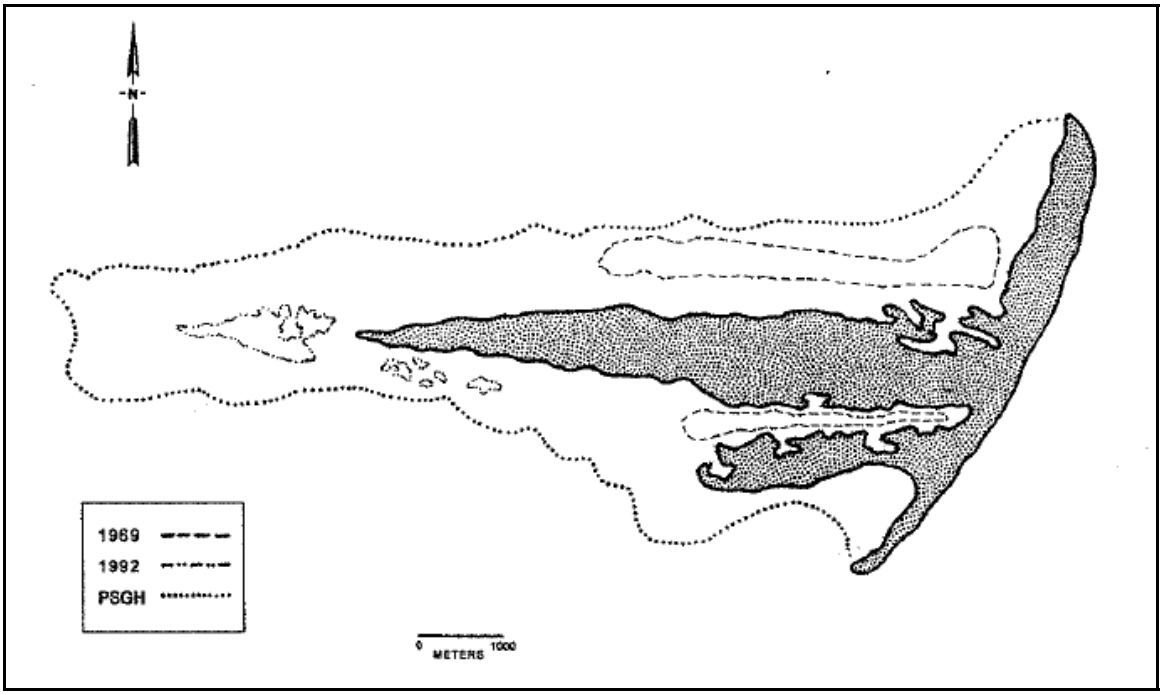
The continued survival and growth of seagrasses (i.e. SAVs) may be threatened by the cumulative effects of man's activities, in addition to, natural processes in the coastal marine environment. Natural causes of SAV (i.e. *D. wrightii, C. manatorum, T. testudinum*, and *R. maritime*) decline, such as disease, storm events, salinity fluctuation, and hypoxic events, coupled with declining water quality caused by anthropogenic eutrophication currently threaten the health of many SAV systems (Montague and Ley 1993, Durako and Kuss 1994, Olesen and Sand-Jensen 1994, Zieman et al 1994). These habitats provide vital refuges, feeding, resting, staging, and spawning grounds for a variety of species found in Mississippi Sound and also in the Gulf of Mexico. Past studies throughout the years have attributed anywhere from 50% to 90% of all marine species to utilize this vital habitat at some point in their life state.

In 1969, an estimated 20,000 acres of SAVs were documented and as of 1998, only 2000 acres were documented (Moncrieff 1998). Dramatic decreases in SAVs along the north shoreline of Horn Island have been observed. An approximate 5,040-acre decrease in coverage was calculated for the period between 1969 and 1992 (Figure 5.5-1). The overall distribution of SAVs among Mississippi's other barrier islands has also decreased considerably in the same time period, with Cat Island losing approximately 430 acres (Figure 5.5-2), Ship Island losing approximately 1,280 acres (Figure 5.5-3), and Petit Bois Island losing approximately 1,330 acres (Figure 5.5-4). Areas of SAVs along coastal Mississippi's mainland have also decline. Buccaneer State Park is estimated to have lost approximately 150 acres while Point-aux-Chenes Bay has lost approximately 680 acres (Figure 5.5-5).



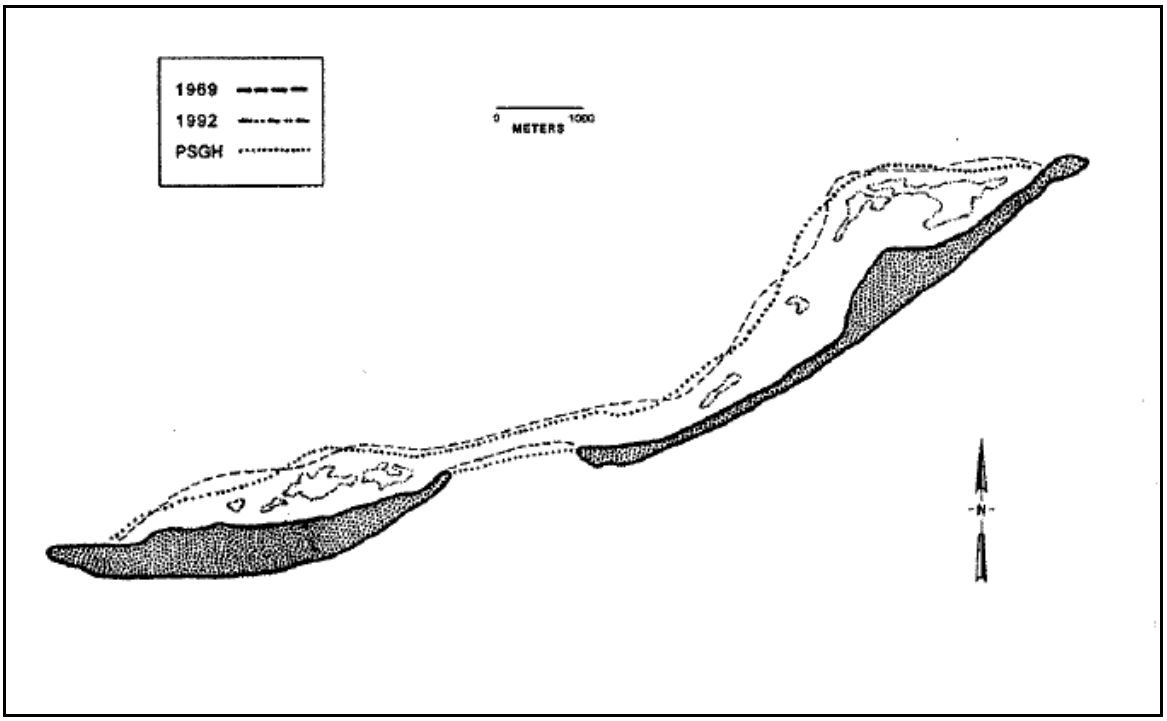
Source: GMEI

Figure 5.5-1. Horn Island – Historical, 1992, and Potential Seagrass Habitat (PSGH)



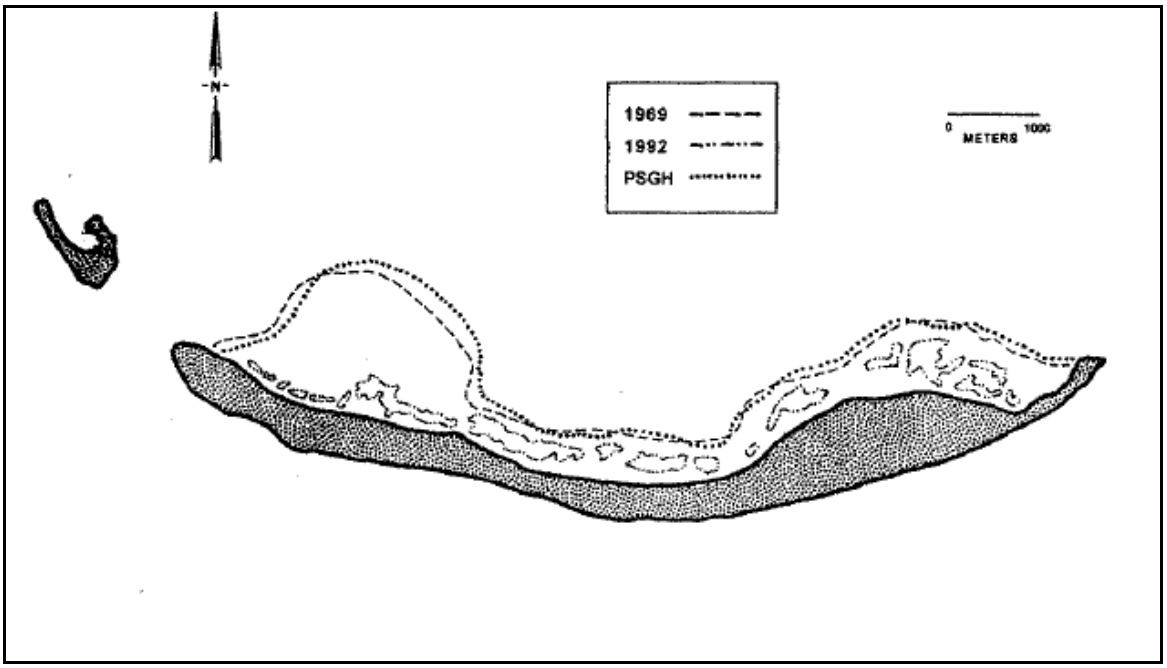
Source: GMEI

Figure 5.5-2. Cat Island – Historical, 1992, and Potential Habitat (i.e. PSGH)



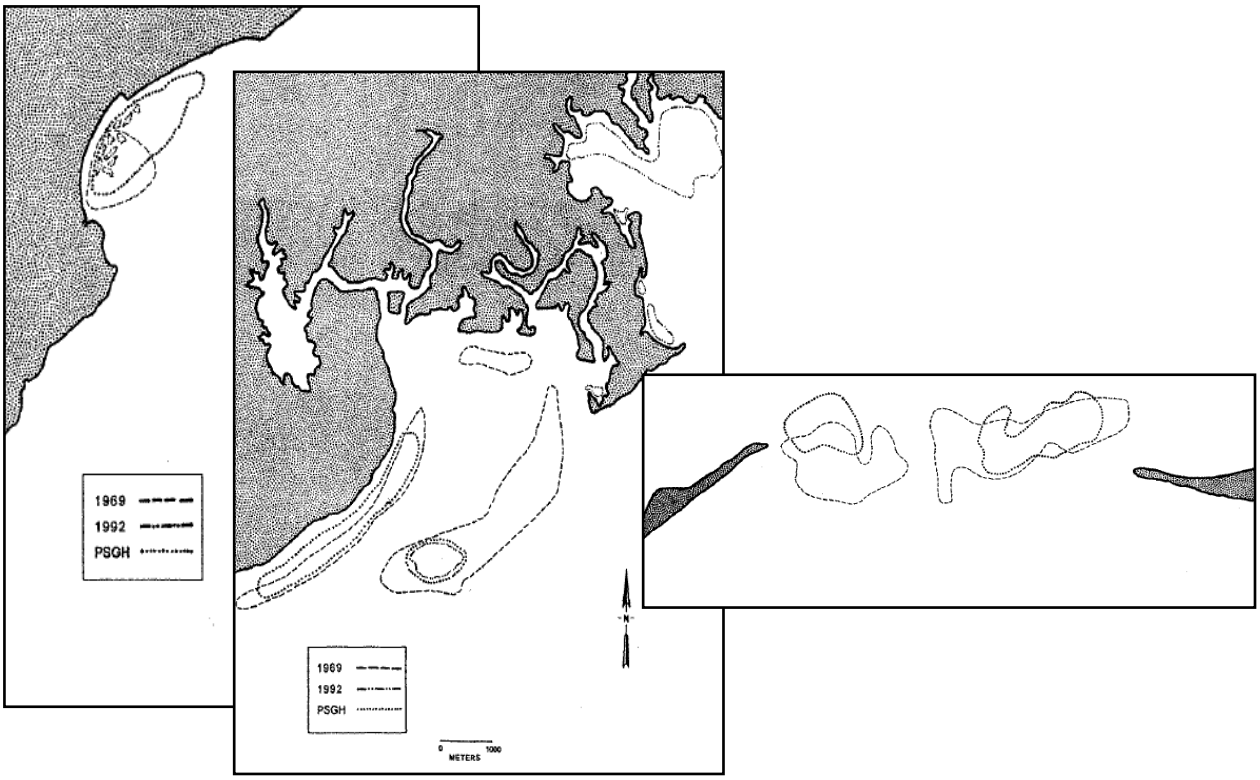
Source: GMEI

Figure 5.5-3. Ship Island – Historical, 1992, and Potential Habitat (i.e. PSGH)



Source: GMEI

Figure 5.5-4. Petit Bois Island – Historical, 1992, and Potential Habitat (i.e. PSGH)



Source: GMEI

Figure 5.5-5. Buccaneer State Park, Point-aux-Chenes Bay, Dog Keys Pass (Left to Right, respectively) – Historical, 1992, and Potential Habitat (i.e. PSGH)

Three areas were documented in which PSGH was less than the historical distribution of SAVs, indicating habitat loss. Dog Keys Pass, Horn Island, and Point-aux-Chenes Bay all exhibited this pattern with 930 acres, 1,220 acres, and 770 acres loss, respectively (Table 5.5-2).

Table 5.5-2.
SAV Historical, 1992 and Potential Habitat

Location	1969 (acres)	1992 (acres)	PSGH
Buccaneer State Park	206	55	316
Cat Island	598	169	5,128
Ship Island	1,536	253	1,603
Dog Keys Pass	2,079	0	1,149
Horn Island	5,567	530	4,350
Petit Bois Island	1,690	364	1,810
Point-aux-Chenes Bay	1,306	627	534
Totals	12,982	1,998	14,890

Reference: Moncrieff 1998

Areas of SAV habitat loss coincide with areas where rapid coastal erosion and massive long-term movement of sand has been well-documented (Otvos 1981 and Oivanki 1994). Loss of vegetated areas corresponds with potential loss in water clarity over time due either to: (1) anthropogenic influences, (2) cyclic shifts in precipitation patterns, which would affect both salinity and turbidity, or

(3) a combination of these factors (Moncrieff 1998). Primary reasons for the disappearance of SAVs are most likely an overall decline in water quality, extended periods of depressed salinities, and physical disturbances, such as tropical storms and hurricanes (Moncrieff 1998). Physical loss of habitat and decreased light availability coupled with declining water quality are the most visible features that directly affect SAVs (Moncrieff 1998). Moncrieff (1998) identified approximately 14,900 acres as being suitable SAV habitat (i.e. PSGH).

Mapping techniques have very much advanced since Moncrieff's last mapping of Mississippi Sound in the late 1990s. In discussing a potential SAV restoration project with the scientific community, the one consistent need was to re-inventory the existing SAVs in Mississippi Sound. Mississippi Sound and barrier island sedimentary processes as related to seagrass biomes are important, but not currently available. The nature, extent and volumes of sediment types within both Mississippi Sound and the barrier islands are constantly in flux, necessitating a comprehensive and ongoing assessment of sedimentary dynamics. Further studies would determine existing conditions and remaining problems that challenge establishment of SAVs within Mississippi Sound. Opportunities exist to create partnerships with other Federal and state resource agencies, and NGOs to begin identifying potential SAV restoration and establishment projects. Restoration efforts should target historical locations as a starting point to begin determining current conditions and challenges, including water quality issues, available nursery stock of plants, etc., prior to implementation of actual projects.

5.5.1 Tentatively Selected Plan

Additional study is required to assess the complex environmental make-up impacting SAVs in Mississippi Sound due to the fact that mere planting would possibly not survive. Many questions must be answered (i.e. water quality, circulation, etc.) prior to SAV restoration implementation. SAV restoration efforts across the nation have proven to be rather challenging and many examples can be identified close to Mississippi, such as in Florida. Therefore, the MsCIP environmental team is recommending additional study and re-inventory the existing SAVs in Mississippi Sound. Opportunities exist to partner with Federal, state, and local resource agencies as well as NGOs. Extensive coordination with the NPS, responsible for managing and operating Gulf Islands National Seashore, would be required for areas of potential restoration within park boundaries. Involvement of local colleges and universities with ongoing research programs would also help to identify and pinpoint specific problems for development of potential solutions. For those brackish SAV systems, limited knowledge of the functional restoration prohibited the team in developing cost effective alternatives; thus, a pilot project was identified at Bayou Cumbest to obtain the much needed described data.

Coordination with the Grand Bay NERR identified restoration of the Bayou Cumbest site to produce data, such as salinity, water quality, currents, substrates, composition of sediments, boating traffic (propellor scarring/turbidity), transplant success rates, and heterogenoity of species composition in order to determine the success criteria for future recovery efforts of SAV within brackish systems in Coastal Mississippi. As noted in other areas in the country, such as Florida, SAV restoration sometimes proves to be challenging. Thus, the MsCIP team has developed the foresight to identify these parameters to increase the recovery rates during the restoration efforts. Parameters, such as water quality/turbidity, sediment compositions, and currents will provide necessary data to better characterize other restoration sites likelihood of success. Turbidity has been noted as a constraint for SAV recovery; thus, this parameter must be quantified. Boating traffic may also limit recovery rates while increasing the species diversity could increase habitat diversity for various species of important shrimp, crabs, and juvenile fish. Until this criteria is obtained, successful recovery of SAV within these systems would prove to be very difficult if not impossible. The data gathered would be used to ensure conditions at historical SAV sites are existing to ensure the success. Future SAV

restoration site could include area north of Deer Island, Bayou La Croix, Bayou Cumbest, adjacent to Round Island, Old Fort Bayou, Davis Bayou, West Pascagoula River, and Mary Walker Bayou.

SAVs are a federally designated Essential Fisheries Habitat under the Magnuson-Stevens Act of 1996. They provide numerous ecosystem services, which include: (1) nursery for juvenile stages of finfish and shellfish, (2) an important food-source to marine species and wading birds, (3) sediment stabilization and increased water clarity, and (4) nutrient uptake and sequestration to mitigate eutrophication.

Species that will benefit directly or indirectly include the SAV - estuarine invertebrates, such as blue crabs (*Callinectes sapidus*) and brown and white shrimp (*Farfantepenaeus spp.*); waterfowl, such as dabbling ducks (*Anas spp.*), numerous anadromous fish species including spotted seatrout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), and mullet (*Mugil cephalus, M. curema*), and marine mammals, such as dolphins (*Terciops truncatus*) and manatees (*Trichechus manatus*), a protected species, that utilize SAV beds as nursery habitat. The economic valuation of the fisheries industry in Mississippi provided by the Center for Fisheries Research and Development at the GCRL indicates that there are more than 50 species of finfish and shellfish commercially harvested in state waters with a market value of $900 million in 2003, and a recreational industry valued conservatively at over $400 million in 2000 (Perry, unpubl data). Clearly loss of habitat would have a disproportionate impact on the socio-economic activities of coastal Mississippi.

This small initial brackish SAV recovery project will investigate the larger issue of SAV losses nationally and rates of natural recovery versus recovery after restoration. SAV are sensitive indicators of estuarine condition because of their high light requirements (Dennison et al 1993) and susceptibility to eutrophication-induced algal blooms and hypoxia (Hauxwell et al 2001). Furthermore, loss of SAV promotes the alteration of the sediment characteristics and nutrient cycling, causing long-term changes in habitat suitability for natural plant recolonization. These changes include loss of fine sediments through resuspension and transport, promoting a feedback loop that further inhibits natural recovery. Therefore, it is vitally important that restorative replanting be undertaken soon after damage or loss of plants to inhibit a negative change in system dynamics (Fonseca et al 2004).

For the SAV restoration effort, MsCIP team assessed the continued survival and growth of seagrasses (i.e. SAVs) and found them threatened by the cumulative effects of man's activities, in addition to, natural processes in the coastal marine environment. Natural causes of SAV decline, such as disease, storm events, salinity fluctuation, and hypoxic events, coupled with declining water quality caused by anthropogenic eutrophication currently threaten the health of many SAV systems (Montague and Ley 1993, Durako and Kuss 1994, Olesen and Sand-Jensen 1994, Zieman et al 1994). These habitats provide vital refuges, feeding, resting, staging, and spawning grounds for a variety of species found in Mississippi Sound and also in the Gulf of Mexico. Past studies throughout the years have attributed anywhere from 50% to 90% of all marine species to utilize this vital habitat at some point in their life state. In 1969, an estimated 20,000 acres of SAVs were documented and as of 1998, only 2,000 acres were documented (Moncrieff 1998).

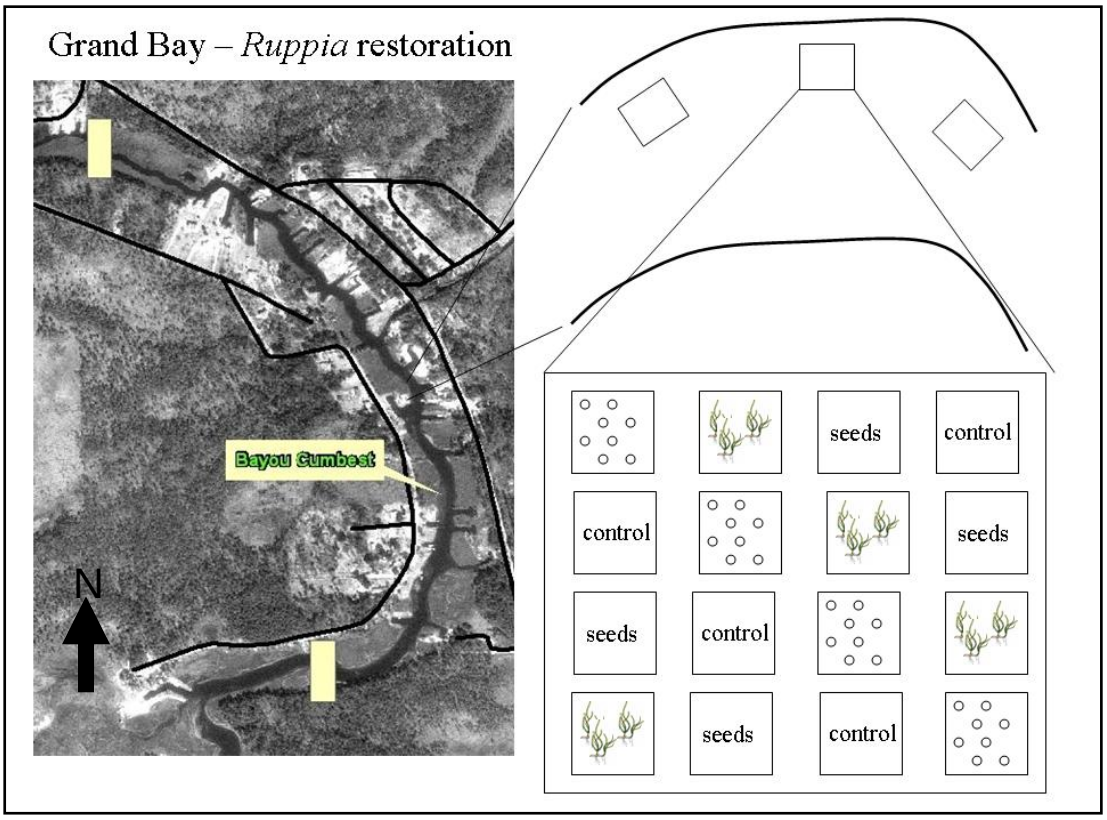
SAV restoration efforts across the nation have proven to be rather challenging and many examples can be identified close to Mississippi, such as in Florida. Thus, Bayou Cumbest was chosen due to its small size to produce data such as salinity, water quality, currents, substrates, composition of sediments, boating traffic (propellor scarring/turbidity), transplant success rates, and heterogenoity of species composition in order to determine the success criteria for future recovery efforts of SAV within brackish systems in Coastal Mississippi. Future SAV restoration site could include area north of Buccaneer State Park, Cat Island, Ship Island, Dog Keys Pass, Horn Island, Petit Bois Island, and Point aux-Chenes.

After discussing the potential SAV pilot project with biologists at ERDC, it has been determined there currently are no assessment tools for quantifying benefits of SAV restoration projects. Although quantified outputs of ecosystem projects have traditionally been used as the basis for justification, little data is available for use in establishing baseline conditions of existing SAVs, organisms currently using established beds, and the specific causes for the overall decline of brackish SAVs. As part of the data collection described above, an index would be developed most likely using acreages and density quantifying environmental outputs generated through the success of the SAV restoration pilot project. This quantifiable environmental output would then be used to demonstrate cost effective criteria for future brackish SAV systems.

SAV Pilot Project – Bayou Cumbest

The first goal of the proposed community-based restoration project in the Grand Bay NERR will result in restoration of up to 5 acres of *R. maritima* resulting in the recovery of an equal amount of SAV habitat to that lost during the 2005 hurricane season (Figure 5.5.1-1). Secondly, the Corps, Mobile District proposed to evaluate 3 restoration techniques to demonstrate their feasibility for larger restoration projects. Finally, the volunteer involvement and educational outreach will increase awareness of the importance of SAV habitat in Mississippi Sound and provide coastal managers and restoration practitioners with the knowledge of techniques to maximize their return on dollars spent.

The MsCIP environmental effort will: (1) restore SAV beds in Bayou Cumbest adjacent to the Grand Bay NERR that have been lost since the 2005 hurricanes through transplanting involving participation by the local community groups and students of the local universities and (2) determine the effectiveness of three transplanting methods (i.e. (1) a donor site, (2) harvesting plant sprigs with one or more meristems (growth regions), or (3) spreading seeds or mature flowering shoots over the restoration site) for restoring *R. maritima* in bayous, streams, and brackish marshes by quarterly monitoring using volunteers. After transplanting, quarterly monitoring for two years will be conducted to determine plant establishment, photosynthesis, growth, and expansion.



Source: MDMR

Figure 5.5.1-1. Grand Bay NERR Low Salinity Restoration Area in Bayou Cumbest using *Ruppia maritima*

The education and outreach components of the project will consist of volunteer involvement and dissemination of results through a professional workshop conducted at the end of the project. Volunteers will be recruited from Grand Bay NERR's established volunteer base, which includes local schools, universities, agencies, and civic groups. Our proposed study will also help determine the most successful and cost- and labor-effective transplanting method for restoring SAV. This information will be used in workshops and dissemination materials developed by Grand Bay NERR to inform commercial and recreational boat users/fishermen and the general public. Results will be disseminated through Grand Bay NERR's Coastal Training Program to inform coastal decision-makers and resource managers of successful restoration techniques.

This community restoration project will address the larger issue of SAV losses nationally and rates of natural recovery versus recovery after restoration. SAV are sensitive indicators of estuarine condition because of their high light requirements (Dennison et al 1993) and susceptibility to eutrophication-induced algal blooms and hypoxia (Hauxwell et al 2001). Furthermore, loss of SAV promotes the alteration of the sediment characteristics and nutrient cycling, causing long-term changes in habitat suitability for natural plant recolonization. These changes include loss of fine sediments through resuspension and transport, promoting a feedback loop that further inhibits natural recovery. Therefore, it is vitally important that restorative replanting be undertaken soon after damage or loss of plants to inhibit a negative change in system dynamics (Fonseca et al 2004).

5.6 Projects from Interim Report Carried Further

During the MsCIP Interim Report development, approximately 180 potential projects were identified. Upon further evaluation, 15 of these potential projects were tentatively selected for immediate construction and have since been funded by Congress as a result of the MsCIP Interim effort. Of the remaining identified projects, the MsCIP PDT categorized each project into the following disciplines - structural, non-structural, environmental, and/or other. The environmental PDT then reassessed those projects identified in Table 4.1.6-1. As a result, some of those projects have been carried forward.

Due to the extreme time constraints, and ultimately funding constraints, given the enormous scope of study, the MsCIP Comprehensive Report and Integrated Programmatic EIS presents tentatively selected features at a number of levels (presented below in decreasing order) of detail:

1) a feasibility-level of detail sufficient for tentative selection for construction;

2) a level of detail requiring only final resolution of technical issues, but containing sufficiently-detailed cost-estimates that would not likely violate the 902 limit on that particular project (i.e., at an “Advanced Engineering” level of detail);

3) a level of detail sufficient to make tentative selections for longer term comprehensive implementation that would require only limited additional data for refining of the final alternative and development of an Microcomputer Aided Cost Engineering System-compliant cost estimate for a tentative selection, and;

4) detail at a “less-than-feasibility” level of analysis requiring a recommendation to seek further study in order to resolve remaining technical, societal, or environmental compliance or analysis of issues, for which a cost estimate will be supplied for both the additional study and Project Engineering and Design.

If it was found applicable to the Corps’s MsCIP recovery mission, the remaining projects were incorporated, in some manner, into the previously discussed Tentatively Selected Plans. In addition, Turkey Creek: Mt. Pleasant UME Audubon site 41, tidal creek restoration of floodplain, Davis Bayou ER, Biloxi Back Bay, Turkey Creek watershed Greenway projects that are environmental in nature and are being recommended.

5.6.1 Construction

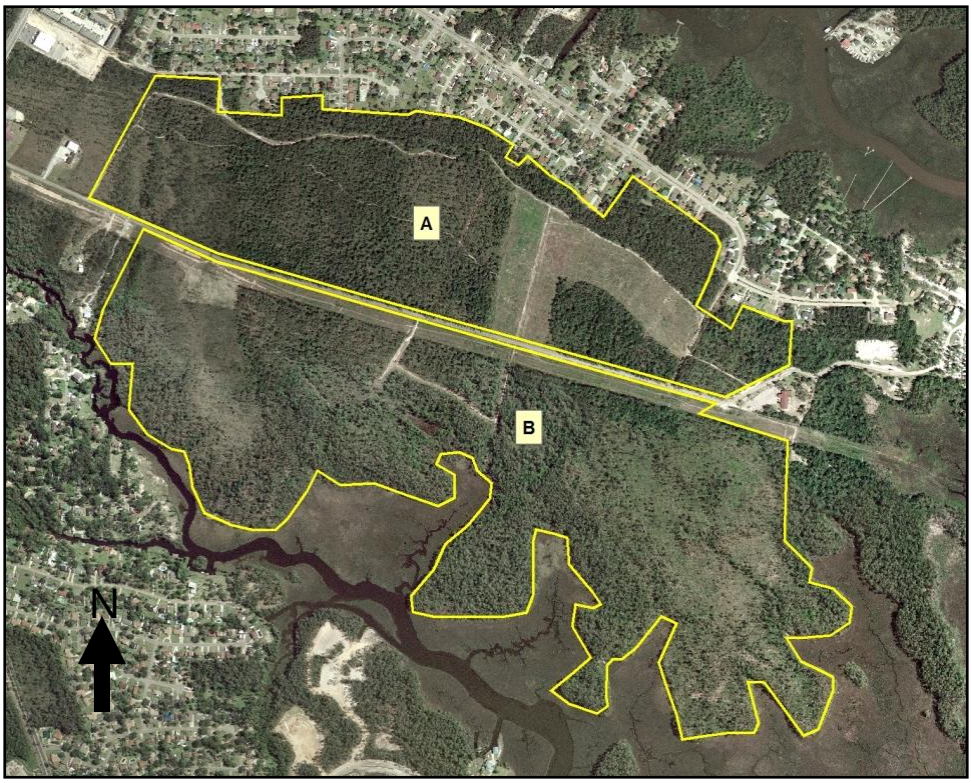
Two initial environmental restoration projects previously discussed – Turkey Creek and Bayou Cumbest – are being tentatively selected for construction.

As previously discussed in *Section 4.1.5.5 State Initiative Projects*, the Governor of the State of Mississippi’s 7-*Point Strategy* for rebuilding coastal resources of the State is anticipated to be an on-going effort over the next 10 to 15 years and included 11 restoration projects. Of those, both Admiral Island and Dantzler were included in that list and were selected to be carried forward in as being tentatively selected for construction.

State of Mississippi Initiative Plans – Dantzler, Jackson County

The original estimate for the Dantzler restoration site was 900 acres – 500 acres of marsh and 385 acres of wet pine savannah habitats (Figure 5.6.1-1). After much discussion between the Environmental PDT, it was decided that the marsh area did not need to be restored (i.e. elevations lowered, hydrology restored, and entire site replanted) but rather the site needed to be cleaned of

debris. Therefore the Environmental PDT, then decided to restore only the 385 acres of wet pine savannah habitat.



Source: MDMR

Figure 5.6.1-1. Dantzler Restoration Site

The Dantzler restoration area contains 385 acres to be restored to wet pine savannah. The restorable area is split by a road, 151 of the acres are north of the road and the remaining 234 acres are south of the road. This area was planted in plantation pine during the 1960s and ditches and stormwater lines were constructed in the early 1970s in anticipation of residential development of the site. The long-term exclusion of fire and the invasion of non-native species, such as Cogon grass and Chinese Tallow tree, have severely degraded the site.

Objective:

1. Restore the natural hydrology.
2. Restore natural fire regime.
3. Restore native wetland plant communities.
4. Provide storm surge protection.
5. Provide fish and tidal wildlife habitat.

Measures:

1. Maintain native savanna vegetation. (Mandatory)
2.

Alternatives:

a) prescribed burning on a 3-5 year cycle.

b) mowing annually.

This measure affects the “area of contiguous fire-maintained landscape”, as well as all plant related variables used in the model. It is assumed that these variables will recover to a score of 1.0 under the burn alternative. Under the mowing alternative, the “area of contiguous fire-maintained” landscape variable will score a 0.0 but the plant related variables will still score a 1.0, similar to burning.

2. 100% removal of exotics and plantation pine; maintain removal of exotic plant species in all areas over project lifetime. (Mandatory in all plans).

   This measure affects the “percent cover by invasive or exotic species” variable, and would raise the variable score to 1.0 under all plans

3. Filling in 100% of existing artificial ditches. (Mandatory)

If this measure is performed in addition to the mandatory measure 1, the hydrologic regime variable score would increase to 1.0 as there would be no more hydrologic alterations to the site.

Table 5.6.1-1.
Dantzler Restoration Measures

Plans 1-2.	Restoring areas both north and south of road (areas A and B)	
	Plan 1. 1a,2,3	Plan 2. 1b,2,3
Plans 3-4.	Restoring only area north of road (Area A)	
	Plan 3. 1a,2,3	Plan 4. 1b,2,3
Plans 5-6.	Restoring only area south of road (Area B)	
	Plan 5. 1a,2,3	Plan 6. 1b,2,3

Benefits:

The following table (Table 5.6.1-2) shows the AAFU benefit under each plan.

Table 5.6.1-2.
Summary of AAFU Benefits From Various Restoration Plans

Site	Restoration Acres	Plan	AAFU Benefit
Dantzler	385	No-action plan	0
Dantzler	385	Plan 1	1,244
Dantzler	385	Plan 2	943
Dantzler	151	Plan 3	488
Dantzler	151	Plan 4	370
Dantzler	234	Plan 5	756
Dantzler	234	Plan 6	573

The management measures were combined to create six plans that were analyzed to determine the cost-effectiveness of each. Economically ineffective plans are identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the six plans

analyzed, three plans were eliminated because they produced less benefit at greater cost than a subsequent plan. Of the three remaining plans, one proved to be more cost-effective and consists of restoration of 385 acres of restoration maintained by burning.

The tentatively selected plan requires filling ditches, maintaining vegetation growth by burning and mowing the project area in the initial year of construction as well as maintaining it by burning every three years over the life of the project, and excavating and removing existing roadbeds and any additional fill.

In order to restore this area to a wet pine savannah habitat, the higher areas will be designated as wet pine savannah. These areas have depression areas within them which will enable water to flow downward to the depression areas; thus, holding water. The wet pine savannah habitat will be restored with wet pine flatwoods, such as *P. elliotti, M. cerifera, L. glabra, S. patens and P. virgatum.*

Many species of wildlife are indigenous to the wet pine savannah habitat. Understory plant communities may contain wiregrass, sedges, orchids, American Chaffseed and rough-leaved loosestrife. Insectivorous plants that may be found include pitcher plants, bladderworts, venus flytrap, and sundews. Rare, threatened or endangered birds that may occur in these areas include Henslow's sparrow, Bachman's sparrow, red-cockaded woodpecker, and Mississippi Sandhill Crane. This ecosystem may also benefit the Mississippi Gopher frog and in drier areas along ridges, the black pine snake and the gopher tortoise. The importance of this habitat and the need for burning has been previously described in the Turkey Creek discussion in *Section 5.1.1.1.2.1.2 Benefits*.

Benefits are measured in terms of AAFU. The HGM approach was used to assess wetland function similar to Turkey Creek. Table 5.6.1-3 shows the AAFU net benefit under each plan. The AAFU net benefit was calculated as the difference between the total functional units for the ecosystem restoration plan and the total functional units for the no action plan.

Table 5.6.1-3.
Summary of Benefits

Plan	Plan Description	AAFU Net Benefit
No Action	No Action	0
Plan 1	385 Acre Restoration Burn Remove Exotics Fill	1,244

Admiral Island, Hancock County

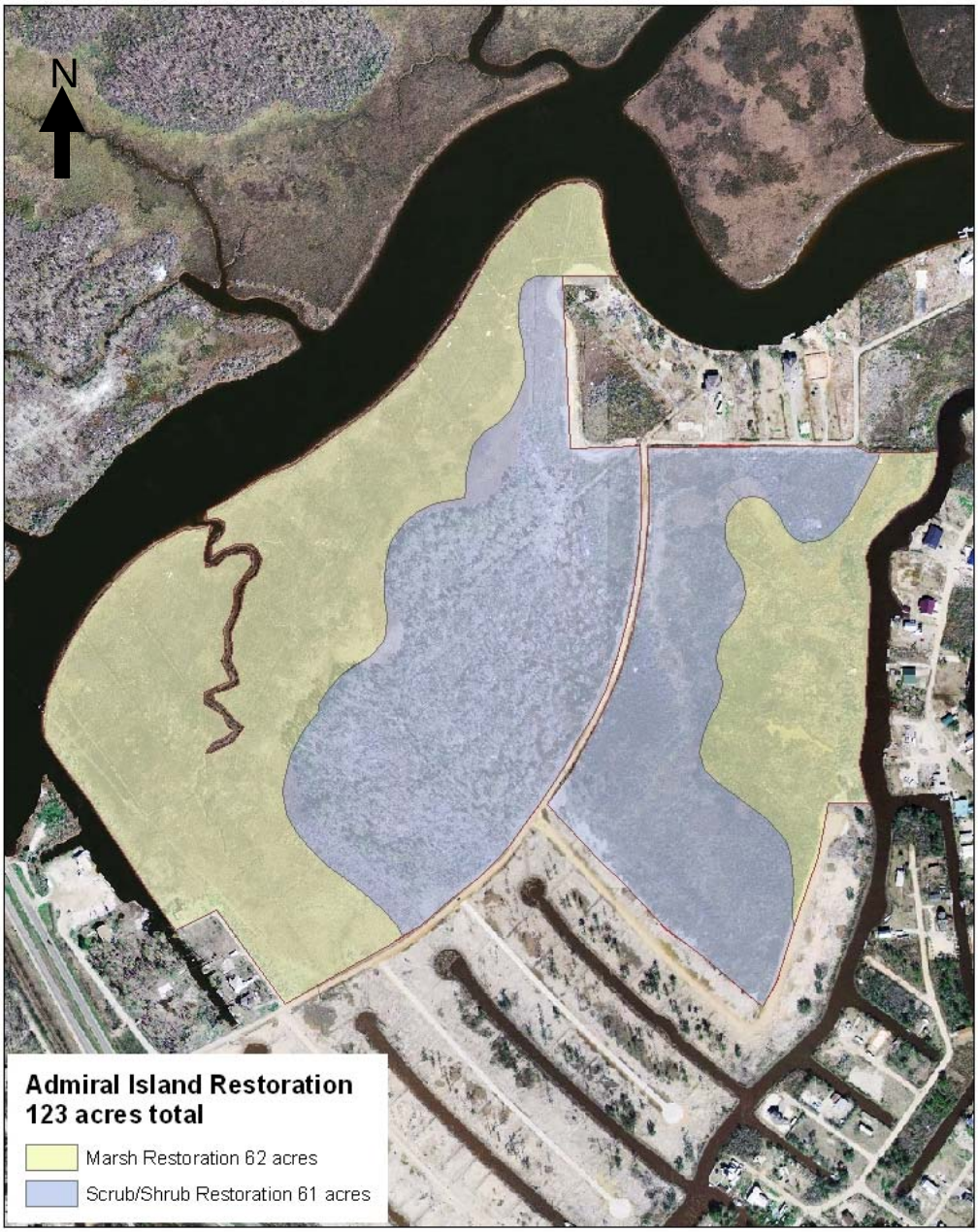
The Admiral Island restoration area contains 123 acres to be restored to 62 acres of emergent tidal marsh and 61 acres of scrub shrub habitats (Figure 5.6.1-2). Existing scrub shrub vegetation at the site supports natural propagation through removal of exotic species that currently outcompete native vegetation. The tidal marshes in this area were ditched during the 1960s causing changes in the natural hydrology and subsequent changes in the species composition. Hurricane Katrina left extensive debris fields and sedimentation in the area and destroyed many native trees and vegetation. Due to the loss of native species this area has a severe infestation of the invasive Chinese Tallow tree, which is invading the marshes and the adjacent flatwoods. For increased habitat diversity, the team proposed to leave some of the higher elevations as is and plant shrub/scrub species in order to enhance environmental benefits at the restoration site. The diverse habitat allows for a variety of fish and wildlife to utilize the area which increases the environmental benefits.

Objective:

1. Restore the natural hydrology.
2. Restore native wetland plant communities.
3. Provide storm surge protection.
4. Provide fish and tidal wildlife habitat.
5. Prevent saltwater intrusion

Measures:

1. Excavation of old fill material (includes 90-95% removal of existing exotic species in excavated areas) (Mandatory).



Source: MDMR

Figure 5.6.1-2. Admiral Island Restoration Site

This measure, in conjunction with measure 3, affects the hydrologic regime variable, which under existing conditions receives a score 0.25, on the assumption that greater than half the site has been filled above the normal tidal flooding zone. This measure by itself would raise the hydrologic regime variable to a 0.75.

2. 100% removal of exotics from non-excavated areas and maintain removal of exotic plant species in all areas over project lifetime. (Mandatory in all plans).

   This measure affects the “percent cover by invasive or exotic species” variable, and would raise the variable score to 1.0 under all plans

3. Filling in 100% of existing artificial ditches/channels.

   If this measure is performed in addition to the mandatory measure 1, the hydrologic regime variable score would increase to 1.0 as there would be no more hydrologic alterations to the site.

4. Native Vegetation Planting

Alternatives:

a) 0.5 meter spacing

b) 1 meter spacing

c) 2 meter spacing

This measure affects the “percent cover by woody plant species”, “wildlife habitat diversity”, “vegetation height”, “wetland indicator status” and “mean percent cover emergent plant species” variables. The relevant vegetation variables are assumed to reach their highest potential score at year 5 under 0.5 meter spacing, year 7 with 1.0 meter spacing, and year 10 with 2.0 meter spacing, and then sustained at that level for the project life (50 years). Variable subindex scores are treated as increasing linearly from their value under the no-action plan up to their highest potential value obtained at year 5, 7, or 10, depending on the planting spacing, and then remaining constant thereafter (Tables 5.6.1-4 and 5.6.1-5).

Table 5.6.1-4.
Measures

Plan 1. 1,2,3,4a	Plan 2. 1,2,3,4b	Plan 3. 1,2,3,4c
Plan 4. 1,2,4a	Plan 5. 1,2,4b	Plan 6. 1,2,4c

Table 5.6.1-5.
Summary of AAFU Benefits From Various Restoration Plans

Site	Restoration Acres	Plan	AAFU Benefit
Admiral Island	62	No-action plan	0
Admiral Island	62	Plan 1	61
Admiral Island	62	Plan 2	60
Admiral Island	62	Plan 3	59
Admiral Island	62	Plan 4	51
Admiral Island	62	Plan 5	50.5
Admiral Island	62	Plan 6	49

The management measures were combined to create six plans that were analyzed to determine the cost-effectiveness of each. Economically ineffective plans are identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the six plans analyzed, two plans were eliminated because they produced less benefit at greater cost than a subsequent plan.

The tentatively selected plan consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas, planting native vegetation at a density of

1.0 meter, and filling existing artificial ditches. The planting of native vegetation consist of *S. alteniflora, J. roemerianus, and S. patens*.

Benefits are measured in terms of AAFU. The HGM approach was used to assess wetland function similar to Bayou Cumbest. Table 5.6.1-6 shows the total functional units under each implemented plan and the AAFU net benefit. To calculate the AAFU net benefit, it is assumed that benefits will be maximized at year 5 with 0.5 meter spacing of vegetation, at year 7 with 1.0 meter spacing of vegetation, and at year 10 with 2.0 meter spacing of vegetation. These benefits are estimated to be sustainable over the life of the project. Net AAFU benefits are calculated as the difference between the total functional units for the ecosystem restoration plan and the total functional units for the no action plan. The tentatively selected plan was selected based on the criteria used for Bayou Cumbest.

Table 5.6.1-6.
Summary of Benefits

Plan	Plan Description	Net AAFU Net Benefits
No Action	No Action	0
Tentatively Selected Plan 2	Excavate Fill Remove Exotics Plant at Density 1.0m Fill Ditches	60

Franklin Creek Restoration Area

The project site is located in eastern Jackson County and has been funded for homeowners assistance and relocation as part of the MsCIP Interim Report and/or the 180 projects previously discussed. The restoration project consists of 149 acres located north and south of the CSX Railroad line, a major thoroughfare through the community. The site received severe flood damages from a decade of hurricanes. Historically, the site consisted of wet pine savannah wetlands. It is assumed that removal of utilities, building slabs, and roadways would be completed as part of the ongoing interim project. The following restoration measures were developed.

Objectives:

The following objectives were developed for ecosystem restoration:

1. Restore native vegetation

2. Restore natural hydrology

3. Restore fish and wildlife habitat

4. Provide storm water storage protection.

Assumptions:

1. Mandatory purchases of the residents as part of the MsCIP Interim Project.

Measures:

Proposed restoration management measures are listed in the following table. Narrative descriptions of each management measure follow this table.

1. Filling in ditches (Mandatory).

This measure affects the “Outflow of Water” variable, which measures the removal of water by ditches or drains. The variable score would increase from 0.1 to 1.0 under this measure.

2. Maintain vegetation (Mandatory).

Alternatives:

a. Burn (3 year cycle)

b. Mow (annual)

This measure affects the “area of contiguous fire-maintained landscape”, as well as all plant related variables used in the model. It is assumed that these variables will recover to a score of 1.0 under the burn alternative. Under the mowing alternative, the “area of contiguous fire-maintained landscape variable will score a 0.05 but the plant related variables will still score a 1.0, similar to burning.

3. Excavate and remove existing roadbeds and any additional fill (Mandatory).

This measure affects the “surface water storage” variable, which measures the presence of excavation or fill, at the site. This variable score would increase from 0.1 to 1.0 in areas with existing roadbeds/fill.

4. Add culverts (Mandatory).

This measure increases the hydrologic connection between the two existing wetland areas separated by an elevated railway. The wetlands are primarily precipitation driven resulting in sheet flow drainage. Additional culverts will result in increased sheet flow drainage reducing standing surface water in the northern wetland area.

A combination of measures resulted in the following plan combinations and a summary of functional unit benefits are shown in the table below:

Table 5.6.1-7.
Measures

Plan 1. 1,2a,3,4	Plan 2. 1,2b,3,4
Plan 3. 1,2a,3	Plan 4. 1,2b, 3

Table 5.6.1-8.
Summary of AAFU Benefits From Various Restoration Plans

Site	Restoration Acres	Plan	Average Annual Functional Unit Benefit
Franklin Creek	149	No-action plan (plans 1-2)	0
Franklin Creek	56	No-action plan (plans 3-4)	0
Franklin Creek	149	plan 1	516
Franklin Creek	149	plan 2	399
Franklin Creek	56	plan 3	194
Franklin Creek	56	plan 4	150

Plan Selection:

The management measures were combined to create six plans that were analyzed to determine the cost-effectiveness of each. Economically ineffective plans are identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same

as a subsequent plan but produces less benefit than that subsequent plan. Of the six plans analyzed, three plans were eliminated because they produced less benefit at greater cost than a subsequent plan. Of the three remaining plans, one proved to be more cost effective and consists of restoration of 149 acres of restoration maintained by burning.

The tentatively selected plan requires filling ditches, maintaining vegetation growth by burning and mowing the project area in the initial year of construction as well as maintaining it by burning every three years over the life of the project, and excavating and removing existing roadbeds and any additional fill.

Benefits:

In order to restore this area to a Wet Pine Savannah habitat, the higher areas will be designated as Wet Pine Savannah. These areas have depression areas within them which will enable water to flow down to the depression areas; thus, holding water. The Wet Pine Savannah habitat will be restored with Wet Pine Flatwoods as previously discussed.

Benefits are measured in terms of AAFU and HGM. Table 5.6.1-9 shows the AAFU net benefit under each plan. The AAFU net benefit was calculated as the difference between the total functional units for the ecosystem restoration plan and the total functional units for the no action plan. The tentatively selected plan was selected based on previous criteria discussed.

Table 5.6.1-9.
Franklin Creek Benefits

Plan	Plan Description	AAFU Net Benefit
No Action	No Action (149 acres)	0
Tentatively Selected Plan	149 Acre Restoration Maintain by Burning	516

5.6.2 Longer Term Comprehensive Plan

Environmental Restoration Sites (i.e. 38 sites in the coastal counties – ex. Bayou Cumbest and Turkey Creek).

5.6.3 Preconstruction Engineering Design for specific features

State Initiative Plans:

- Wachovia, Hancock County – There are roadways to be removed.
- Ansley, Hancock County – There are roadways to be removed.
- DuPont, Harrison County – There are roadways to be removed.

5.6.4 Additional Feasibility Studies

State Initiative Plans:

- LaFrancis Camp Trenaisse, Hancock County (water modeling needed)
- Enhancement of the Barrier Islands – Restoring Vegetation and Dune systems
- SAV Restoration on the Northern Portions of the Barrier Islands

- Round Island, Jackson County
- Pascogoula River Marsh, Jackson County
- Twelve Oaks and Helmer's Lane, Jackson County

5.6.5 Advanced design studies for innovative concepts

- Freshwater Diversion Structures – Grand Bay, Pearl River, Escatawpa
- Biloxi Marsh Comprehensive Ecosystem Restoration
- West Pascagoula Delta Ecosystem Restoration
- Watershed Planning Approach
- Maximize Beneficial Use of Dredged Material
- Littoral Placement of Sandy Material adjacent to Barrier Islands
- Coastal Mississippi Artificial Reef Projects for Remediation of Hurricane Damage
- Oyster Reef Restoration
- Wetland Restoration along main drainage systems to increase capacity of flood storage during rainfall and storm events
- Prevention of coastal erosion of archaeological sites
- SAV long-term monitoring program (i.e. advanced technological mapping)

5.6.6 State of Mississippi Environmental Initiative

Several projects have been tentatively selected for construction by the State of Mississippi.

5.7 Forrest Heights Levee, City of Gulfport, Harrison County

5.7.1 General

The culturally historical Forest Heights residential community in the City of Gulfport, Harrison County, Mississippi, has frequently been inundated by flood waters due to storm surges from Mississippi Sound and from inland flooding along the lower Turkey Creek. Water reached a depth of 2- to 8-foot over the entire community during Hurricane Katrina inundation. The Forest Heights levee is proposed to be constructed as a pilot project for the MsCIP comprehensive plan. The levee will address the combination of storm surge protection, inland flooding protection, and evacuation. The levee is intended to be constructed to a height, such that the levee might be certified under the National Flood Insurance Program. A preliminary engineering analysis suggests a levee built to approximately elevation 21 feet North American Vertical Datum (NAVD) 88 would satisfy or exceed certification elevation criteria.

Engineering performance and economic evaluations of protection options were done using the Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA. HEC-FDA modeling was done using variations in with-project conditions compared to the future without-project conditions for the Turkey Creek study. Details regarding the methodology are presented in the Economic Appendix. Additional evaluation to determine the precise levee height will

be performed during final engineering and design based upon analyzing the risk and uncertainty associated with the coincident occurrence of inland flooding and storm surge impacts.

5.7.2 Location

The Forrest Heights community is located in an area known as North Gulfport within the City of Gulfport on the Mississippi Gulf Coast. The location of the levee at Forrest Heights is shown below in Figures 5.7.2-1 and 5.7.2-2. The community lies along the lower Turkey Creek floodplain, which has a tendency to frequently exceed its stream channel capacity and flood adjacent low-lying areas.

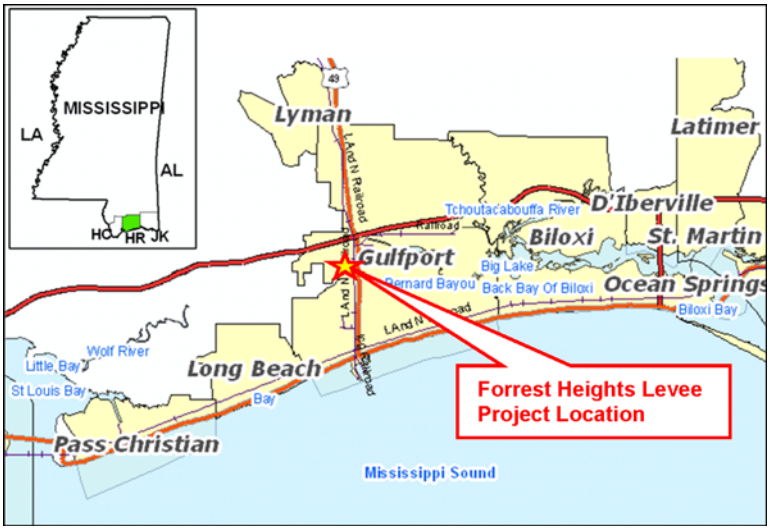
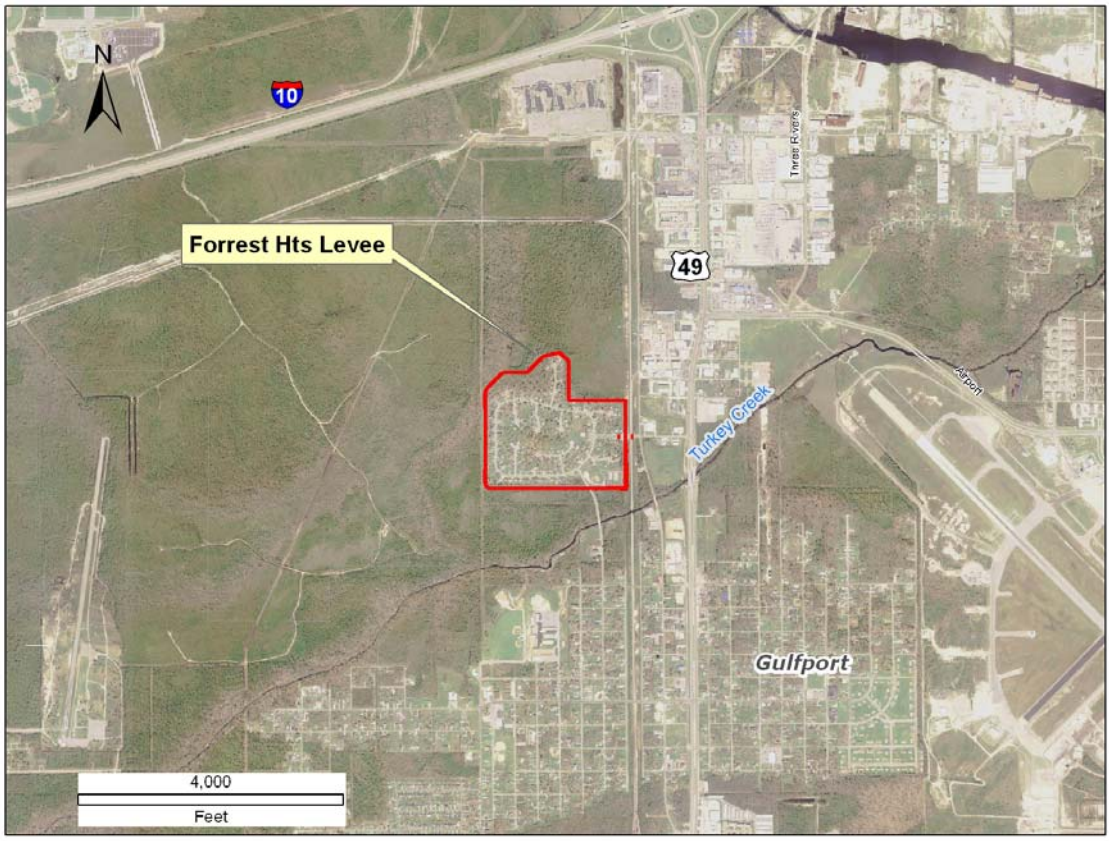


Figure 5.7.2-1. Vicinity Map



Source: Corps

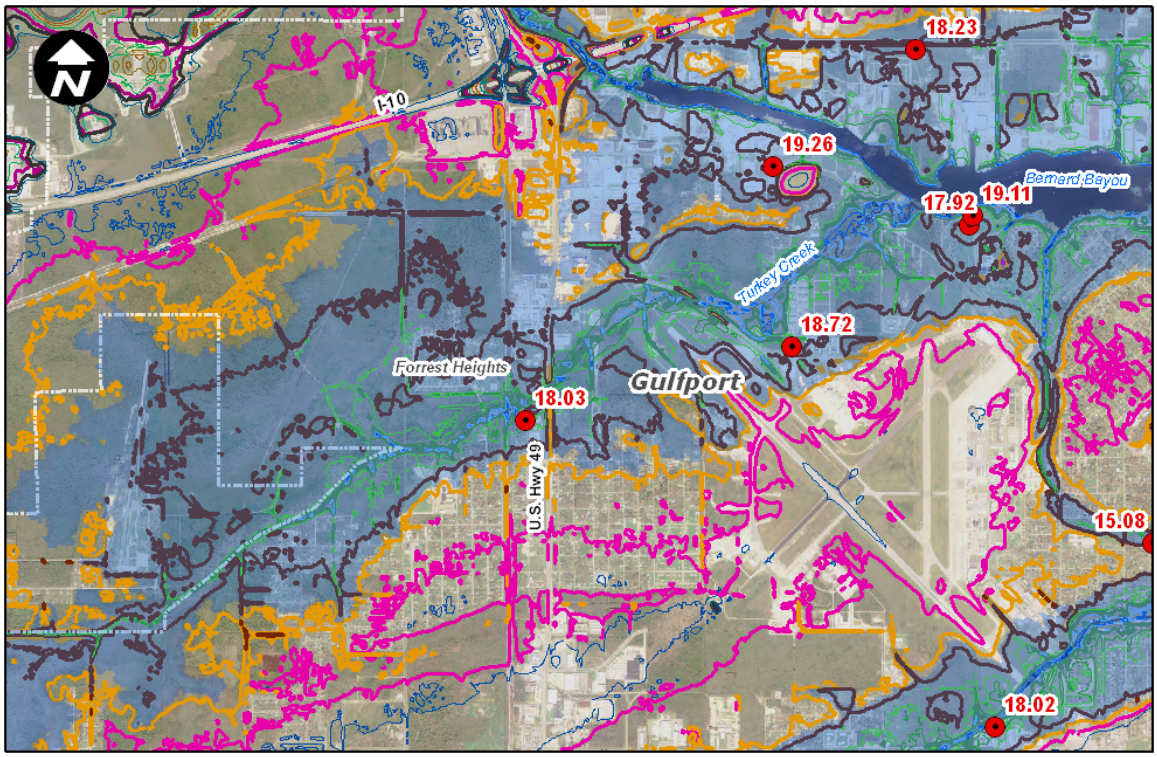
Figure 5.7.2-2. Forrest Heights Ring Levee Location

5.7.3 Existing Conditions

The community of Forrest Heights lies on the bank of Turkey Creek about 2.6 miles from the mouth at Bernard Bayou. Ground elevations over most of the residential area are between elevations 10-14-foot NAVD88. Drainage is mostly along streets and through natural drainage ways to the Turkey Creek. Impacts from flooding and hurricanes have been devastating. Hurricane Katrina in August, 2005 resulted in significant flood damages to residences in the Forrest Heights community. A levee with top width of 6 feet was constructed around the community to elevation 16.5 feet NGVD with sideslopes of 1 vertical to 1.5 horizontal in 1969, prior to Hurricane Camille. It has not had adequate maintenance and is a state of disrepair. It is scheduled to be restored to as-built condition by January of 2009. However, the restored levee will not be sufficient to meet the present day standard for certification according to the existing FEMA flood profiles in the vicinity. It is assumed that the as-built condition of this restored levee will be the existing condition for this report.

5.7.4 Coastal and Hydraulic Data

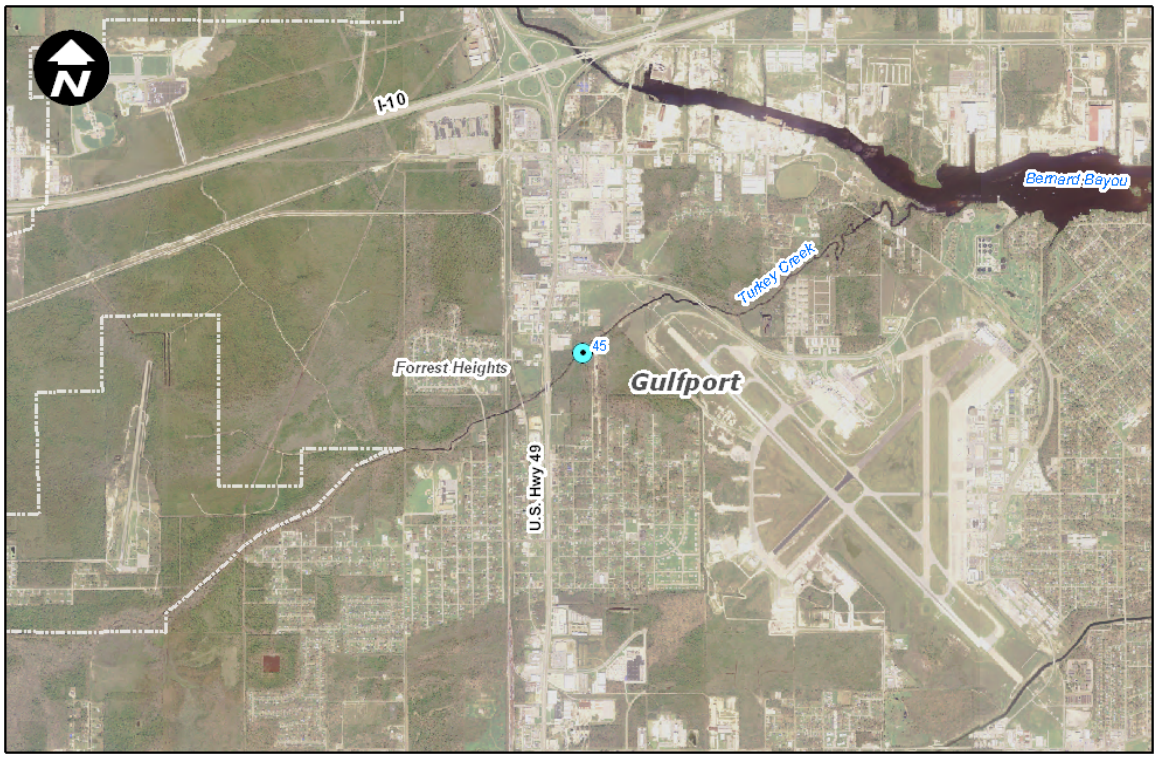
High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-foot (blue), 8-foot (dark green), 12-foot (green), 16-foot (brown), 20-foot (orange), and 20-foot (pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 5.7.4-1. The data indicates the water was as high as 18-20 feet NAVD88 near the site, totally inundating the entire area.



Source: Corps

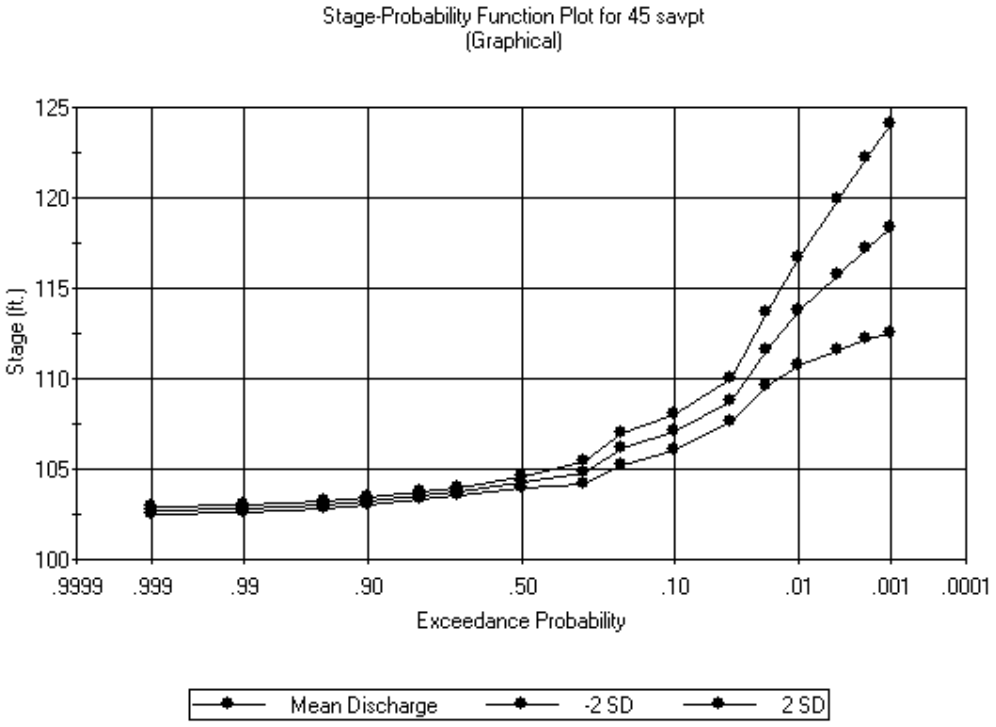
Figure 5.7.4-1. Hurricane Katrina Inundation and High Water, Forrest Heights

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by ERDC for 80 locations along the study area. These data were combined with historical coastal tide gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area. Points near Forrest Heights at which data from hydrodynamic modeling was saved are shown below in Figure 5.7.4-2, and the stage frequency curve for that location is shown in Figure 5.7.4-3. Hydrodynamic output stage-frequency pairs, with uncertainty, are displayed in Table 5.7.4-1.



Source: Corps

Figure 5.7.4-2. Hydrodynamic Modeling Save Point near Forrest Heights



Source: Corps

Figure 5.7.4-3. Surge-only Stage Frequency Curve, Vicinity of Forrest Heights

Table 5.7.4-1.
Surge Stage-Probability and Uncertainty

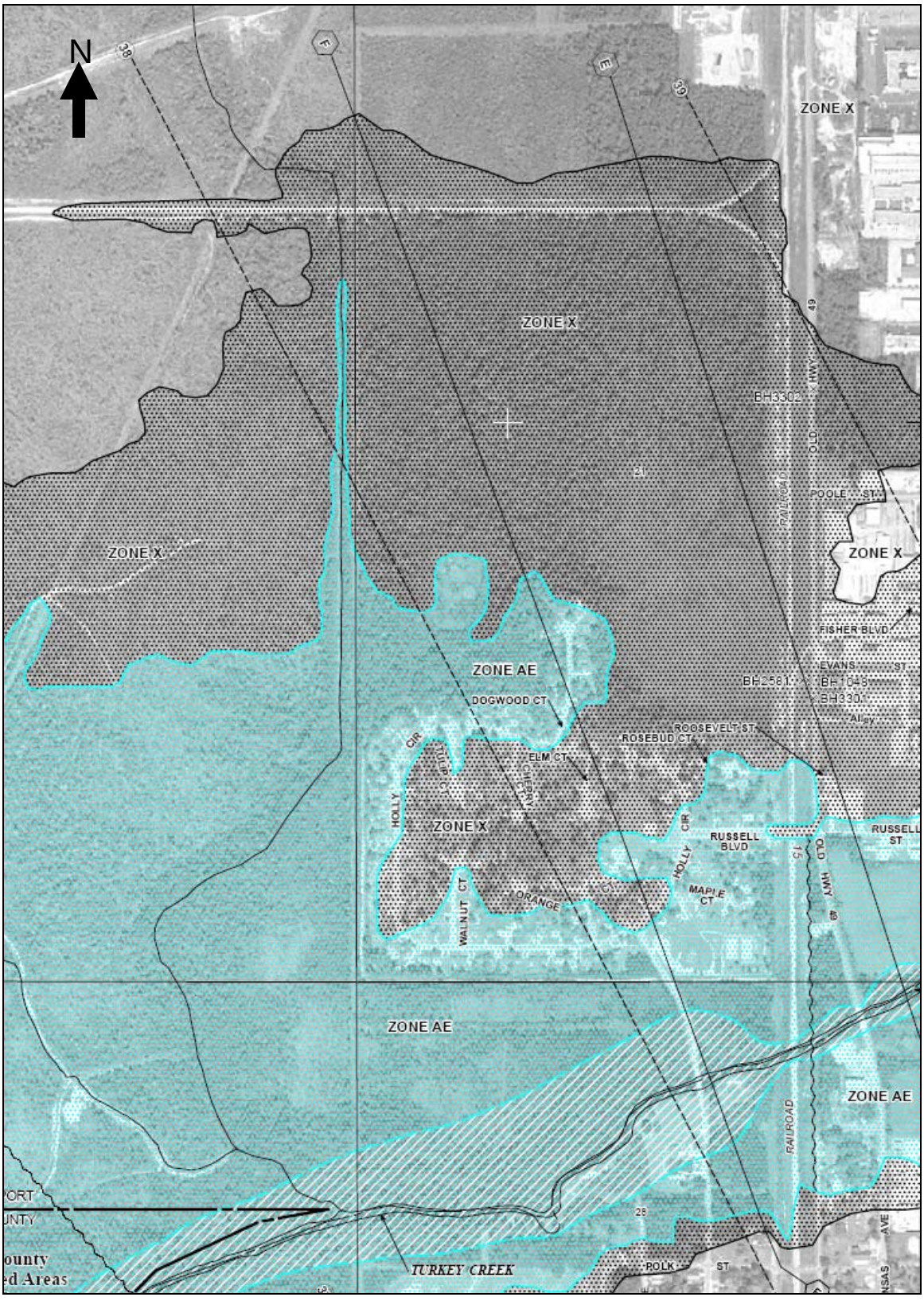
Annual Probability	Stage (Ft. NAVD88)	Standard Deviation (Feet)
0.04	8.8	0.6
0.02	11.6	1
0.01	13.7	1.5
0.002	17.2	2.5
0.001	18.3	2.9

It should be noted that the frequency curve reflects only that flooding resulting from storm surge in the Gulf. The Forrest Heights community is also subject to riverine flooding by Turkey Creek. The preliminary FEMA Harrison County Flood Insurance Study (FIS) dated November 2007 provides computed Turkey Creek flood profiles which appear to have been adjusted for the effects of coincident surge in Back Bay of Biloxi. Table 5.7.4-2 shows relevant discharge and stage information from the FIS for Turkey Creek at Ohio Avenue, the southern entrance to the Forrest Heights community. In comparison to the preliminary FEMA Flood Insurance Study dated November 2007, which is based on contemporary (post-Katrina) FEMA contractor hydrodynamic modeling, the ERDC frequency curve, which is based on surge alone, suggests a lower stage associated with the annual one in one hundred chance (0.01 exceedance probability) event.

Table 5.7.4-2.
Turkey Creek Flood Stages at Ohio Avenue, Harrison County FIS.

Exceedance Probability	Discharge (cfs)	Stage (ft. NAVD '88)
0.1	2600	12
0.02	3650	14.2
0.01	5500	15.5
0.002	7950	18.3

Figure 5.7.4-4 shows a portion of the preliminary Harrison County Flood Insurance Rate Map in the vicinity of Forrest Heights. Low-lying peripheral areas of the neighborhood are shown in a shaded blue field as being in the 1% annual chance ('100-yr') regulatory floodplain, with the remainder of the community occupying a shaded Zone X field, being areas subject to shallow flooding at annual probabilities of occurrence between 0.02 (2%) and 0.01 (1%).



Source: Corps

Figure 5.7.4-4. Preliminary FEMA Flood Insurance Rate Map, Vicinity of Forrest Heights.

Hydraulic data was developed for use in the HEC-FDA program. The HEC-FDA program uses risk-based analysis methods for evaluating flood damage and flood damage reduction alternatives. The program relies on hydrologic, hydraulic, and economic data input. Uncertainties in these data are input and used by the model for computing annual damages. Version 1.2.3b dated August 2007 was used. As described in Engineering Appendix - Chapter 2, this is a customized version of the current official release version 1.2 dated March 2000. This section describes the model's hydrologic and hydraulic input as applied to the Forrest Heights community. The Economic appendix describes the economic input and results. The Main Report describes how the model output was examined and used in the plan formulation process. Additional explanation is provided in the Engineering Appendix.

5.7.5 Engineering Performance

Project engineering performance was computed using HEC-FDA. Engineering performance was computed for the existing and future without project conditions; and a variety of existing and future with-project conditions. Performance was computed with risk and uncertainty. The base year was assumed to be 2012, and the future year was assumed to be 2061 (50 year period of analysis). Scenarios were also evaluated assuming (a) existing sea level, (b) expected sea level rise, and (c) high sea level rise.

The existing condition assumes that the NRCS has reconstituted their levee around the Forest Heights community to a crest elevation of 16.5 feet. The existing and future hydrologic and hydraulic conditions are presumed to be as represented by the FIS hydrology and flood profiles with uncertainty. Typically, one would consider increasing future flood discharges to account for possible increases in runoff due to development and urbanization. However, in this case, the underlying FIS hydrologic information is dated, being circa 1976, and subsequent studies have suggested that the effective tributary drainage area in this relatively flat and undifferentiated portion of the Turkey Creek watershed is less than the 25 or so square miles attributed to the creek at the location of Forest Heights. The existing hydrology is most likely conservative, and revisions downward for an un-gauged stream seem ill-advised. Additionally, the area in question benefits from an updated and contemporary FIS, where the Turkey Creek profiles have been adjusted for coincident surge elevations, and the floodplain has been re-mapped accordingly. In the end, it seems advisable to rely on the existing FIS profiles and hydrology for conservative results.

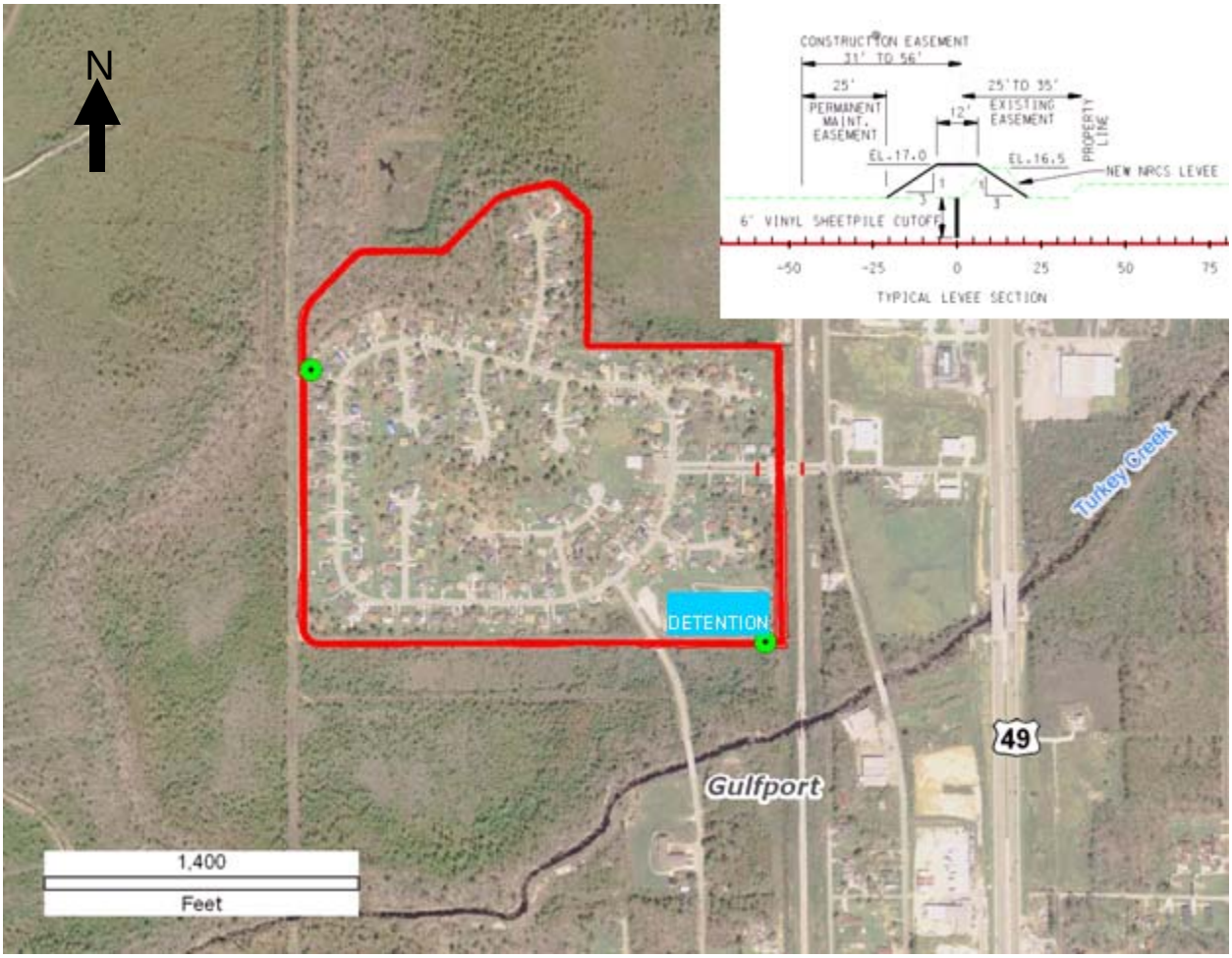
With-project conditions were evaluated for levees with crest elevations of 17 and 21 feet. The existing with-project condition assumes clearing and snagging of debris in Turkey Creek will counteract any local water surface profile impact due to flow obstruction by the levee. Future with-project conditions assume that the channel maintenance has been neglected, and thus the rating curve at Ohio Avenue is shifted upwards by 0.3 feet.

Performance was also evaluated assuming a levee built to the local Base Flood Elevation (BFE) - the regulatory one in one hundred annual chance water surface elevation plus three feet. Historically, FEMA required levees to be built to the BFE plus three feet for certification. This condition no longer in and of itself satisfies certification criteria, which now requires that risk and uncertainty also be considered. This condition was evaluated for the purposes of levee certification. Assuming the BFE is defined by the FIS water surface elevation at Ohio Avenue as described on the FIS Turkey Creek Flood Profile, this elevation is 15.5 feet plus 3 feet, or elevation 18.5 feet.

Forest Heights occupies a small fringe of the floodplain, and the FDA simulations assume that when the levee is overtopped, the interior floods to the exterior flood elevation.

5.7.5.1 Option A - Elevation 17 ft NAVD88

This option consists of an earthen dike around the Forrest Heights community as shown on the following Figure 5.7.5.1-1, along with the levee culvert/interior pump/detention location. The earth dike will be trapezoidal in shape with a 12-foot top width with one foot vertical to three foot horizontal slopes on both sides. For this option, the two existing roadway entrances will be ramped over the restored levee. The total length of the levee will be approximately 7,900 feet.



Source: Corps

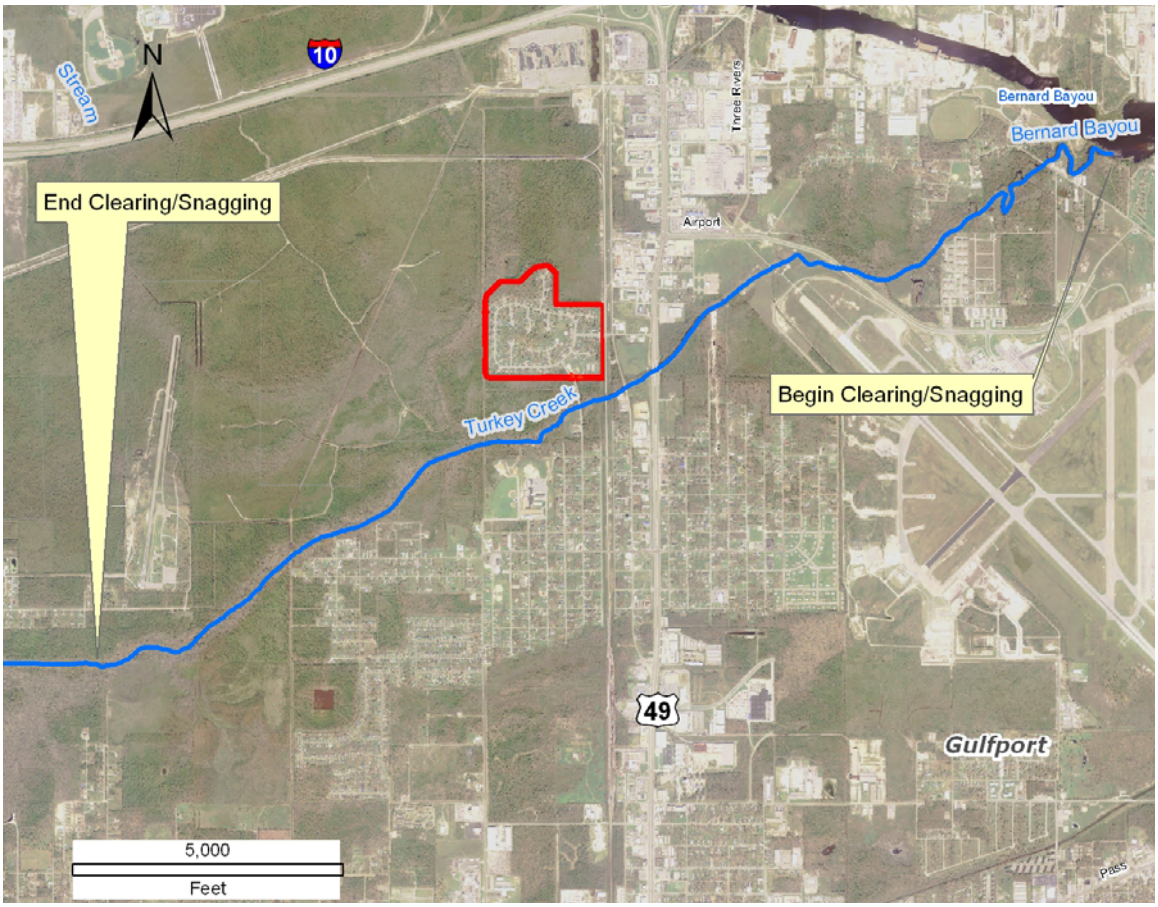
Figure 5.7.5.1-1. 17-ft Elevation Levee Alignment with Culvert and Pump/Detention Basin Locations

Levees reduce the storage capacity and overbank flow conveyance of the adjacent floodplain. The reductions in overbank flow area could induce higher water levels upstream. An HECRAS model was used to evaluate the potential for induced damages and solutions. The modeling indicates that selective clearing and snagging would prevent increases in water surface elevations upstream that would occur due the placement of the levees in the floodplain.

The selective clearing and snagging would extend for approximately 4.5 miles from the mouth of Turkey Creek at Bernard Bayou to the upstream limits as shown in Figure 5.7.5.1-2. Selective clearing and snagging would remove obstructions such as debris dams and excessive sedimentation that hinders the flow through the Turkey Creek channel. While the selective clearing and snagging component of the plan does not eliminate flooding along Turkey Creek, the plan does reduce flood

damages along the creek and at the upper end of the canals at 28th Street. The main purpose of the selective clearing and snagging is to make sure that induced damages do not occur due to the construction of the levee.

The selective clearing and snagging work will follow Stream Obstruction Removal Guidelines established by the American Fisheries Society. Only debris, snags and sediment that obstruct the flow will be removed. Material to be removed includes: 1) fine sediment accumulations that obstruct flows and alter flow patterns; 2) Debris blockages that currently or in the near future cause obstructed flow and altered flow patterns; and 3) Rooted trees that obstruct flow or need to be cleared for equipment access. Access areas that are cleared will be reestablished at the conclusion of the selective clearing and snagging activities. Some access points, however, may remain for the non-Federal sponsor to use for maintenance activity of the completed project. The existing bank alignment along the entire reach will not be changed, including the downstream reaches of Turkey Creek along the meander bends. Specific reaches to be cleared and snagged will be identified by an interdisciplinary team prior to construction.



Source: Corps

Figure 5.7.5.1-2. Channel Clearing and Snagging Limits

Damage and failure by overtopping of levees could be caused by storm surges greater than the levee crest. Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that

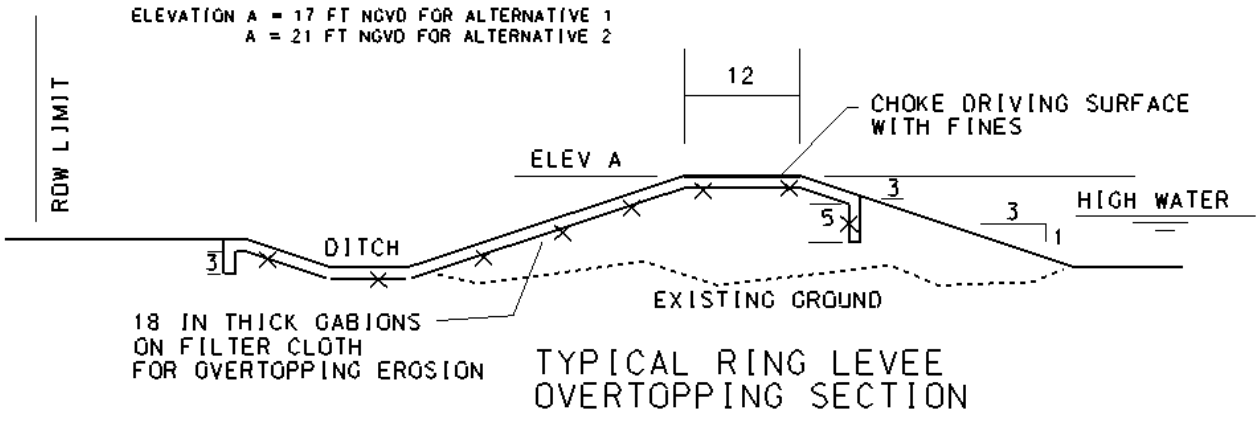
major damage did not occur from wave action. The erosion shown below in Figure 5.7.5.1-3 was caused by approximately 1-2 foot of overtopping crest depth.



Source: Corps

Figure 5.7.5.1-3. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet Levee in St. Bernard Parish, New Orleans, LA

An overtopping reach of the levee with a revetment at the detention/culvert location would be included in the levee design to prevent overtopping failure. The levee would be protected by gabions on filter cloth as shown in Figure 5.7.5.1-4, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.



Source: Corps

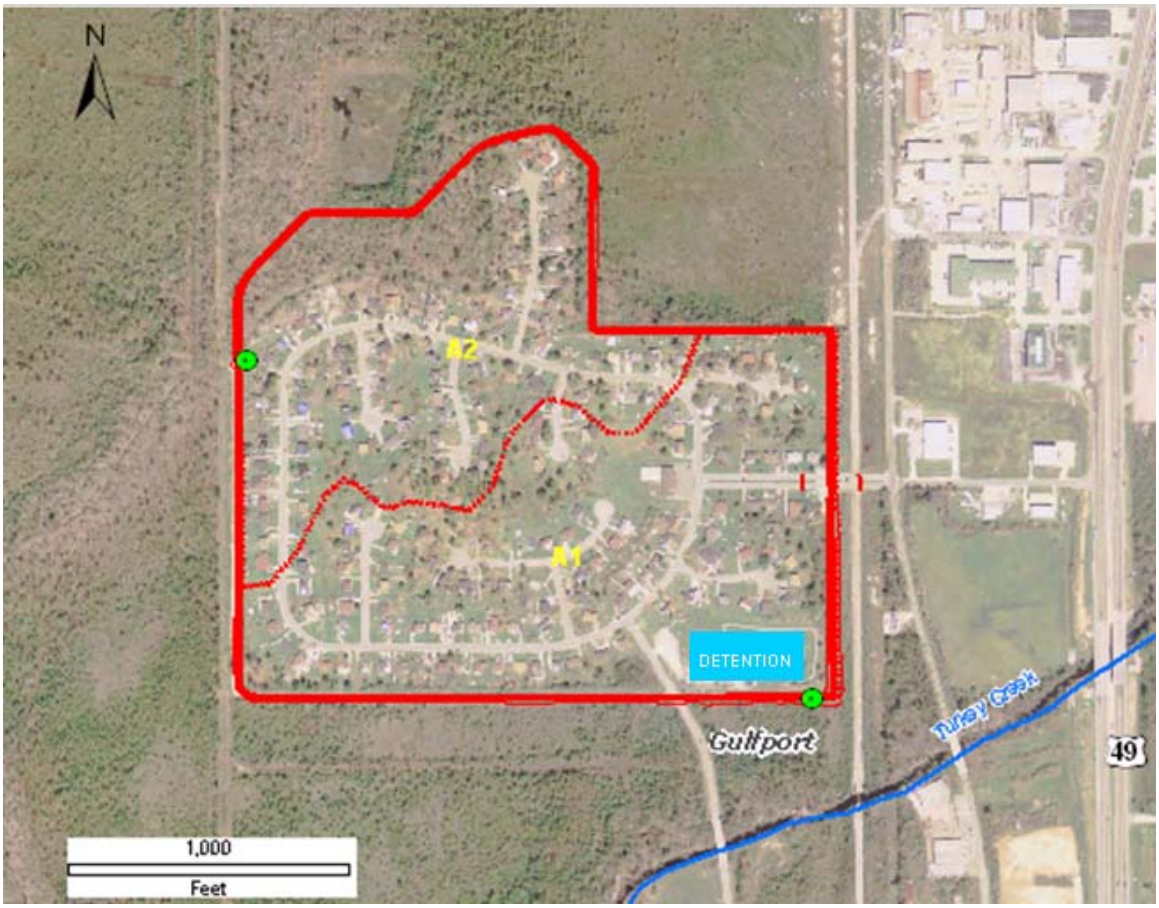
Figure 5.7.5.1-4. Typical Levee Overtopping Section

5.7.5.1.1 Interior Drainage

Drainage at the site is impacted by hurricanes in the Gulf and by adjacent flooding from Turkey Creek. Backwater from each of these sources prevents water from running off. The existing NRCS levee at elevation 16.5 NAVD 88 protects the neighborhood to some degree from these sources, but does not eliminate the flooding during times when the water outside the levee is up and there is

rainfall inside the levee. This is the present condition at the site. Construction of the Corps levee will follow the footprint of the NRCS levee and provide additional protection from flooding from hurricanes and Turkey Creek. The interior flooding will be improved by adding a detention basin and pumping facility.

Flow within the levee interior was determined by subdividing the interior of the ring levee into major sub-basins shown below in Figure 5.7.5.1.1-1 and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number. The curve number was determined from previous studies done for Turkey Creek.



Source: Corps

Figure 5.7.5.1.1-1. 17-ft Elevation Levee Sub-basins

Peak flows for the 1-year to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley Culvert Master application. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 10 feet NAVD88 with a tailwater elevation of 6 feet NAVD 88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

During periods of high water in Turkey Creek or Mississippi Sound, pumping would be required to evacuate rainfall. Pump size was determined for the peak flow resulting from a 10-year rainfall.

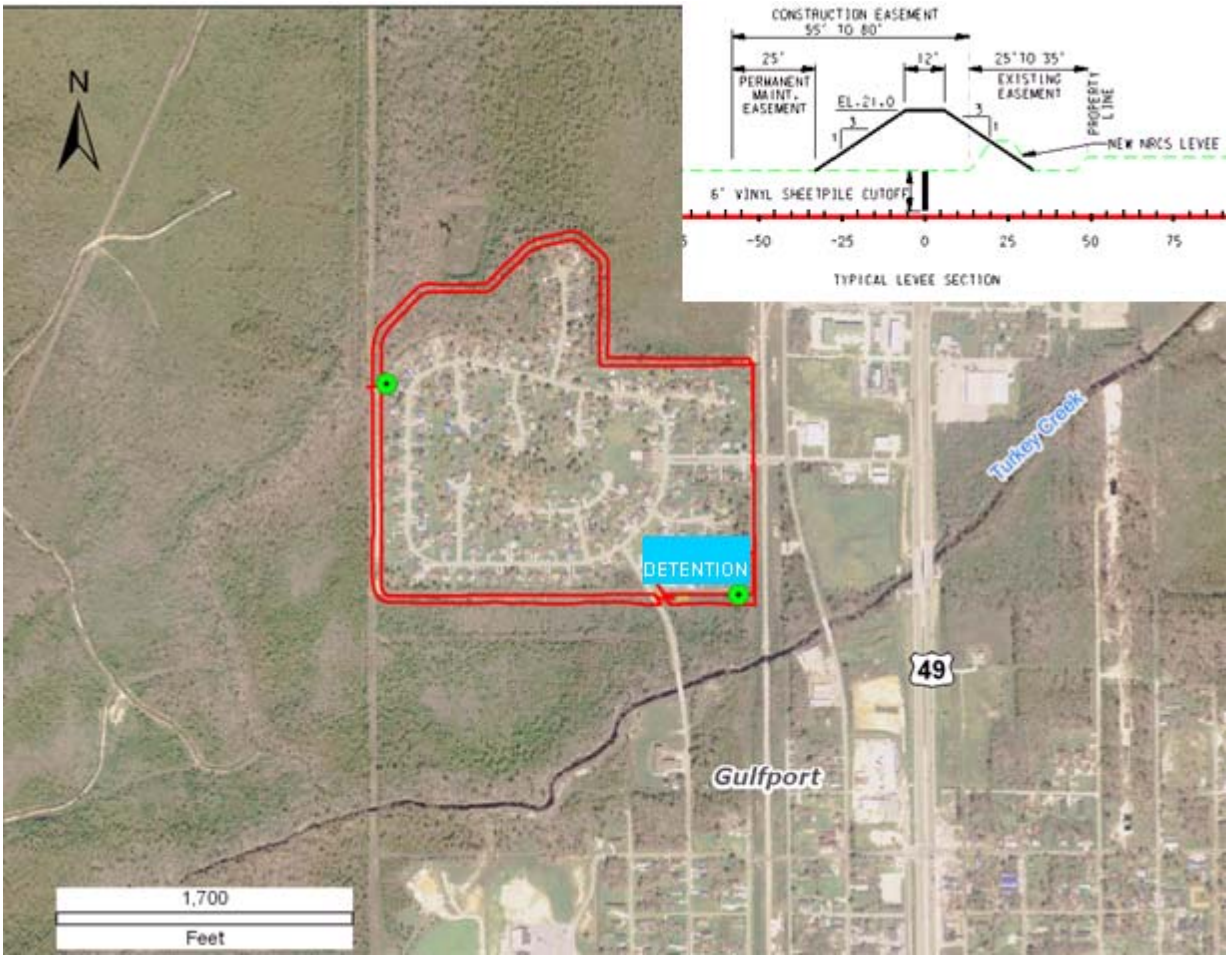
Additional information concerning this decision is included in the Engineering. During some hurricane events or high water in Turkey Creek, when the culvert gates are shut, and rainfall exceeds the average 10-year intensity over the basin, some ponding from rainfall will occur. A detention basin was added to help reduce the size of required pumps. The detention basin would have an area of approximately 3 acres but would not be excavated. The area is the lowest site in the subdivision and is presently used for recreation facilities, such as baseball and tennis. Detailed modeling of the area was not possible for this report; therefore, the exact extent of the detention basin is not precisely defined. Designing the pumps for the peak 10-year flow provides a significant pumping capacity. Further design during construction will refine the requirement for the appropriate detention area and pump sizes to provide protection from 100-year rainfall.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-year event occurs, the pump could also be used to augment the flow capacity of the levee culverts.

Additional details concerning the levee at Forest Heights are located in the Engineering Appendix.

5.7.5.2 Option B - Elevation 21 ft NAVD 88

This option consists of an earthen levee around northern, western, and southern sides of the Forrest Heights community. Because of the height of the levee, the eastern side will be constructed with a concrete “T”-wall structure. The “T” wall will take less space than an earthen levee and encroach less into property along the alignment. The alignment of the levee is generally the same as Option A, but is shown below in Figure 5.7.5.2-1. Closure gates across the two access roads to the subdivision will be required. The lengths of the levee culverts will be slightly longer than those used in Option A. Other features and methods of analysis are the same.



Source: Corps

Figure 5.7.5.2-1. 21-ft Elevation Levee Alignment with Culvert and Detention Basin/Pump Locations

5.7.5.2.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

5.7.6 Summary

The proposed action would consist of raising the existing levee to an elevation of 21 feet along the current alignment of the lower existing levee. Under this alternative, there is an expected loss of 19.85 acres of non-tidal wetland vegetation impacted by construction of the levee. Additionally, construction of the levee to 21 feet would cause the loss of 3.15 acres of other vegetation, which consists of mainly mixed pine hardwood forests. Although native vegetation under the levee footprint would be lost, the levee itself would be vegetated with non-native species for stabilization of the structure.

5.8 High Hazard Area Risk Reduction Plan (HARP)

Although the coastal areas of the nation are attractive to commercial, industrial, and residential developers, the consequences (as evidenced by Hurricane Katrina and past large hurricanes)

associated with locating damageable property and unwary residents along the Gulf Coast can be extreme. Despite ongoing regulation through FEMA and other coastal zone management techniques, damageable property would still remain in high-hazard areas and people would still be in danger during hurricanes.

The non-structural team formulated a series of non-structural measures that would work either independently of structural measures or in concert with them to provide substantial reductions in flood damages due to surge inundation and waves associated with future hurricane or storm events. Additional information would need to be collected and analyzed in order to address uncertainties regarding the cost and effectiveness of non-structural measures; however the team identified primary measures that include permanent acquisitions, floodproofing by elevation and other means, relocations of public buildings, flood preparedness and evacuation planning, public education, changes in the current municipal and county National Flood Insurance Program and building codes, implementation of either a transfer of development rights or purchase of development rights program, potential changes in zoning ordinances, development impact fees, and redirection of new development. These measures have been combined into eight separate plans that could be implemented by either Federal, State, or local agencies, county and local governmental units, or some collaboration thereof. The following projects have been developed further for implementation under this MsCIP Comprehensive Plan and are discussed in the following paragraphs.

5.8.1 High Risk HARP

The HARP alternative would provide an effective means to induce and assist devastated and displaced property owners in relocating outside of high-hazard surge-plain throughout coastal Mississippi. Acquisition of those properties where the residential owners have not yet rebuilt and continue to be displaced presents a unique window of opportunity to assist landowners while minimizing cost to the U.S. Government. The HARP, an acquisition strategy, would provide a non-structural alternative for reducing property damage resulting from hurricanes, storm surge and flooding, and by extension, reducing threats to lives in those areas, in the most hazardous areas throughout coastal Mississippi.

5.8.2 Moss Point Municipal Relocation Component

This component consists of relocating the City of Moss Point's municipal buildings to a lower risk site with regards to flooding within the incorporated limits. This will aid the city in providing basic community services in a more timely fashion after future storm events, and further demonstrate the effectiveness of relocations projects as a hurricane and storm damage reduction measure along the Mississippi coast. These buildings include the city hall, police station, fire station and community services building and will be replaced to current standards and based upon the existing community needs. Implementation of this project would allow a demonstration of a relocation project in order to determine the effectiveness of the hurricane and storm damage reduction measure by relocation of the city's municipal services at a lower risk area.

5.8.3 Waveland Floodproofing

The City of Waveland is located in Hancock County, Mississippi and was directly in the path of Hurricane Katrina. Because of the critical habitat surrounding the city and its low lying areas, the only flood damage reduction measures available to a portion of Waveland are either acquisition or floodproofing the individual structures. In order to evaluate the different foundation and building types, 25 structures would be selected in the Waveland area that could be safely elevated out of the 1% chance storm event, and which could not be protected by any other structural measures evaluated as part of this study.

5.9 Deer Island Restoration

Deer Island is located within the boundaries of Harrison County, Mississippi near the mouth of the Biloxi Bay and offshore of the City of Biloxi. The island is considered a mainland remnant and is not part of the coastal barrier system of islands along the Mississippi coast. It is unique in that it is one of the only few islands along the Northern Gulf of Mexico, which are totally surrounded by an estuarine environment. The storms of 2005 and other past storm events have exacerbated an already eroding shoreline and degrading interior marshes and coastal maritime forest areas. The island contains a diverse habitat of beach/dunes, emergent tidal marshes, and coastal maritime forests.

Without intervention (i.e. the No Action Plan), Deer Island would continue its degradation and ultimately increased wave action would occur along the mainland at the City of Biloxi. The southern shorelines would continue to erode; thus, adversely impacting those dependant species, such as birds and crabs. Wave action from daily occurrences and storm events would eventually erode the beach and then begin eroding the emergent tidal marsh and coastal maritime forests. Furthermore, the Section 204 emergent tidal marsh restoration site would continue to degrade. Ultimately, this unique habitat would continue to change from a productive beach/dune, emergent tidal marsh, and coastal maritime forest habitat to stressed and non-functioning habitats.

Deer Island contains a diverse habitat of beach/dunes, emergent tidal marshes, and coastal maritime forests. Its proximity to the City of Biloxi provides a certain amount of protection to the city from waves generated by approaching hurricanes. Currently, the uninhabited island is part of the MDMR Coastal Preserves Program. Restoration efforts have been funded under the Section 528 of WRDA of 2000 for breaches at the west end and near Grand Bayou, and parts of the southern shoreline. Although a substantial restoration effort in its own right, there are significant opportunities to further restore the island and repair hurricane-caused damage to the islands' ecosystems. Deer Island restoration consists of a combination of the following alternatives to form the tentatively selected plan:

- Continued restoration for the southern shoreline as part of the Section 528 of WRDA of 2000 project (assessed in the *Environmental Restoration in Coastal Mississippi: Deer Island Restoration Projects, Harrison County, Mississippi Environmental Assessment* dated September 2007);
- Repair/Replace the Section 204 containment dike (containment dike assessed in the *Section 204 Ecosystem Restoration Project In Connection with Construction, Operations, or Maintenance Dredging of a Federally Authorized Project, Environmental Restoration in Coastal Mississippi Marsh Re-Establishment Project, Harrison and Jackson Counties, Mississippi Environmental Assessment* dated July 2002);
- Add/Replace material in the Section 204 containment dike (placement of material assessed in the *Section 204 Ecosystem Restoration Project In Connection with Construction, Operations, or Maintenance Dredging of a Federally Authorized Project, Environmental Restoration in Coastal Mississippi Marsh Re-Establishment Project, Harrison and Jackson Counties, Mississippi Environmental Assessment* dated July 2002);
- Analyze new stone training dikes on the northern and southern ends of the islands as a result of Section 204 (requires minor additional study);
- Lengthen stone containment dikes on northern and southern ends as a result of Section 204 (various alignments assessed in the *Section 204 Ecosystem Restoration Project In Connection with Construction, Operations, or Maintenance Dredging of a Federally Authorized Project, Environmental Restoration in Coastal Mississippi Marsh Re-Establishment Project, Harrison and*

Jackson Counties, Mississippi Environmental Assessment dated July 2002 but requires some minor additional study); and

- Create additional marsh habitat area adjacent to the existing created marsh area (requires minor additional study).

Tables 5.9-1 and 5.9-2 provide an overview of benefits associated with implementation of the proposed project:

Table 5.9-1.
Functional Habitat Index Restoration of Grand Bayou, the West End Breach and Entire Southern Shoreline

Functions	Shoreline Birds	Migratory Birds	Native Fish	Sport Fish	Macro Invertebrates & Primary Producers	Bivalves	Proposed Alternative		Future Without	
							Functional Habitat Index (FHI)	FHI 525 acres	Future w/o FHI	FHI 0 acres
Restoration of Emergent Beach and Dune System	0.10	0.10	0.05	0.05	0.05	-	0.35	183.75	-	0.0
Restoration of Maritime Forest Habitat	0.10	0.10	-	-	0.05	-	0.25	131.25	-	0.0
Soft Substrate	0.05	0.05	0.10	0.10	0.05	0.05	0.40	210	-	0.0
Reestablishment of pre-disturbance shoreline	0.05	0.05	-	-	-	-	0.10	52.5	-	0.0
Reduced Wave Energy along Grand Bayou and the Southern Shoreline	0.10	0.10	0.05	0.05	0.05	0.05	0.40	210	-	0.0
Shoreline Stabilization	0.05	0.05	0.05	0.05	-	-	0.20	105	-	0.0
Roosting Habitat	0.10	0.10	-	-	-	-	0.20	105	-	0.0
Nesting Habitat	0.10	0.10	-	-	-	-	0.20	105	-	0.0
Native Vegetation Propagation	0.10	0.10	0.05	0.05	0.10	-	0.40	210	0.10	0.0
Shoreline Foraging Habitat	0.10	0.10	0.10	0.10	0.05	0.05	0.50	262.5	0.10	0.0
Erosion Control	0.05	0.05	0.05	0.05	0.05	0.10	0.35	183.75	-	0.0
Sediment Stabilization	0.05	0.05	0.05	0.05	0.05	0.10	0.35	183.75	-	0.0
Water Quality	-	-	0.05	0.05	0.05	0.05	0.20	105	-	0.0
Hard Substrate-ocean bottom or submerged rip-rap	-	-	0.05	0.05	-	0.10	0.20	105	-	0.0

Direct Benefit = 0.10 Indirect Benefit = 0.05

Table 5.9-2
Functional Habitat Index Re-establishment of marsh adjacent to Deer Island in conjunction either concrete rubble or riprap dike project

Functions	Shoreline Birds	Migratory Birds	Native Fish	Sport Fish	Macro Invertebrates & Primary Producers	Bivalves	FHI	FHI 15 acres	FHI 30-45 acres	FHI 90 acres
Hard Substrate – ocean bottom or submerged riprap	-	-	0.05	0.05	0.10	0.10	0.30	4.5	9-13.5	27
Soft Substrate	-	-	0.05	0.05	0.10	-	0.20	3	6-9	18
Containment Dike along the Northeast Portion of Deer Island	0.05	0.05	0.05	0.05	0.05	-	0.25	3.75	7.5-11.25	22.5
Breakwater along northeastern portion of Deer Island, (composed of riprap and within site sediment)	0.05	0.05	0.05	0.05	0.10	0.10	0.40	6	12-18	36
Reduced Wave Energy along Deer Island	0.05	0.05	0.05	0.05	0.05	0.05	0.30	4.5	9-13.5	27
Substrate Diversity	0.05	0.05	0.05	0.05	0.10	0.05	0.35	5.25	10.5-15.75	31.5
Nutrient Input	0.10	0.10	0.10	0.10	0.10	0.10	0.60	9	18-27	54
Nutrient Processing	0.05	0.05	0.05	0.05	0.05	0.05	0.30	4.5	9-13.5	27
Shoreline Stabilization	0.10	0.10	-	-	0.10	-	0.30	4.5	9-13.5	27
Roosting Habitat	0.10	0.10	-	-	-	-	0.20	3	6-9	18
Nesting Habitat	0.10	0.10	-	-	-	-	0.20	3	6-9	18
Native Vegetation Propagation	0.05	0.05	0.10	0.10	0.10	-	0.40	6	12-18	36
Shoreline Foraging Habitat	0.10	0.10	-	-	0.10	-	0.30	4.5	9-13.5	27
Erosion Control	0.05	0.05	-	-	0.05	-	0.15	2.25	4.5-6.75	13.5
Sediment Stabilization	0.05	0.05	0.05	0.05	0.05	0.05	0.30	4.5	9-13.5	27
Planted Vegetation Protection from Predation	-	-	0.10	0.10	0.10	-	0.30	4.5	9-13.5	27
400-foot long Breakwater Protection from Predation	-	-	0.10	0.10	0.10	0.10	0.40	6	12-18	36
Adjacent marsh re-establishment	0.05	0.05	-	-	0.05	-	0.15	2.25	4.5-6.75	13.5
Offset marsh re-establishment	-	-	-	-	-	-	0	0	0	0
Channel flow between Deer Island and marsh creation	-	-	-	-	-	-	0	0	0	0

Functions	Shoreline Birds	Migratory Birds	Native Fish	Sport Fish	Macro Invertebrates & Primary Producers	Bivalves	FHI	FHI 15 acres	FHI 30-45 acres	FHI 90 acres
Dissolved Oxygen Concentration in Channel	-	-	-	-	-	-	0	0	0	0
Erosion due to offset marsh	0.05	0.05	-	-	0.05	-	0.15	2.25	4.5-6.75	13.5

Direct Benefit = 0.10 Indirect Benefit = 0.05

5.10 Longer Term Comprehensive Effort For Environmental Restoration

5.10.1 Introduction

Development of the GIS based SDSS tool allowed the MsCIP environmental team, working in cooperation with the USFWS and MDMR, to identify and prioritize potential wetland restoration areas throughout Coastal Mississippi (Lin 2007). A detailed explanation of this GIS based SDSS tool has been discussed earlier and also is provided in ERDC's technical report included as part of this Environmental Appendix. Using Phase II - Longer Term Comprehensive Effort allows the Corps, Mobile District to approach environmental restoration throughout Coastal Mississippi holistically while evaluating the natural ecosystems using an overall systems wide approach. Establishment of a Longer Term Comprehensive Effort for environmental restoration would allow us to further evaluate the results and prioritize potential projects for construction as funding becomes available. Establishment of this program would ensure our commitment to restoration of the damaged and destroyed ecosystems in Coastal Mississippi; thus, allowing us to meet the overall objectives found in the Emergency Supplemental legislation authorizing this Comprehensive Report.

Unique habitats exist in Coastal Mississippi that are critical to the continued health of a number of fish and wildlife species. Most of these proposed restoration habitats have been impacted and/or destroyed nationally, regionally, and locally by development and/or natural events. These sites require man-intervention in order to restore to their historical environmental setting. Failure to restore these sites could impact all Coastal Mississippi.

5.10.2 Program Development

Using the GIS based SDSS model, the MsCIP environmental team was able to effectively analyze needs in Coastal Mississippi. A subset of potential restoration sites was identified by the SDSS tool and then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS. Using this interagency team allowed us to both confirm the accuracy of the SDSS results and to collect additional on-site information pertinent to restoration efforts. The MsCIP environmental team recommends immediate construction of the above 2 initial environmental restoration projects – Turkey Creek, Harrison County and Bayou Cumbest, Jackson County. In addition, the team recommends potential environmental restoration projects specified in *Table 5.1.1.1-1* that would be studied further and restored under a MsCIP Environmental Restoration Longer Term Comprehensive Effort. The Environmental PDT anticipates studies, such as Project Information Reports, would range from $100,000 to $350,000 depending upon the specific project complexness. This cost has been incorporated into the cost estimates. The Environmental PDT anticipates in order

to accomplish the MsCIP Longer Term Comprehensive Effort for environmental restoration of Coastal Mississippi an upward estimated limit of $5,453,700,000 would be required. The Environmental PDT will utilize the SDSS tool to prioritize environmental restoration site construction. The Longer Term Comprehensive Effort for environmental restoration of Coastal Mississippi is anticipated to require $5,453,700,000.

5.10.3 Partnerships

Development of partnerships with Federal resource agencies, state agencies, and NGOs is crucial to the success of this program. These partnerships would provide opportunities to access local knowledge of the existing environment. Specialists in specific restoration techniques would be available as well as opportunities to build on existing programs.

5.10.4 Planning and Evaluation Teams

Development of teams would be necessary to organize the program, establish prioritization of projects, development and evaluation of project plans, and future monitoring. Development of assessment models as well as monitoring plans would be accomplished by various interdisciplinary planning and evaluation teams.

5.10.5 Projects

The SDSS model identified many potential restoration sites. The list was verified in the field and through existing partnerships with Federal and state agencies, and based on personal knowledge of the overall comprehensive natural system, these sites were screened further. A list of 38 restoration sites has been proposed. Two of the sites have been chosen as initial projects and have been tentatively selected for construction through this technical report. Additionally, two state projects have been targeted for restoration through this technical report. The remaining projects are found in *Section 4.1.5.5 State Initiatives.* Further prioritization and ranking of importance would ensure best use of future funding.

5.10.6 Sequencing Plan

Once the restoration sites have been prioritized, a sequencing plan would need to be developed identifying the events necessary to accomplish restoration. This would ensure prioritized sites received immediate attention and further details developed for the required analysis. This plan would serve as an outline of the longer term comprehensive structure.

5.10.7 Project Information Reports

As projects are being developed, specific details would be necessary to ensure compliance with regulations, policies, and acts. This information would be complied in a Project Information Report (PIR) and would consist of NEPA documents, project designs and details, economic analysis including incremental cost analysis for use in selection of a best buy plan, and other necessary documentation for approvals. The level of detail contained in a PIR should be commensurate with the complexity and cost of the project while including the information necessary to meet requirements.

5.10.8 Costs

A rough order of magnitude cost estimate has been prepared for each project based on existing conditions and restoration measures. This would serve as an upward limit of funding for this longer term comprehensive effort. Cost covers site acquisitions including associated relocation costs, removal and site demolition activities, and planting activities. A summary of costs is provided in the Cost Appendix .

5.10.9 Construction

Once the PIR received approvals, a contracting mechanism would need to be put forward. The District Project Delivery Team would need to incorporate Contracting Division in order to establish the most efficient type and beneficial use of contracting options and/or existing construction contracts. Oversight and quality assurance would ensure restoration was accomplished as envisioned.

5.10.10 Adaptive Management

Monitoring project performance, followed by adaptive changes to the project if necessary, is a responsible means of ensuring project performance. Monitoring determines if the projected outputs are being achieved and provides feed back for future projects. Post-implementation monitoring of ecosystem restoration components of the Comprehensive Plan is projected to be conducted for no more than five years at a cost of less than 1% of the total first cost of the project's ecosystem restoration features.

Adaptive management of proposed comprehensive ecosystem restoration programs and projects is an important aspect of project success. It is generally anticipated that some post-implementation project modifications will be required based on the feed back provided by project monitoring. Because the nature of the tentatively selected plans made in this Comprehensive Report is not extremely risky in terms of projected outputs, it is anticipated that adaptive management would not be a major project expense. Adaptive management of ecosystem restoration features is expected to cost no more than 3% of ecosystem restoration feature first costs, and may in some cases be less than that figure. Monitoring and adaptive management costs have been accommodated in the cost estimates for each potential ecosystem restoration component as part of the contingency estimate.

Information gained from post-implementation monitoring and adaptive management of tentatively selected ecosystem restoration plans will be used to provide "lessons learned" for the design and implementation of future ecosystem restoration projects. These "lessons learned" will provide important information, which will be used to improve the effectiveness and reduce the costs of future ecosystem restoration components of the Comprehensive Plan.

5.10.11 Program Status Reports

Program Status Reports would accomplish a system-wide reevaluation that would consider program and project-level considerations, and the level of success of overall met program goals and objectives. Project level formulation activities would address optimization of the overall program's contribution to the system-wide goals and objectives in general, and project goals and objectives would be more specific. The individual project monitoring reports may result in project modifications that impact or modify system output, however, these modifications would not address system-wide issues within the comprehensive plan. Status reports would provide updates on the overall success of environmental restoration throughout Coastal Mississippi.

CHAPTER 6. CONCLUSIONS

The tentatively selected MsCIP Environmental Plan has been developed and discussed during numerous interagency PDT workshops and online meetings. Further, this approach has been coordinated with MDEQ and MDMR.

The tentatively selected plan has been determined to be suited for long-term implementation as a key component of the MsCIP Comprehensive Plan. The environmental restoration projects could be implemented within the near-term with longer term approval allowing for development of the remaining environmental restoration sites based on the SDSS results and as land becomes available. Additionally, the tentatively selected approach establishes a program that would allow for important data collection in the expanse marsh systems located on the western and eastern portions of the state. Upon collection and further analysis of this data, appropriate freshwater diversions could be developed that would mitigate saltwater intrusion. Continued coordination and future partnering with the NPS and other Federal, state, and local NGOs allows us to establish a program to restore lost and damaged ecosystems found on the barrier islands and SAVs throughout Mississippi Sound. The tentatively selected environmental approach allows for establishment of programs under longer term comprehensive effort or through existing authorities to partner with local efforts with ongoing restoration program.

The tentatively selected plan also appears to be cost-effective in light of the risk and consequences of not implementing the project. The risks and consequences of *not* implementing this plan include:

- Continued flood and storm damages throughout the study area;
- Continued damage to fish and wildlife habitat;
- Continued coastal erosion and loss of valuable marsh systems;
- Continued saltwater intrusion and loss of valuable fisheries and oyster resources;
- Continued loss of barrier island exacerbating saltwater intrusion; and
- Change of Mississippi Sound estuarine conditions converting to marine conditions.

The tentatively selected environmental plan addresses the following stated goals and objectives in the guidance of the Coastal Mississippi Comprehensive Hurricane Protection and Restoration effort:

a) future hurricane storm and flood damage reduction;

b) prevention of saltwater intrusion;

c) prevention of coastal erosion;

d) preservation of fish and wildlife; and

e) other water related resources (reduction of flooding).

Further, **the tentatively selected plan complements and supports the objectives of the State and/or local plans and desires for this area**, including Governor Barbour's Seven Point Strategy for Coastal Recovery. This environmental approach allows us to establish a program for coastal wetland restoration. The 2 previously identified sites have been identified as initial environmental projects that will specifically depict problems and opportunities for restoration. By restoration of these sites, we will be able to ensure that homes will not be reconstructed within the 100-year floodplains,

restore vital functions of historical wetlands, and remove people out of areas subject to future damaged by storm surge, erosion, flooding.

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1.2 CULTURAL RESOURCES

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ACRONYMS

CFR	Code of Federal Register
FEMA	Federal Emergency Management Agency
MDMR	Mississippi Department of Marine Resources
NCPTT	National Center for Preservation Training and Technology
NEPA	National Environmental Protection Act
NHPA	National Historic and Preservation Act
NPS	National Park Service
NRHP	National Register of Historic Places
SHPO	State Historic Preservation Officer

CHAPTER 1. CULTURAL RESOURCES

1.1 Introduction

Cultural resources are pre-contact and historic sites, structures, districts, artifacts, or any other physical evidence of human activity considered important to a culture, subculture, or community for traditional, religious, scientific, or any other reason. Cultural resources are discussed here in terms of archaeological sites, including both pre-contact and historical occupations, architectural resources, and locations of concern to Native American groups, including Traditional Cultural Properties (Table 1.1-1).

Procedures for the identification, evaluation, and treatment of cultural resources are contained in a series of Federal and state laws and regulations and agency guidelines. Archaeological, architectural, and Native American resources are protected by a variety of laws and their implementing regulations: the National Historic Preservation Act (NHPA) of 1966 as amended in 2000; the Archeological and Historic Preservation Act of 1974; the Archaeological Resources Protection Act of 1979; the American Indian Religious Freedom Act of 1978; and the Native American Graves Protection and Repatriation Act of 1990. The Advisory Council on Historic Preservation further guides treatment of archaeological and architectural resources through the regulations, Protection of Historic Properties [36 Code of Federal Regulation (CFR) 800]. Historic properties, as defined by the NHPA, represent the subset of cultural resources listed on, or are eligible for, inclusion on the National Register of Historic Places (NRHP).

Table 1.1-1.
Federally-Recognized American Indian Tribes Associated with Southern Mississippi

Muscogee (Creek) Nation of Oklahoma
Choctaw Nation of Oklahoma
Tunica-Biloxi Tribe of Louisiana
Coushatta Tribe of Louisiana
Mississippi Band of Choctaw Indians
Miccosukee Tribe of Indians of Florida
Seminole Nation of Oklahoma
Seminole Tribe of Florida
Poarch Band of Creek Indians
The Chickasaw Nation
Thlopthlocco Tribal Town
Alabama-Coushatta Tribe of Texas
Alabama-Quassarte Tribal Town of the Creek Nation

1.2 Evaluation Criteria

The NRHP's standards for evaluating the significance of properties were developed to recognize the accomplishments of all peoples who have made a significant contribution to our country's history and heritage. The criteria are designed to guide State and local governments, Federal agencies, and others in evaluating potential entries in the NRHP.

1.2.1 Criteria for Evaluation

The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

A. That are associated with events that have made a significant contribution to the broad patterns of our history; or

B. That are associated with the lives of persons significant in our past; or

C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. That have yielded or may be likely to yield, information important in prehistory or history.

1.2.2 Criteria Considerations

Ordinarily cemeteries, birthplaces, graves of historical figures, properties owned by religious institutions or used for religious purposes, structures that have been moved from their original locations, reconstructed historic buildings, properties primarily commemorative in nature, and properties that have achieved significance within the past 50 years shall not be considered eligible for the NRHP. However, such properties will qualify if they are integral parts of districts that do meet the criteria or if they fall within the following categories:

A. A religious property deriving primary significance from architectural or artistic distinction or historical importance; or

B. A building or structure removed from its original location but which is primarily significant for architectural value, or which is the surviving structure most importantly associated with a historic person or event; or

C. A birthplace or grave of a historical figure of outstanding importance if there is no appropriate site or building directly associated with his or her productive life; or

D. A cemetery which derives its primary importance from graves of persons of transcendent importance, from age, from distinctive design features, or from association with historic events; or

E. A reconstructed building when accurately executed in a suitable environment and presented in a dignified manner as part of a restoration master plan, and when no other building or structure with the same association has survived; or

F. A property primarily commemorative in intent if design, age, tradition, or symbolic value has invested it with its own exceptional significance; or

G. A property achieving significance within the past 50 years if it is of exceptional importance.

CHAPTER 2. MISSISSIPPI COAST CULTURAL RESOURCES OVERVIEW

2.1 Introduction

The Mississippi Gulf Coast is rich in history and as a result is rich in the resources left behind by past cultures. Mississippi's coastline has been home to some of America's earliest peoples, as well as the crossroads for several of the earliest European colonial efforts in North America. The accessibility and numerous natural resources that lured people here initially have kept people here to the present day. All of the comings and goings of these people left behind artifacts in the form of houses or buildings or tools and sometimes just articles of daily life. These artifacts that remain from human life and industry form cultural resources that can be honored and studied and maintained as sentimental reminders of the people who have come before us. The following discussion will briefly define what cultural resources are, how they are categorized in the disciplines of archaeology and history, and summarize the types and condition of the cultural resources that were known to exist along the Mississippi Coast prior to hurricane Katrina in August 2005.

Cultural resources can include buildings or other structures; historic or prehistoric districts, such as the historic districts in Biloxi and Ocean Springs; archaeological sites, such as Indian mounds or other remains of prehistoric life; objects, such as statues or paintings; or sunken vessels, such as those that have been found in Mississippi Sound. Traditional cultural properties can also be considered significant cultural resources because of their traditional religious or cultural importance to an Indian tribe or other traditional community. The NHPA of 1966 established the Federal government's policy on historic preservation, as well as the national historic preservation program through which that policy is implemented. The NHPA also established the NRHP, which is a list of important resources that experts have identified as significant to our national heritage. The NRHP is the nation's official list of buildings, structures, objects, sites, and districts considered worthy of preservation because of their significance in American history, architecture, archaeology, engineering, and culture. The National Park Service (NPS) maintains the list.

Resources on the NRHP must meet criteria for evaluation established by the NHPA. Nominations to the NRHP are submitted from each state by its State Historic Preservation Officer (SHPO). Resources are nominated and considered to be significant when they have integrity of location, design, setting, materials, workmanship, feeling, and association, and:

They are associated with events that have made significant contributions to the broad patterns of our history; They are associated with the lives of persons who are significant in our past; They embody the distinctive characteristics of a type, period, or method of construction, represent the work of a master, or have high artistic value, or they represent a significant and distinguishable entity whose components might lack individual distinction; or They have yielded, or might be likely to yield, information important in prehistory or history. Properties, such as cemeteries or buildings that are less than 50 years old, are usually not considered eligible for the NRHP, but there are exceptions. For example, certain buildings associated with the Cold War are considered so important to our history that they are eligible for the NRHP.

The National Environmental Policy Act (NEPA), under which this document is being prepared, states that potential effects on cultural resources that are listed or might be eligible for listing on the NRHP must be considered when Federal agencies are considering an action.

This section discusses the prehistoric and historic context of the cultural resources along the Mississippi coast, and provides a table that lists some of the area's historic structures. The project area for cultural resources analysis is bounded to the north by a line 2 miles north of Interstate-10 and on the south by the Mississippi border. It is bounded on the west by the Louisiana border and on the east by the eastern edge of the Biloxi Bay watershed. The area includes most of Hancock, Harrison, and Jackson Counties; part of the Mississippi Sound; and Cat, Ship, Horn, Round, and Deer Islands. The known cultural resources in the project area are discussed in this section.

2.2 Baseline Conditions

Cultural resources in the project area considered eligible for listing on the NRHP include historic standing structures, submerged shipwrecks, historic cemeteries, and prehistoric and historic archaeological sites. There are currently 298 known archeological sites within the project area (Tables 2.2-1 – 2.2.3), including submerged shipwrecks and historic cemeteries. Of these, 63 sites are listed on or are eligible for the NRHP, 80 have been determined ineligible by the Mississippi SHPO, and the remainders are potentially eligible. Sites whose NRHP status is listed as "unknown" in the appendix might be eligible for listing. Because of the risk of looting, the specific locations of cultural resource sites are not shown in this document.

The potential for identifying additional buried archaeological sites and submerged historic shipwrecks in the project area is considered high, based on the number of known resources (Mississippi SHPO, 2001).

Many of the cultural resource sites contain shell middens, which are mounds of discarded shells that offer evidence of the early use of certain shellfish (mollusks). Some of the sites are prehistoric Indian mounds. The sites also include the remains of ancient villages, historic forts, campsites, and cemeteries. The sunken vessels that have been found include schooners, barges, and sailing vessels.

Table 2.2-1.
Archaeological Sites Within the Hancock County Project Area

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Ha-502	Lakeshore Midden	Eligible	Shell midden	Unknown Prehistoric
22-Ha-505	Cowand Point	Eligible	Shell midden	Late Woodland
22-Ha-510	Joe's Bayou	Unknown	Village site, Shell midden	Middle Woodland
22-Ha-510	Joe's Bayou	Unknown	Village site, Shell midden	Historic Indian
22-Ha-512	Campbell Bayou I	Unknown	Processing camp area, no kitchen midden	Unknown Prehistoric
22-Ha-512	Campbell Bayou I	Unknown	Processing camp area, no kitchen midden	Unknown Prehistoric
22-Ha-519	Owen Heitzman	Eligible	Shell midden	Mississippian
22-Ha-520	Cedar Island	Eligible	Shell midden	Woodland
22-Ha-521	Carver Site	Eligible	Shell midden	Late Woodland
22-Ha-522	Bryan Bayou	Eligible	Shell midden	Unknown Prehistoric
22-Ha-524	Brush Bayou	Eligible	Shell midden	Unknown Prehistoric
22-Ha-525	Redfish Bayou	Eligible	Shell midden	Unknown Prehistoric
22-Ha-526	Ebeneezer Reese	Eligible	Shell midden	Unknown Prehistoric

Table 2.2-1.
Archaeological Sites Within the Hancock County Project Area (continued)

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Ha-527	East Side Jourdan River	Unknown	Shell midden	Mississippian
22-Ha-528	Ramsay Mound	Eligible	Flat top mound. Sank pit in top 15 years ago.	Unknown Prehistoric
22-Ha-536		Ineligible		Late Archaic
22-Ha-541	Gibbens	Ineligible	Chenier	Unknown Prehistoric
22-Ha-542	Lambert Site	Unknown	Light disturbance	Unknown Prehistoric
22-Ha-542	Lambert Site	Unknown	Light disturbance	Woodland: Middle, Late
22-Ha-543		Unknown		Unknown Prehistoric
22-Ha-543		Unknown		Unknown Prehistoric
22-Ha-544		Ineligible	Chenier	Historic
22-Ha-545		Ineligible	Estuary	Mississippian
22-Ha-546	Schaefer Mound	Eligible	Small conical mound	Middle Woodland
22-Ha-550	Diamondhead	Eligible	Large shell midden	Woodland
22-Ha-550	Diamondhead	Eligible	Large shell midden	Woodland: Middle, Late
22-Ha-551		Ineligible	Estuary	Unknown Prehistoric
22-Ha-553	#GCS-21	Unknown		Woodland: Middle, Late
22-Ha-554		Unknown	Must be real location of Ha-518	Historic
22-Ha-555	1	Unknown		Mississippian
22-Ha-556		Unknown		Unknown Prehistoric
22-Ha-557		Unknown	Ammunition magazine	Historic
22-Ha-558		Unknown	Subdivision; British soldiers reputedly buried there during War of 1812	Historic
22-Ha-581		Eligible	*Rangia* (clam) shell midden	Early Woodland, 2680 +/- 75 years before present
22-Ha-591		Eligible	Mounds: conical, pyramidal, indeterminate	Middle Woodland
22-Ha-593		Ineligible		Woodland
22-Ha-593		Ineligible		Woodland: Early
22-Ha-597		Ineligible		Late Archaic
22-Ha-605	B.W.Y.C.	Unknown	Material on shoreline on north peninsula of Yacht Club	Unknown Prehistoric
22-Ha-605	B.W.Y.C.	Unknown	Material on shoreline on north peninsula of Yacht Club	Woodland
22-Ha-605	B.W.Y.C.	Unknown	Material on shoreline on north peninsula of Yacht Club	Unknown Prehistoric
22-Ha-606	Cuevas Home	Unknown	Found during street construction, Diamondhead subdivision	Historic: 19th century
22-Ha-608	Rotten Bayou West	Unknown	Material eroded and scattered along bayou bank	Woodland
22-Ha-613		Unknown		Unknown Prehistoric
22-Ha-614	Dix	Unknown		Woodland

Table 2.2-1.
Archaeological Sites Within the Hancock County Project Area (continued)

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Ha-614	Dix	Unknown		Unknown Prehistoric
22-Ha-614	Dix	Unknown		Archaic: Late
22-Ha-626		Unknown		Woodland

Source: Mississippi SHPO, 2001.

Table 2.2-2.
Archaeological Sites Within the Harrison County Project Area

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Hr-500	Deer Island Shell Midden	Eligible	Shell midden	Unknown Prehistoric
22-Hr-500	Deer Island Shell Midden	Eligible	Shell midden	Historic: Early
22-Hr-501	Bayou Park Mound	Eligible	Mound	Unknown Prehistoric
22-Hr-502	Oak Grove I, II, & II	Eligible	Shell midden, possible village or camp	Unknown Prehistoric
22-Hr-502	Oak Grove I, II, & II	Eligible	Shell midden, possible village or camp	Historic: 1719-1722
22-Hr-503		Eligible	Shell midden	Unknown Prehistoric
22-Hr-504	Irby	Eligible		Historic
22-Hr-504	Irby	Eligible		Unknown Prehistoric
22-Hr-505		Unknown	Eroded shell midden	Unknown Prehistoric
22-Hr-509	Back Bay Beach	Unknown	Shell ridge	Mississippian
22-Hr-510	Lopez Place	Unknown	Shell ridge	Unknown Prehistoric
22-Hr-511	Joe Moran	Unknown	Burials of Eastern European settlers	Historic
22-Hr-513	Old Fort Louis Site	Unknown	Old Fort Louis site	Unknown Prehistoric, Historic
22-Hr-515	Brodie II	Unknown		Unknown Prehistoric
22-Hr-516	Brodie I	Unknown		Unknown Prehistoric
22-Hr-517	O'Neal	Unknown		Unknown Prehistoric
22-Hr-518	Atcheson	Unknown		Unknown Prehistoric
22-Hr-520	Caron Site	Eligible	Dense *Rangia* (clam) midden, many sherds only	Mississippian
22-Hr-524	Fritz Site	Unknown		Mississippian
22-Hr-529	Jim Parker	Unknown		Woodland
22-Hr-531	Boiler Point, Cat Island	Unknown	Old village site	Unknown Prehistoric
22-Hr-532	Little Bay I, Cat Island	Unknown	Shell midden heap	Unknown Prehistoric
22-Hr-532	Little Bay I, Cat Island	Unknown	Shell midden heap	Woodland
22-Hr-533	Little Bay II, Cat Island	Unknown	Midden	Unknown Prehistoric

Table 2.2-2.
Archaeological Sites Within the Harrison County Project Area (continued)

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Hr-533	Little Bay II, Cat Island	Unknown	Midden	Unknown Prehistoric
22-Hr-536	Brodie III	Unknown		Woodland
22-Hr-537	Williams	Unknown		Mississippian
22-Hr-538	Acadian Bayou I	Unknown	Shell midden	Middle Woodland
22-Hr-539	Discovery Bay	Unknown	Shell midden	Middle Woodland
22-Hr-540	Leon	Unknown	Shell midden	Middle Woodland
22-Hr-541	De Metz Site	Eligible	Shell midden	Middle Woodland
22-Hr-542	Sutter Site	Eligible	Shell midden	Woodland
22-Hr-543	Cedar Bayou	Unknown	Low shell midden	Middle Woodland
22-Hr-544	DeLisle	Unknown		Late Woodland
22-Hr-545	Diane	Eligible	Small clam shell midden	Historic: French- 19th and 20th century
22-Hr-546	Dupont	Eligible	Shell midden; possible mounds	Middle Woodland
22-Hr-550	Carron	Unknown	Probably Marksville permanent station	Late Archaic
22-Hr-554	Jaycee Hill	Unknown	Apparently once a large station	Historic: mid-19th century
22-Hr-556	Alpha	Ineligible	Camp site	Unknown Prehistoric
22-Hr-565	Rail Spur #1	Ineligible		Unknown Prehistoric
22-Hr-566	Rail Spur #2	Ineligible		Unknown Prehistoric
22-Hr-567	Wreck of the Pelican	Unknown	Shipwreck: 1848 steamboat, the Pelican	Historic
22-Hr-571		Ineligible		Late Mississippi
22-Hr-572		Ineligible		Early Woodland
22-Hr-573		Unknown	Shell midden	Early Mississippi
22-Hr-574	DeLisle Cemetery	Unknown	Shell midden	Early Mississippi
22-Hr-575	Tom Parker	Unknown		Early Archaic
22-Hr-576		Unknown		Late Woodland
22-Hr-577		Unknown		Early Archaic
22-Hr-578		Unknown	Shell midden	Early Woodland
22-Hr-579		Unknown	Shell midden	Middle Mississippian
22-Hr-591	Godsey	Unknown	Issaquena phase shell midden	Unknown Prehistoric
22-Hr-630		Ineligible		Woodland and Mississippian
22-Hr-630		Ineligible		Historic
22-Hr-631	Morse	Ineligible		Historic
22-Hr-632	AAA	Unknown	Shell midden	Woodland
22-Hr-633	AAE	Unknown	Shell midden	Late Archaic
22-Hr-634	AAD	Unknown	Shell midden	Woodland
22-Hr-635	Richard Site	Eligible	Burial and shell midden	Mississippian
22-Hr-636	Raymond Bass	Accepted 1987	Coal black midden and burial site	Historic: 1910-1920

Table 2.2-2.
Archaeological Sites Within the Harrison County Project Area (continued)

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Hr-638	French Warehouse	Accepted 1991	French warehouse-keepers' house	Historic, Unknown Prehistoric
22-Hr-639	Quarantine Station	Unknown		Archaic: Middle, Late
22-Hr-640	Ship Island Lighthouse	Unknown		Paleo-Indian: Late
22-Hr-641	Ft. Massachusetts /GUIS 102	Unknown	Standing mid-19th century brick masonry fort	Historic
22-Hr-643		Ineligible	On small knoll adjacent to creek	Woodland
22-Hr-647	Biloxi Beach Loop	Unknown		Woodland: Middle, Late
22-Hr-647	Biloxi Beach Loop	Unknown		Unknown Prehistoric
22-Hr-647	Biloxi Beach Loop	Unknown		Woodland
22-Hr-659	Catchment No. 11	Ineligible		Woodland
22-Hr-673		Ineligible	1m2-pit dug; 12 sherds at ca. –10 cm	Woodland
22-Hr-683	DeLisle West Shell	Eligible	Shallow shell midden	Unknown Prehistoric
22-Hr-684	Rusty Skillet	Ineligible		Woodland
22-Hr-685	Pine Hill Northwest	Ineligible	Disturbed by bulldozing	Woodland
22-Hr-686	Pine Hill Central	Ineligible	Destroyed by bulldozing	Unknown Prehistoric
22-Hr-690		Ineligible		Unknown Prehistoric
22-Hr-691		Ineligible		Woodland
22-Hr-740		Ineligible		Early Archaic
22-Hr-741		Unknown	Reported by informant; not field checked	Paleo-Indian: Middle
22-Hr-831		Ineligible		Woodland
22-Hr-843	Wreck of the Josephine	Accepted 2000	Sunken iron-hull sidewheeler shipwreck	Historic
22-Hr-844		Unknown		
22-Hr-845	Holley Cemetery/ "Sunkist" Cemetery	Unknown	Mid to late 19th-century family cemetery	Historic
22-Hr-847		Ineligible		
22-Hr-848		Ineligible		
22-Hr-848		Ineligible		
22-Hr-857		Ineligible		Unknown Prehistoric
22-Hr-859	Schooner *Oleander*	Unknown	Sunken wreck of 1903 schooner *Oleander*	Historic
22-Hr-860	Cedar Lake 1	Unknown	Sunken vessel, possibly a schooner	Historic
22-Hr-861	Cedar Lake 2	Unknown	Sunken vessel, possibly a schooner	Historic
22-Hr-862	Cedar Lake 3	Unknown	Sunken wooden vessel, possibly a ferry barge	Historic
22-Hr-863	Schooner Graveyard	Unknown	10–15 sunken Biloxi-style schooner hulls	Historic
22-Hr 869		Ineligible		Unknown Prehistoric

Table 2.2-2.
Archaeological Sites Within the Harrison County Project Area (continued)

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Hr-870		Ineligible		Unknown Prehistoric
22-Hr-871		Ineligible		Unknown Prehistoric
22-Hr-872	Hamilton Cemetery	Ineligible		Unknown Prehistoric
22-Hr-878		Ineligible		Late Archaic
22-Hr-879		Ineligible		Unknown Prehistoric
22-Hr-880		Ineligible		Unknown Prehistoric
22-Hr-897	Florence Garden # 1	Ineligible		Archaic: Early, Middle

Source: Mississippi SHPO, 2001.

Table 2.2-3.
Archaeological Sites Within the Jackson County Project Area

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Ja-500	Point Aux Chenes	Unknown	3 mounds	Unknown Prehistoric
22-Ja-502	Green; Buena Vista	Eligible	Shell midden	Unknown Prehistoric
22-Ja-503	Graveline Mound	Accepted 1987	Rectangular ramped platform mound	Mississippian
22-Ja-503	Graveline Mound	Accepted 1987	Rectangular ramped platform mound	Unknown Prehistoric
22-Ja-504	Magnolia, Taneksanya	Eligible	Shell midden, at least 20 burials	Mississippian
22-Ja-504	Magnolia, Taneksanya	Eligible	Shell midden, at least 20 burials	Woodland: Middle, Late
22-Ja-504	Magnolia, Taneksanya	Eligible	Shell midden, at least 20 burials	Historic: 19th century
22-Ja-504	Magnolia, Taneksanya	Eligible	Shell midden, at least 20 burials	Unknown Prehistoric
22-Ja-504	Magnolia, Taneksanya	Eligible	Shell midden, at least 20 burials	Gulf Formational: Middle, Late
22-Ja-507	Gollotte, S.P. Starks~	Eligible	Low earth mound	Historic
22-Ja-530	Apple Street	Accepted 1985	Shell midden, no app. submidden feature	Woodland: Early, Late
22-Ja-530	Apple Street	Accepted 1985	Shell midden, app. no submidden feature	Unknown Prehistoric
22-Ja-530	Apple Street	Accepted 1985	Shell midden, app. no submidden feature	Historic: 18th century
22-Ja-530	Apple Street	Accepted 1985	Shell midden, app. no submidden feature	Mississippian
22-Ja-530	Apple Street	Accepted 1985	Shell midden, app. no submidden feature	Unknown Prehistoric
22-Ja-531	North Street; Elizabeth	Unknown		Late Mississippian
22-Ja-531	North Street; Elizabeth	Unknown		Historic: Early Colonial

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Table 2.2-3.
Archaeological Sites Within the Jackson County Project Area (continued)

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Ja-531	North Street; Elizabeth	Unknown		Unknown Prehistoric
22-Ja-531	North Street; Elizabeth	Unknown		Archaic: Middle, Late
22-Ja-532	Soy Caphil Point	Unknown		Woodland: Middle, Late
22-Ja-534	Fort Maurepas I, Old Fort	Unknown		Gulf Formational: Late
22-Ja-535	Lemon	Unknown		Early Woodland
22-Ja-538	Fort Maurepas IB	Eligible		Woodland: Early, Middle, Late
22-Ja-539	Maurepas II	Eligible	Stake roots of old wall or bulkhead	Historic Indian
22-Ja-540	Ocean Springs I			Protohistoric~
22-Ja-542	Biloxi Bay Shipwreck	Eligible	Sunken wreck of 18th-century sailing vessel	Historic
22-Ja-553	Stone Site	Unknown		Late Mississippian
22-Ja-554	Old Shell Landing	Unknown	Shell midden	Historic
22-Ja-554	Old Shell Landing	Unknown	Shell midden	Late Archaic
22-Ja-555	Shepards Island	Unknown	Elevated area covered with shell midden	Mississippian
22-Ja-555	Shepards Island	Unknown	Elevated area covered with shell midden	Woodland: Middle, Late
22-Ja-555	Shepards Island	Unknown	Elevated area covered with shell midden	Middle Mississippian
22-Ja-555	Shepards Island	Unknown	Elevated area covered with shell midden	Late Woodland
22-Ja-556	Mrs. C.M. Shepard, B	Unknown	Thin shell midden	Late Mississippian
22-Ja-556	Mrs. C.M. Shepard, B	Unknown	Thin shell midden	Late Mississippian
22-Ja-557	Steve's Site	Unknown	Scattered shell midden	Middle Woodland
22-Ja-558	Cedar Point, Seacliff	Unknown	Oyster shell midden	Woodland: Middle, Late
22-Ja-558	Cedar Point, Seacliff	Unknown	Oyster shell midden	Late Woodland
22-Ja-558	Cedar Point, Seacliff	Unknown	Oyster shell midden	Middle Woodland
22-Ja-558	Cedar Point, Seacliff	Unknown	Oyster shell midden	Middle Woodland
22-Ja-558	Cedar Point, Seacliff	Unknown	Oyster shell midden	Historic: 20th century
22-Ja-558	Cedar Point, Seacliff	Unknown	Oyster shell midden	Woodland
22-Ja-559	Camp Lamotte	Unknown	Heavy extensive oyster shell midden	Mississippian
22-Ja-559	Camp Lamotte	Unknown	Heavy extensive oyster shell midden	Late Woodland
22-Ja-569	Dolphin	Unknown		Mississippian

Table 2.2-3.
Archaeological Sites Within the Jackson County Project Area (continued)

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Ja-572	Winchester	Unknown	Large Marksville campsite	Middle Woodland
22-Ja-573	Blue Heron Bayou	Unknown	Camping area	Mississippian
22-Ja-590	Debbie T.	Unknown		Middle Woodland
22-Ja-591	Shepherds' Tree Farm	Unknown		Early Mississippian
22-Ja-591	Shepherds' Tree Farm	Unknown		Early Woodland
22-Ja-594	Porteaux Bay I	Ineligible		Mississippian: Early, Middle, Late
22-Ja-595	Point Ascot, Porteaux Bay II	Ineligible		Late Woodland
22-Ja-596	Porteaux Bay III	Ineligible		Historic: 19th century
22-Ja-597	Caldwell Home, Porteaux Bay IV	Ineligible		Middle Mississippian
22-Ja-598	Dundolph Home, Porteaux Bay V	Ineligible		Woodland: Middle, Late
22-Ja-599	Albert Tiblier	Ineligible		Historic
22-Ja-600	Bijou Tiblier Home, Porteaux #7	Ineligible		Woodland: Early, Middle
22-Ja-601	Scarbrough Saw Mill, Porteaux 8	Ineligible		Middle Woodland
22-Ja-602	Graveline Mound #2	Unknown	Large sand mound	Historic
22-Ja-602	Graveline Mound #2	Unknown	Large sand mound	Early Woodland
22-Ja-602	Graveline Mound #2	Unknown	Large sand mound	Late Archaic
22-Ja-610	Buena Vista	Ineligible		Middle Woodland
22-Ja-610	Buena Vista	Ineligible		Middle Mississippian
22-Ja-611	Swetman	Ineligible		Woodland
22-Ja-611	Swetman	Ineligible		Early Woodland
22-Ja-612	Marlin	Ineligible		Middle Woodland
22-Ja-619	Janice–Gulf Hills	Ineligible		Middle Mississippian
22-Ja-622	Tiblier	Ineligible		Late Woodland
22-Ja-623	Gulf Hills	Ineligible		Late Woodland
22-Ja-624	Riviera I –II	Ineligible		Late Woodland
22-Ja-626	Magnolia Bank, Four H Club	Unknown		Unknown Prehistoric
22-Ja-628	Eagle Point	Unknown	Buried remnant of Chenier-Bayou site	Unknown Prehistoric
22-Ja-629	Aunt Jennys	Eligible	Aunt Jenny's, Marksville Period campsite possible Marksville	Historic Indian: Early to Middle 18th century
22-Ja-629	Aunt Jennys	Eligible	Aunt Jenny's, Marksville Period campsite	Mississippian: Late
22-Ja-630	Stark Bayou I	Eligible		Mississippian: Middle, Late
22-Ja-635	Morning Site	Ineligible	Shell midden	Middle Mississippian

Table 2.2-3.
Archaeological Sites Within the Jackson County Project Area (continued)

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Ja-636	Picnic Site	Ineligible	Oyster shell midden	Protohistoric
22-Ja-637	Hilltop Site	Ineligible		Late Woodland
22-Ja-638	Upper Crossing Site	Ineligible		Late Mississippian
22-Ja-638	Upper Crossing Site	Ineligible		Middle Woodland
22-Ja-639	Office Site	Ineligible		Unknown Prehistoric
22-Ja-640	Desk Site	Ineligible		Unknown Prehistoric
22-Ja-641	Second Chance Site	Ineligible		Unknown Prehistoric
22-Ja-642	West Bank Site	Unknown		Woodland
22-Ja-643	Old Ladder Site	Unknown	Oyster shell midden	Archaic: Early
22-Ja-646		Unknown	Shell midden	Historic: 19th century
22-Ja-647	Belle Fountain Beach	Unknown		Historic Indian
22-Ja-648	Y	Unknown		Woodland
22-Ja-649	Tapp Site	Unknown		Woodland: Middle, Late
22-Ja-650	Brown Street Site	Ineligible		Late Woodland
22-Ja-651	Stone II	Eligible	Intact midden present	Unknown Prehistoric
22-Ja-651	Stone II	Eligible	Intact midden present	Late Woodland
22-Ja-651	Stone II	Eligible	Intact midden present	Woodland
22-Ja-651	Stone II	Eligible	Intact midden present	Historic
22-Ja-652	Seymour Lane	Ineligible	Small Late Woodland site	Late Woodland
22-Ja-653	Britt, Cedar Point	Unknown		Woodland, Historic
22-Ja-653	Britt, Cedar Point	Unknown		Unknown Prehistoric
22-Ja-654	Tyler Site	Unknown		Unknown Prehistoric
22-Ja-655	Carluse Bayou	Unknown		Unknown Prehistoric
22-Ja-656	Bilbo	Ineligible		Historic
22-Ja-657		Unknown		Mississippian
22-Ja-658		Unknown		Woodland: Middle, Late
22-Ja-658		Unknown		Gulf Formational: Late
22-Ja-659		Unknown		Historic
22-Ja-660		Unknown		Woodland
22-Ja-660		Unknown		Archaic
22-Ja-662	Guis 107	Ineligible		Late Woodland
22-Ja-663	Guis 106	Unknown		Woodland
22-Ja-672	CCC Training Camp	Unknown		Woodland
22-Ja-673	Magnolia Park	Unknown		Woodland
22-Ja-673	Magnolia Park	Unknown		Mississippian
22-Ja-687	Cooking Ball Corner	Unknown		Mississippian
22-Ja-688	Mary Mahoney	Unknown	Rangia (clam) and oyster shell midden	Mississippian
22-Ja-689	Point Clear Pier	Unknown	Material apparently washing down from bluff	Woodland
22-Ja-689	Point Clear Pier	Unknown	Material apparently washing down from bluff	Unknown Prehistoric
22-Ja-695		Ineligible		Unknown Prehistoric
22-Ja-696		Ineligible		Late Archaic

Table 2.2-3.
Archaeological Sites Within the Jackson County Project Area (continued)

Site Number	Site Name	National Register Status	Site Description	Time Period
22-Ja-697		Ineligible		Middle Archaic
22-Ja-697		Ineligible		Unknown Prehistoric
22-Ja-698		Ineligible	Material from eroded slope	Unknown Prehistoric
22-Ja-704		Ineligible		Early Archaic
22-Ja-704		Ineligible		Unknown Prehistoric
22-Ja-707		Unknown		Unknown Prehistoric
22-Ja-707		Unknown		Unknown Prehistoric
22-Ja-715		Ineligible		Woodland: Middle, Late
22-Ja-716		Ineligible		Mississippian
22-Ja-723	Oak North	Unknown	Intact deposits possible	Woodland
22-Ja-725		Unknown		Woodland
22-Ja-726		Unknown	Midden exposed in road cuts	Woodland
22-Ja-726		Unknown	Midden exposed in road cuts	Woodland
22-Ja-727		Unknown	Midden exposed in road cuts	Unknown Prehistoric
22-Ja-727		Unknown	Midden exposed in road cuts	Unknown Prehistoric
22-Ja-727		Unknown	Midden exposed in road cuts	Woodland
22-Ja-729	Graveline West Mounds	Eligible	2 mounds	Unknown Prehistoric
22-Ja-730	Graveline East Mounds	Eligible	3 mounds	Unknown Prehistoric
22-Ja-733		Ineligible		Unknown Prehistoric
22-Ja-734		Ineligible		Unknown Prehistoric

Source: Mississippi SHPO, 2001.

2.2.1 Prehistoric Period Resources

Archaeologists divide the prehistoric occupation in the Coastal Mississippi region into six major periods: the Paleo-Indian Period, which began around 10,000 B.C.; the Archaic Period; the Gulf Formational Period; the Woodland Period (Middle and Late); and the Mississippian Period, which ended in colonial times (the 1600s). Most of the resources from prehistoric times have been found along the rivers, especially the river mouths, and on the barrier islands. It is worth noting, though, that most of the known sites were identified in surveys conducted at only limited locations and, therefore, their locations cannot predict exactly where other (currently unknown) sites might exist.

2.2.1.1 Paleo-Indian Period (circa [ca.] 10,000 B.C. to ca. 8,000 B.C.)

The Paleo-Indian Period is the period with the earliest evidence of humans' existence in the North America. The climate during this time period was cooler than our present environment, and large animals, such as mammoth and sloth, flourished. Paleo-Indian peoples were nomadic hunters and gatherers who lived in small groups and ate wild plants and animals. This period is distinguished by a low population density with groups residing in seasonal or base camps. As a result, Paleo-Indian

sites are rare and usually very small. The Paleo-Indian Period is also noted for diagnostic fluted projectile points and the exploitation of Pleistocene megafauna. Some artifacts from this period have been recovered from the Mississippi Sound area (Pearce and Mikell 2000).

2.2.1.2 Archaic Period (ca. 8,000 B.C. to ca. 1,000 B.C.)

The Archaic Period is divided into three time frames: Early, Middle, and Late. Between 10,000 B.C. and 5,000 B.C. substantial ecological changes occurred across the North American continent. These changes were accompanied by a shift from Paleo-Indian to Archaic traditions. During the Archaic Period the cold, dry climate that had existed during the Paleo-Indian Period changed to a warmer and wetter one. Deciduous (leafy) forests gradually replaced coniferous (evergreen) forests. Mammals present included white-tailed deer, turkey, bear, and smaller mammals and birds. Groups responded to these changes; archaeological evidence shows an increasing use of the new forested environment. Stone axes and fishing paraphernalia appear in larger numbers.

During the Late Archaic Period, the ecology and climate became much the same as they are today. The sea level rose, and the climate became wetter than that of the previous period. These changes led to greater floral and faunal diversity, accompanied by an increase in human population in response to this rich environment. Late Archaic sites are more common as a result of this population increase. Settlement patterns reconstructed by archaeologists indicate that sites were located on terraces, ridges, and bluffs above bodies of water that included rivers, creeks, and swamps. Sites are also found at the edges of floodplains and marshes, where edible plants and animals existed in large numbers and species were diverse. Some sites might now be submerged. Late Archaic sites can also include remains of larger “base camps” and shell middens. The Pearl River phase has been defined for the Late Archaic Period (Pearce and Mikell 2000).

2.2.1.3 Gulf Formational Period (ca. 2,000 B.C. to ca. 100 B.C.)

This period is identified by the first appearance of fired ceramics along the Gulf Coast, as well as the earliest mound construction. Based on size and artifacts recovered, some of the sites from this period represent a sedentary, possibly permanent, society. Two sites at the mouth of the Pearl River, the Claiborne and Cedarland Plantation sites, have large Early Gulf Formational components. Reflecting the Late Gulf Formational Period, the larger sites were replaced by more numerous but smaller sites representing smaller villages as well as food collection sites such as shellfish collection camps. Evidence of domesticated plants, including squash and bottle gourd, has been recovered at some sites dating to this period.

2.2.1.4 Woodland Period—Middle and Late (ca. 100 B.C. to A.D. 1100)

The Woodland Period is represented in the project area by artifacts from the Middle and Late Woodland Periods. This period was similar to the Late Archaic Period in climate and ecology. Dramatic changes in social structure occurred at this time from somewhat egalitarian, nomadic hunter-gatherers who relied primarily on wild plants and animals, to more settled villagers who practiced agriculture. The remains of large villages reflect the change from nomadic to settled life. Burial mounds as well as evidence of far-flung trade networks have been identified for this period. Archaeological remains include the appearance of stockaded villages, ceramic pottery, storage pits and hearths, and small triangular stone projectile points. According to Pearce and Mikell (2000, p. 16), the sites “are clustered along major rivers and usually located on high bluffs above the rivers or along tributary creeks above the floodplain and on coastal high ground near a freshwater source. Coastal sites are usually located in hardwood hammocks. Burial mounds are present on some larger village sites and isolated Woodland burial mounds are also known . . . .”

2.2.1.5 Mississippian Period (ca. A.D. 1200 to A.D. 1600)

To date no artifacts or sites from the Early Mississippian Period phase have been identified in the project area. The Middle Mississippian Period has been identified for the Gulf Coast area. Artifacts include shell-, sand-, or grog- (crushed ceramic fragments) tempered pottery. (Tempering material is added to the clay during the manufacturing process to strengthen it when fired.) The groups living in the project area at this time were mainly hunters and gatherers along the coast and river valleys; they probably practiced horticulture as well. Sites, including the remains of small villages and camps, have been found along the coast and along the major rivers. Most of the sites in the region are coastal shell middens. Although the Mississippian Period was generally one of stratified societies with chiefdoms, evidence of those types of such large-scale settlements has not been found in the Coastal Study Area.

2.2.2 Historic Period Resources

The historic time periods are the Protohistoric Period and Historic Period, which date from colonial times (1600s) forward.

2.2.2.1 Protohistoric Period

The first contact between the American Indians that lived in the project area and Europeans occurred during the Protohistoric Period. The first European to arrive was most likely Don Diego Miruelo, who probably sailed into the Mississippi Sound in 1516. Spanish explorers, likely including Cabeza de Vaca and Panfilo de Narvaez, were in the region during the 16th century as well.

2.2.2.2 Historic Period

In the 17th century French explorers began to arrive in the region, and soon French settlers also arrived, cleared the land, and built settlements. Pierre LeMoyne, Sieur d'Iberville, established the first French settlement at Old Biloxi (now Ocean Springs) in 1699. In 1723, Biloxi became the capital of the French colony. With the Treaty of Paris in 1763, the French abandoned the Mississippi coast to the English; in 1779 the English ceded the coast to Spain. With the Louisiana Purchase in 1812 the area became part of the United States; Mississippi became a state in 1817. The cultural influence of early French settlers continued over the years; a local form of French was spoken in the area until just before World War II (Moreton 1998).

Historic American Indians who lived in the region included the Pascagoula, Biloxi, Moctobi, Capinan, and Mobile peoples. The Apalachee also lived along the Pearl River during the 17th century (Pearce and Mikell, 2000). The American Indians were decimated by disease and warfare associated with European contact, and by the 19th century very few remained in the region.

Early French settlements grew up around the waterways and developed into thriving port towns. The economy was centered on agriculture, including dairy, cattle, and poultry; timber harvesting (primarily yellow pine) and charcoal and tar production; sheep and wool production; and commercial fishing and oyster and shrimp processing (Hancock Bank 1982; Sullivan 1985). Tremendous oyster reefs lay offshore. In the mid-19th century the region also began to develop as a resort area. For example, Pass Christian was a summer retreat for plantation owners and wealthy citizens of Louisiana, Mississippi, and Alabama (Ellis 1998). Many people came to escape yellow fever. In addition, seafood factories became a mainstay of the area. The area's seafood industry continues to be important, although it has experienced a significant decline in recent years (Ellis 1998).

During the Civil War the area's economy suffered because of the Federal blockade of southern ports. After the war, however, a number of transportation improvements were instituted. The New

Orleans, Mobile & Chattanooga Railroad was constructed through the project area. With the railroad, truck farming expanded and farmers prospered through the early part of the 20th century (Alexander 1998). A deep-water channel was completed at Gulfport in 1902 (Sullivan 1985). The seafood industry was also stimulated by post-Civil War innovations in preserving and exporting seafood. As a result, the shrimping industry boomed (Hancock Bank 1982). The region's lumbering business also thrived during this period. These traditional businesses continued into the present.

One nontraditional business that developed during the 1920s and continued through the Great Depression was bootlegging [Mississippi Department of Marine Resources (MDMR) 1998]. Bootlegging grew in part because those out of work during the Depression turned to this means of supporting their families. Liquor was made in stills in isolated areas along the coast and sold locally or to bootleggers that brought the alcohol up the coast and to the west (for example, deliveries to Chicago by truck and rail). In addition to the locally made alcohol, rumrunners smuggled alcohol, including rum, from Cuba and other Caribbean ports. According to M.H. Powell (1998), "by the mid-1920s more illegal alcohol entered the United States through the Gulf Coast than any other point of entry, including Canada." Along with the bootlegging, gambling casinos were built—in 1939, for example, the Broadwater Beach Hotel was constructed in Biloxi to accommodate gamblers. These hotels were the forerunners of today's coastal casinos and hotels.

2.2.3 Historic Architectural Resources

Numerous historic architectural resources are present in the project area. To date 62 standing structures, 14 historic districts, and one ship have been listed on the NRHP. Historic districts have been designated in Biloxi, Ocean Springs, and Bay St. Louis. Table 2.2.3-1 lists these resources and their locations.

Table 2.2.3-1.
NRHP Standing Structures and Historic Districts

Name	Address	Date Listed on NRHP	Description	Location / Multiple Listing Name	UTM Coordinates (Zone 16)
Hewes Building	2505 14th Street	10/7/1982		Gulfport	E298840
					N3361212
Bailey House	1333 East Beach Blvd.	5/18/1984		Biloxi MRA	E321040
					N3363630
E. Barq Pop Factory	224 Keller Ave.	5/18/1984		Biloxi MRA	E319590
					N3363970
Biloxi's Tivoli Hotel	863 East Beach Dr.	5/18/1984		Biloxi MRA	E319980
					N3363750
Bond House	925 West Howard Ave.	5/18/1984		Biloxi MRA	E318060
					N3364110
Brunet-Fourchy House	138 Magnolia Street Mall	5/18/1984		Biloxi MRA	E318580
					N3363805
Church of the Redeemer	Bellman Street	5/18/1984		Biloxi MRA	E319205
					N3363725
Clemens House	120 West Water Street	5/18/1984		Biloxi MRA	E318650
					N3363825
Gulf Coast Center for the Arts	138 Lameuse Street	5/18/1984		Biloxi MRA	E318740
					N3363790

Table 2.2.3-1.
NRHP Standing Structures and Historic Districts (continued)

Name	Address	Date Listed on NRHP	Description	Location / Multiple Listing Name	UTM Coordinates (Zone 16)
House at 121 West Water Street	121 West Water Street	5/18/1984		Biloxi MRA	E318635 N3363800
Nativity BVM Cathedral	West Howard Ave. and Fayard Street	5/18/1984		Biloxi MRA	E318310 N3364120
Peoples Bank of Biloxi	318 Lameuse Street	5/18/1984		Biloxi MRA	E318740 N3363980
Redding House	126 West Jackson Street	5/18/1984		Biloxi MRA	E318640 N3363950
Saenger Theater	416 Reynoir Street	5/18/1984		Biloxi MRA	E318420 N3364100
Scherer House	206 West Water Street	5/18/1984		Biloxi MRA	E318600 N3363850
Seashore Campground School	Leggett Dr. and Chalmers Street	5/18/1984		Biloxi MRA	E315540 N3363990
Suter House	165 Suter Pl.	5/18/1984		Biloxi MRA	E317580 N3364140
Glenn Swetman House	2770 Wilkes Ave.	5/18/1984		Biloxi MRA	E314340 N3363990
U.S. Post Office and Customhouse	2421 13th Street	3/19/1984	Second Renaissance Revival	Gulfport	E298910 N3361080
Beauvoir	200 West Beach Blvd.	9/3/1971	Raised cottage	Biloxi	E310470 N3364271
Harbor Square Historic District	Roughly bounded by L & N Railroad, 23rd Ave., 13th Street, and 27th Ave.	8/13/1985	Georgian Revival	Gulfport	E299130 N3361430
West Beach Historic District	Roughly U.S. 90 between Rosell and Chalmers Ave.	5/18/1984		Biloxi MRA	E317300 N336428
Fort Massachusetts	South of Gulfport on Ship Island, in Gulf Islands National Seashore	6/21/1971		Gulfport	E309633
Louisville and Nashville Railroad Depot at Ocean Springs	1000 Washington Ave.	12/31/1979	Picturesque Eclecticism	Ocean Springs	E324520 N3366030
Biloxi Lighthouse	On U.S. 90 at Porter Ave.	10/3/1973		Biloxi	E317350 N3363815
U.S. Post Office, Court house, and Custom house	216 Lameuse Street	1/30/1978		Biloxi	E318850 N3364000

Table 2.2.3-1.
NRHP Standing Structures and Historic Districts (continued)

Name	Address	Date Listed on NRHP	Description	Location / Multiple Listing Name	UTM Coordinates (Zone 16)
Magnolia Hotel	137 Magnolia Street	3/14/1973		Biloxi	E318499 N3363826
Biloxi Garden Center	410 East Bayview Ave.	1/18/1973		Biloxi	E319145 N3365756
Beach Boulevard Historic District	Roughly bounded by Beach Blvd., Necaise Ave., Seminary Dr., 2nd and 3rd Streets	11/25/1980	Creole; shotgun	Bay St. Louis MRA	E276620 N3357610
Main Street Historic District	Main Street	11/25/1980	Creole; shotgun	Bay St. Louis MRA	E274660 N3355910
Sycamore Street Historic District	Sycamore Street	11/25/1980	Creole; shotgun	Bay St. Louis MRA	E274580 N3355140
W.J. Quarles House and Cottage	120 and 122 East Railroad Street	10/16/1980		Long Beach	E293260 N3359470
Scenic Drive Historic District	Scenic Drive	5/7/1979		Pass Christian	E280840 N3354730
Washington Street Historic District	Washington Street	11/25/1980	Creole; shotgun	Bay St. Louis MRA	E274820 N3354920
Toledano-Philbrick-Tullis House	947 East Beach Blvd.	11/5/1976		Biloxi	E320310 N3363660
Milner House	720 East Beach Blvd.	7/31/1972		Gulfport	E301643 N3361965
Gillis House	513 East Beach Blvd.	7/7/1978	French Colonial	Biloxi	E319270 N3363730
Taylor House	808 North Beach Blvd.	11/21/1986		Bay St. Louis MRA	E275910 N3357170
Glen Oak-Kimbrough House	806 North Beach Blvd.	11/21/1986		Bay St. Louis MRA	E275920 N3357130
House at 407 East Howard Avenue	407 East Howard Ave.	7/17/1986			E319100 N3363980
Webb School/Gulf Coast Community Action Agency	300 Third Street	11/21/1986		Bay St. Louis MRA	E275100 N3354620
Taylor School	116 Leonard Street	1/15/1987		Bay St. Louis MRA	E275660 N3357520
Building at 242 St. and Charles Street	242 Street and Charles Street	11/25/1980		Bay St. Louis MRA	E274670 N3354500
Carter-Callaway House	916 State Street	4/20/1987		Ocean Springs MRA	E324810 N3365850

Table 2.2.3-1.
NRHP Standing Structures and Historic Districts (continued)

Name	Address	Date Listed on NRHP	Description	Location / Multiple Listing Name	UTM Coordinates (Zone 16)
Cochran-Cassanova House	9000 Robinson Street	4/20/1987		Ocean Springs MRA	E324390 N3365870
Hansen-Dickey House	108 Shearwater Dr.	4/20/1987	Prairie Renaissance	Ocean Springs MRA	E325090 N3364460
House at 1112 Bowen Avenue	1112 Bowen Ave.	4/20/1987		Ocean Springs MRA	E324620 N3365610
House at 1410 Bowen Avenue	1410 Bowen Ave.	4/20/1987		Ocean Springs MRA	E324910 N3364570
Thomas Isaac Keys House	1017 DeSoto Ave.	4/20/1987		Ocean Springs MRA	E324630 N3365790
O'Keefe-Clark Boarding House	2122 Government Street	4/20/1987		Ocean Springs MRA	E325815 N3365660
Old Farmers and Merchants State Bank	998 Washington Ave.	4/20/1987		Ocean Springs MRA	E324440 N3365870
Vancleave Cottage	1302 Government Street	4/20/1987		Ocean Springs MRA	E324770 N3365700
Sullivan-Charnley Historic District	Shearwater Dr. and Holcomb Blvd.	4/20/1987		Ocean Springs MRA	E326095 N3364000
Hermann House	523 East Beach Blvd.	5/18/1984		Biloxi MRA	E319340 N3363740
Pleasant Reed House	928 Elmer Street	1/11/1979	Shotgun house	Biloxi	E318940 N3364820
Saint John's Episcopal Church	NW corner of Rayburn and Porter Ave.	4/20/1987		Ocean Springs MRA	E324090 N3365600
Indian Springs Historic District	Iberville Street, Church Street, and Washington Ave. ,N	4/20/1987		Ocean Springs MRA	E324460 N3366460
Lover's Lane Historic District	Lover's Lane	6/9/1987		Ocean Springs MRA	E322980 N3366520
Bertuccini House and Barbershop	619–619A Washington Ave.	6/9/1987		Ocean Springs MRA	E324420 N3365590
Marble Springs Historic District	Along Iberville Ave., between Washington Ave., N, and Sunset Ave.	4/20/1987		Ocean Springs MRA	E324760 N3366610
Miss La-Bama	243 Front Beach Dr.	4/20/1987		Ocean Springs MRA	E323580 N3365123
Elmwood Manor	902 North Beach Blvd.	11/21/1986	French Colonial	Bay St. Louis MRA	E275850 N3357610
Delcastle	4010 Government Street	4/20/1987	Spanish Eclectic	Ocean Springs MRA	E329270 N3364070

Table 2.2.3-1.
NRHP Standing Structures and Historic Districts (continued)

Name	Address	Date Listed on NRHP	Description	Location / Multiple Listing Name	UTM Coordinates (Zone 16)
Halstead Place	East Beach Dr.	4/20/1987		Ocean Springs MRA	E3 26970
					N3363590
Shearwater Historic District	Shearwater Dr.	8/24/1989		Anderson, Walter, MPS	E325090
					N3364880
Ocean Springs Community Center	Washington Ave.	8/24/1989		Anderson, Walter, MPS	E324460
					N3365520
Old Ocean Springs Historic District	Roughly bounded by Porter and Dewey Aves., Front Beach Dr., Martin Ave., Cleveland Street, and Rayburn Ave.	10/7/1987		Ocean Springs MRA	E324310
					N3365660
Margaret Emilie (schooner)	1036 Fred Haise Blvd.	5/30/1989			E317352
					N3363876
G.B. Dantzler House	1238 East Beach Blvd.	12/1/1989		Biloxi	E300765
					N3361650
Fisherman's Cottage	138 Lameuse St reet	3/9/1990	Creole Cottage	Biloxi MRA	E319190
					N3365730
Old Ocean Springs High School	Magnolia and Government Street	8/2/1990	English Renaissance	Ocean Springs MRA	E325140
					N3365660
Col. Alfred E. Lewis House	1901 Watersedge Dr.	10/16/1980		Walter Anderson MPS (AD) (Gautier)	E342400
					N3359700
James Krebs House	4702 River Rd.	12/20/1991		Pascagoula MPS	E331575
					N3361775
French Warehouse Site	Gulf Islands National Seashore	12/13/1991		Ocean Springs	E318150
					N3346300
Brielmaier House	710 Beach Blvd.	9/28/1995		Biloxi MRA	E318830
					N3363670
Onward Oaks	972 South Beach Blvd.	11/1/1996	Creole Cottage	Bay St. Louis MRA	E274730
					N3353690
West Central Historic District	Roughly bounded by U.S. 90, Hopkins Blvd., Howard and Benachi Aves.	5/18/1984		Biloxi MRA	E317960
					N3364195

Notes: MRA = multiple-resource area, a term used before 1984, when it was replaced with MPS.
MPS = multiple-property submission
Walter Anderson MPS = Walter Inglis Anderson (1903–1965) was a well-known artist who lived in the project area.
UTM = universal transverse mercator spatial coordinate system, serves to locate a place exactly in the world
Source: Mississippi SHPO, 2001.

2.2.4 Underwater Resources

Underwater resources in the project area include remains of prehistoric sites and of Protohistoric and Historic Period shipwrecks. To date, at least 13 shipwreck sites have been identified along the

coast. One, the wreck of the *Josephine*, is listed on the NRHP. The others are potentially eligible for listing. Shipwrecks in the Coastal Study Area could date from the colonial period (French, Spanish, and English) through the Civil War and into the early 20th century (McGahey, personal communication, 2001).

2.3 Previous Cultural Resources Work Along the Mississippi Gulf Coast

Several cultural resource surveys have been conducted in the past for a variety of projects in the study area as summarized below.

In 1980, a survey was conducted for the route of proposed Interstate Highway 110, to be located between Chartres Street, Biloxi, and U.S. Highway 90, in Harrison County. No potentially significant cultural resources were identified in that project area (Hyatt 1980).

In 1987, a 75-mile-long cultural resources survey was conducted along a route paralleling the southern boundary of Interstate-10, across Hancock, Harrison, and Jackson counties (Lauro 1987 and Sims 1999). No cultural resources were identified.

In 1998, a reconnaissance-level survey of seven submerged vessels found in the Biloxi and Tchoutacabouffa Rivers, Harrison County, was conducted (Sims 1999).

In 1998, a cultural resources survey was conducted in the project area of the proposed Broadwater Beach Resort Complex, in Biloxi, Harrison County (Lauro 1998; U.S. Army Corps of Engineers, Mobile District 2000). The survey found no archaeological sites in the project area, in part because of extensive disturbance associated with previous construction, including offshore dredging projects. The survey identified four standing structures within the viewshed of the Broadwater Complex project area: Beauvoir, the last home of Jefferson Davis; the Southern Memorial Park Cemetery; the Broadwater Beach Hotel, constructed in 1937 and greatly altered since then; and the Old Brick House, a historic home constructed in about 1850. The Old Brick House and Beauvoir are listed on the NRHP; Beauvoir is also a National Historic Landmark.

The Mississippi Gulf Coast Research Project, conducted a survey in the eastern portion of Harrison County and in all of coastal Jackson County south of Interstate-10 (Mann 2000).

In 1999, a Phase I cultural resources survey was completed for five alternative routes proposed for the East Harrison County Connector (Mann 2000). The proposed routes are located in the current project area and run roughly north-south from Interstate-10 to Highway-90. Existing cultural resources site files were examined, and a total of about 22.4 miles were surveyed. The review of the site files identified a total of nine archaeological sites within 1 mile of the proposed alternative routes. Shovel tests were conducted at 30.48-meter intervals along the alternate routes; in areas with well-drained soils adjacent to flowing water, the spacing was 15 meters. Shovel tests were also conducted at 30-meter intervals along the centerline of each of the five routes. Structures identified in this survey include the Veterans Administration Center, which is eligible for the NRHP. The remaining structures were recommended as ineligible. Three new prehistoric archaeological sites (22-Hr-881, 22-Hr-882, and 22-Hr-883) and two isolated artifacts were identified within the alternative routes.

Finally, in 2000 a Phase IA survey (background/literature search, site file check) was conducted for a proposed fiber-optic line to run through Hancock, Harrison, and Jackson Counties (Pearce and Mikell, 2000). All together, 99 sites, including prehistoric shell middens, submerged vessels, and historic cemeteries were identified within a one-mile radius of that project area during the archival research. Six of the sites were adjacent to or within the cable corridor: 22-Ha-586, 22-Ha-527, 22-Hr-

524, 22-Ja-568, 22-Ja-586, and 22-Ja-608. Site 22-Ja-608 was ineligible. Information for 22-Ha-586 is missing. Site 22-Ha-586 is located near the Pearl River in a high-probability area. In a previous study, the remaining sites did not yield any cultural material. (The consultant completed a Phase I cultural resource excavation survey). Two high-probability areas were identified and one site was identified. One site was recommended as ineligible for NRHP listing. Site Ha-527 was identified as a Mississippian Period shell mound.

CHAPTER 3. EARLY DAMAGE ASSESSMENT EFFORTS FOLLOWING HURRICANE SEASON OF 2005

Cultural building and site assessments began almost immediately after the storm in early September 2005. The NPS and the Mississippi Department of Archives and History have led efforts in damage assessments to cultural properties and still have much work ahead of them. Additionally, the Mississippi Heritage Trust, and the National Trust for Historic Preservation have been working closely with assessment teams. The National Center for Preservation Training and Technology (NCPTT), a branch of the NPS, developed a series of checklists designed to be used by Federal Emergency Management Agency (FEMA) volunteers and professional preservationists to compile uniform data on the post-storm condition of cultural properties. The checklists, known as a "Rapid Building and Site Condition Assessment" and a "Detailed Building and Site Condition Assessment" incorporate information including the property description, potential safety hazards that would prevent someone from getting near the property, basic evaluations of structural integrity or the presence of exposed archaeological material, recommendations, and graphs for a field sketch of the site. These forms made it possible for a task force to gather enough data to create an initial status report for Hancock, Harrison, and Jackson counties as well as several other counties to the north. Although the report released by the NPS Task Force is general in nature, the extreme extent of the damage recorded is readily noticeable (Table 3-1). Most efforts have been directed at studying the architectural rather than archaeological resources, but the amount of damage suffered by both types is staggering. The efforts documented in Table 3-1 below are some of the earliest accounts, and much more work remains to be done to fully account for and assess the damage sustained to Mississippi's coastal cultural properties.

Table 3-1.
General Cultural Property Assessment for the Mississippi Coast
(NPS Status Report 30 December 2005)

State of Mississippi	Institution or Site	Status
Hancock County		
Bay St. Louis	Multiple properties	Two of 5 National Register Districts destroyed. 90% of remaining properties that were assessed are judged salvageable.
Harrison County		
Biloxi	Beauvoir, The Jefferson Davis Home and Presidential Library	Home: Aerial photo shows holes torn in slate roof and galleries (porches) missing. Library: Built to withstand category 5 hurricane; first floor washed out by storm surge. Portraits salvaged after event additional recovery of artifacts begun. Archeologist assisting in recovering artifacts from debris scattered over 60-acre site. Historic library pavilion, Hayes cottage, Soldier's Home Barracks replica, Confederate Soldier's Museum, Giftshop, and director's home destroyed. Replicas of destroyed buildings will be built after restoration of Beauvoir and Presidential Library. Sewage contamination to pond behind Beauvoir to be addressed (as of 11/14).
Biloxi	Breilmaier House (c. 1895)	Destroyed.
Biloxi	Biloxi Cemetery	Many trees uprooted; markers broken.
Biloxi	Dantzler House	Destroyed.
Biloxi	Maritime and Seafood	A portion of the building remains. Some artifacts salvaged,

State of Mississippi	Institution or Site	Status
	Industry Museum	including lens from Ship Island lighthouse.
Biloxi	Ohr-O'Keefe Museum of Art	Aerial photo shows two of five buildings in new museum complex left (JLH). Pleasant Reed House destroyed (DP).
Biloxi	Tullis-Toledano Manor	Aerial photo shows Tullis-Toledano House (c. 1860) destroyed (under the displaced casino barge); Tullis Slave Quarters (c. 1860) destroyed; Crawford House (c. 1850) destroyed
East Ship Island	Gulf Islands National Seashore, French Warehouse and associated cemetery, Quarantine Station	Quarantine Station site submerged, under 5-6 feet of water; French Warehouse site and cemetery sustained damage but are accessible.
Jackson County		
Ocean Springs	Gulf Coast Research Laboratory	Coast Guard permitted access to collections on 9/15/05. Collections flooded. NPS Incident Management Team assisting with recovery of herbarium and hazardous tree and debris removal.
Ocean Springs	Gulf Islands National Seashore	Storm surge flooded exhibits and museum collections at Davis Bayou Visitor Center. Museum Emergency Response Team is stabilizing collections. Collections moved to NPS Southeast Archeological Center and Timucuan Ecological and Historic Preserve. Frozen archives to be shipped and treated off-site. See report for Gulf Coast Research Laboratory where some park herbarium specimens are stored.
Ocean Springs	Shearwater	Most of the work of Anderson Family potters destroyed; 12 of 15 buildings destroyed
West Ship Island	Gulf Islands National Seashore Ft. Massachusetts; reconstructed Ship Island Lighthouse	Storm surge flooded and damaged fort: earthen berm damaged, large granite blocks dislodged and in moat, interior filled with mud and debris several inches thick. Most of the mud removed by 10/13/05. Extent of damage to Rodman cannon, artifacts and exhibits unknown. Conservator visit scheduled. Reconstructed lighthouse destroyed. Archeologist surveyed 9/19. Parts of the fort's rampart were breached by storm surge. Domed surface of casements exposed when earthen berm removed by storm. Sally Port damaged, extensive beach erosion. Cannon carriage flooded by salt water, but not cannon. Brick foundation and scattered brick, probably associated with archeological remains of lighthouse, identified.

3.1 Expected Impacts to Resources

Once a full assessment of damage is complete, we can expect to see the destructive impacts to cultural properties caused by Hurricane Katrina to fall under two categories: direct and indirect. Direct impacts should include damage directly caused during the storm by surging water, wind and flying debris, while indirect impacts would be those caused largely by the effects of standing water, exposure to the elements, or mold and decay due to water saturation. These impacts will differ slightly between archaeological and architectural resources.

3.1.1 Direct Impacts

Properties directly in the path of the storm surge appear to have suffered the most damage. Many of the historic homes and mansions that lined the shoreline highways were completely demolished. Some of the more well known historic properties along Beach Boulevard in Biloxi that are now completely gone include the Dantzler House, the Breilmaier House, the Pleasant Reed House, and the Tullis-Toledano mansion.

The Dantzler House lay in splinters behind the bronze statue of Pierre Le Moyne d'Iberville. The Breilmaier House, built in 1895, was reported missing and may have been sighted "floating down the street during the storm" (Williams 2005). The only remaining evidence of the Pleasant Reed House, a shotgun style house built in 1887, is the chimney (ibid). Also, the Tullis-Toledano mansion was found flattened under a casino barge (ibid). Reassuringly, the Beauvoir Mansion, Jefferson Davis's home designated as a National Historic Landmark is substantially damaged, but the main portion of the house remains standing. The first floor of the presidential library is destroyed as well as several cottages on the grounds, but many of the most valuable artifacts were removed prior to Katrina's landfall and survive. Additionally, because of Beauvoir's status as a National Historic Landmark, funds will be set aside eventually for its refurbishment.

Because archaeological sites are unique resources in that they cannot be recreated or restored, the damage many have sustained is irreparable. Several have had huge chunks gouged out by wayward fishing vessels beached on top of the remains of ancient American Indian coastal settlements. Wave scour, and giant uprooted trees have cleared 2,000 year old mounds immediately along the coastline of vegetation and exposed them for further erosion and looting. Shipwrecks that were once buried under several feet of sand have been exposed, and will suffer accelerated degradation as the wooden hull timbers dry into dust. The full extent of the loss is yet to be fully documented, and the work and funding required to salvage any remaining information is yet to be fully estimated.

3.1.2 Indirect Impacts

Archaeological resources where most of the resources lie below the ground or on the ground surface can be expected to suffer indirect effects from exposure of materials to sunlight that previously were kept in the dark moist earth. Materials, such as bone, oxidized metal, and organic remains, will dry and become brittle or may disintegrate. Also, the loss of vegetation that once held a site in place and obscured artifacts from view will cause site erosion. Other issues will occur as a result of materials becoming exposed that may be attractive to looters. Alternately, archaeological resources close to the shore that were on dry ground before the storm may now be permanently inundated, or in a surf zone and subject to constant erosion by sand and tidal action. Conversely, architectural resources where most of the resource lies above the ground can be expected to suffer from mold and mildew, and the rotting of wood and other materials. Additionally, sunlight and air can access portions of the structure and allow vegetation to take over and cause damage with the roots. Wood and cellulose eating insects will cause a loss of structural integrity and irreversible damage to furnishings that otherwise made it through the storm intact. As with archaeological resources, the threat of theft is present when objects of value are exposed to the outside or left unattended.

CHAPTER 4. MSCIP COMPREHENSIVE EFFORT TENTATIVELY SELECTED PROJECTS

The Corps, Mobile District has a responsibility under the NHPA Section 106 process, to consider the effects that projects may have on Historic Properties [sites eligible for or listed on the NRHP]. The process involves a number of steps which include: establishing an undertaking has the potential to cause effects to historic properties; determination of the projects APE; determination of interested and consulting parties; creation of inventory strategy; completion of inventory (identification of cultural resources); identification of property NRHP eligibility; determination of effects; consultation; avoidance strategies (if needed); and resolution of adverse effects (if required).

As such, the Corps has been working to comply with Section 106 and its implementing regulations at 36 CFR 800 while moving forward with the mission of MsCIP. Initial plans as outlined for coastal recovery included a number of very large, complex projects. These projects, including ring levees, flood walls, and other massive civil works efforts, which would have involved huge impact areas and multiple state and Federal agencies. As such, the Corps recommended pursuing a Programmatic Agreement (PA) as an alternative method to Subpart B of 36CFR800, as outlined in 36CFR800.14(b). This would have allowed for greater involvement of interested parties and a streamlined process for compliance with NHPA. However, after consultation with the Mississippi SHPO and interested tribes (Mississippi Band of Choctaw Indians have responded to date), it was requested that the idea of approaching cultural compliance through the use of a PA be dropped for the MSCIP program.

There were two primary reasons for the dropping of the PA approach. First, the nature of the projects has become less complex from a cultural compliance standpoint than was first envisioned. Therefore, the PA approach was thought to be “overkill” for the most likely actions that would be approved for construction. Second, both the SHPO representatives and the tribal representatives expressed a reluctance to pursue a PA due to what they described as “PA overload”. It was the thought of the participants that pursuing compliance on a project by project basis would be the most efficient and economical way to handle the program.

A list of those projects for which funding and authorization have been requested is provided below. Details of the plans for each project are available in Chapter 5 of the Environmental Appendix and in the Main report, in Chapter 4. Should funding be approved, these projects would be the first to be constructed. The list does not include all of the possible plans, since all of the possible plans have not been identified.

MsCIP Projects currently proposed or awaiting funding:

- Turkey Creek Environmental Restoration
- Bayou Cumbest Environmental Restoration
- Franklin Creek Environmental Restoration
- Coast-wide Beach/Dune
- Forrest Heights Levee
- Moss Point Municipal Relocation
- Admiral Island Ecosystem Restoration
- Barrier Island Restoration

- Deer Island Ecosystem Restoration
- HARP Buyout
- Waveland Flood proofing
- Mississippi Sound Sub-aquatic Vegetation (SAV) Restoration
- Violet Louisiana Freshwater Diversion

To date, since none of the listed projects has been fully authorized and funded, only preliminary cultural resources compliance work has taken place. This includes meeting with the Mississippi SHPO staff, with FEMA, and with some of the cultural resource consultants that are currently working on non-Corps recovery efforts on the coast. Discussions included the determination of APE, inventory strategy, and preferred consultation method. The Mississippi SHPO staff expressed concern that many of the current efforts the Corps, Mobile District is working on appear similar to those being worked on by other agencies from a cultural resource aspect. In the aftermath of the storm, a number of Federal agencies and federally funded state agencies have been conducting and proposing to conduct activities that have the potential to effect historic properties. As such, these agencies have been conducting cultural resources compliance work and are planning more work, in order to deal with their legal responsibilities. Agencies involved include, but are not limited to, the Corps (New Orleans District, Mobile District and Vicksburg District), FEMA, Coast Guard, MMS, HUD and the Mississippi Development Authority. In many cases, there is the potential for a "duplication" of efforts, such as creation of cultural histories; historical documentation scanning; creation of GIS data layers for archaeological sites, standing structures, monuments, cemeteries, etc.; inventory for cultural resources; site testing and evaluation of cultural properties; and consultation. As a proactive measure to reduce duplication, the Mobile District will continue coordination with these agencies on the proposed projects.

In addition to meeting with the SHPO and other agencies, the Corps, Mobile District has conducted a literature review for all the project locations. This includes the gathering of base line historic and archaeological information of the proposed above project sites. This could best be described in the BLM terminology as a "Class I survey" or as it is also called, a background search. This includes viewing local histories, historic maps, and gray literature for the project areas. Also checked were the state archaeological and architectural data bases. State site location and survey maps were checked. Previous surveys conducted in the areas were reviewed. Informal discussions were held with local informants as well.

As projects become authorized and funded, the Corps will proceed with Section 106 consultation. Project APE's will be formally identified. Through consultation, inventory strategies will be outlined. The resulting inventory work will identify potential historic properties. Determination of NRHP eligibility and project effects to historic properties will be made. Consultation with the SHPO and other agencies and interested tribes will be continued. Should historic properties be identified within the project APE, avoidance will be the preferred mitigation measure. Should avoidance not be possible, resolution of potential adverse effects to historic properties will be handled as outlined in 36CFR800. This will include requiring the signing of a Memorandum of Agreement, notification of Adverse Effect to historic properties, offering the Advisory Council on Historic Preservation an opportunity to participate in the process, and possibly archaeological mitigation or historic documentation.

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1.3 Impact Analysis of Alternatives Not Being Considered in Main Report

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CHAPTER 1 ENVIRONMENTAL EFFECTS

The environmental effects section in the MsCIP Comprehensive Main Report/Integrated EIS provides an evaluation of proposed projects being tentatively selected for construction or advanced engineering and design and their effects to the environment. The environmental effects analysis is conducted on two different levels which include an evaluation of the overall Comprehensive Plan and its components that require further study before being tentatively selected for construction in the future. The second level of analysis considers effects of specific projects being tentatively selected for construction and/or advanced engineering and design. Due to this complex nature, the projects screened out early during the plan formulation process are addressed for their environmental impacts in this attachment of the Environmental Appendix.

Hurricane Katrina caused tremendous damage to the overall natural environment within coastal Mississippi as documented in Chapter 2, Effected Environment Section in the MsCIP Comprehensive Main Report/Integrated EIS. The extent of the damage to many resources is still unknown and additional research, studies, surveys, etc, are ongoing. In some instances, the extent of damaged resources may never be known.

Many measures that may be tentatively selected in the Comprehensive Plan have been categorized in either structural, non-structural, or environmental restoration types of projects; however, further study is needed in order to assess benefits, effects, and to obtain specific details needed for development of plans. Numerous projects have been developed to a feasibility-type level and are being tentatively selected for construction although some will need advanced engineering and design prior to development of plans and specifications. Still other measures will establish a framework within which future projects have been identified under continuing authorities that would require specific Project Information Reports after development of plans and specifications.

As a result of the diversity of potential projects that have come forth from this Comprehensive Report, further environmental considerations and analyses will be required prior to projects being implemented. There could be supplemental EISs to evaluate projects that would result in significant impacts and further EAs for projects that are less complex in nature with less impacts associated with them. During development of NEPA documentation, detailed discussions of potential impacts and subsequent mitigation will be incorporated as measures and alternatives are being developed.

Provisions for “tiering” of EISs are found in 40 CFR 1502.20 whenever a broad EIS has been prepared (such as a program or policy statement) and a subsequent statement or EA would then be prepared on an action included within the entire program or policy. This EIS will serve as the basis from which further required environmental analyses and documentation could be tiered from. Additionally, the projects being tentatively selected for construction or for advanced engineering and design will be evaluated for environmental impacts as part of this integrated EIS. These impacts are discussed in the following sections and paragraphs.

Due to the complexity of this comprehensive project for coastal Mississippi, the measures and alternatives that were screened out during the plan formulation effort have been included in the following information. This was done in order to allow the reader an easier path forward in this complex recovery approach of coastal Mississippi.

CHAPTER 2 BARRIER ISLAND ANALYSIS

2.1 Soils

Soils would persist as they are today.

2.2 Sediments

Re-suspension of sediments would likely occur within specific project sites. Silt fences and other BMPs would be used to minimize the adverse impacts to the environment during construction activities to the maximum extent practicable. Containment structures, silt curtains, and other BMPs would be used to contain sediment deposition at restoration sites. It is expected that solids that remain suspended in the water column would migrate by littoral drift. Any impacts that might occur would typically be isolated to each construction site, minor and of short duration.

2.3 Geology

There should be no effects to geology. Potential projects have been or would be designed to avoid impacts to current geological formations.

2.4 Climate

There should be no effects to the existing climate.

2.5 Air Quality

Currently all areas within coastal Mississippi are in attainment with the NAAQS. Air quality in the immediate vicinity of project construction would be slightly affected for a period of time by the fuel combustion and resulting engine exhausts. The standards would not be violated by the implementation of the proposed project.

2.6 Noise

Noise from the construction type equipment is expected to increase during the proposed operations in the project vicinities. Noise levels will resume to existing conditions as construction activities are completed. It is anticipated there would be no significant impacts to noise during implementation of these measures.

2.7 Vegetation

2.7.1 Line of Defense 1 – Barrier Island Restoration

Several measures have been developed which would allow for storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife habitats, and prevention of coastal erosion. Restoration of the barrier islands could provide a benefit to vegetation.

2.7.1.1 Option A: Restore Island Footprint

It is anticipated there would be no adverse impacts to vegetation from implementation of this measure because this would consist of open-water habitat to expand the actual islands' footprint. In fact, restoring the islands to historical footprints would provide a benefit to the existing vegetation already on the island due to it providing additional habitat for colonization.

2.7.1.2 Option B: Replenish Sand in Littoral Zone, Inland Source

It is anticipated there would be no impacts to vegetation from implementation of this measure. Addition of land to the barrier islands would provide a positive benefit to the vegetation through natural colonization.

2.7.1.3 Option C: Replenish Sand in Littoral Zone, Offshore Source

It is anticipated there would be no impacts to vegetation from implementation of this measure. Addition of land to the barrier islands would provide a positive benefit to the vegetation through natural colonization.

2.7.1.4 Option D: Environmental Restoration With 2-Foot Dune

This measure would involve environmental restoration of the barrier islands consisting of shaping existing sand into dunes on the beaches. Dune features would be planted with native vegetation. Planting of marshes, maritime forests, and sea grasses in the near-shore areas of the islands would serve to restore or enhance lost habitat. Implementation of this measure would provide significant benefits to the existing damaged vegetation as a result of the hurricanes of 2005. Further studies during project development would determine the specific benefits gained by implementation of this measure.

2.7.1.5 Option E: Environmental Restoration With 6-Foot Dune

This measure would involve environmental restoration of the barrier islands consisting of shaping existing sand into dunes on the beaches. Dune features would be planted with native vegetation. Planting of marshes, maritime forests, and sea grasses in the near-shore areas of the islands would serve to restore or enhance lost habitat. Implementation of this measure would provide significant benefits to the existing damaged vegetation as a result of the hurricanes of 2005. Further studies during project development would determine the specific benefits gained by implementation of this measure.

2.7.1.6 Option F: Environmental Restoration of Sea Grass Beds

This measure would involve enhancement and restoration of historical sea grasses located in Mississippi Sound. Implementation of this measure would provide significant benefits to the existing vegetation that has suffered as a result of the hurricanes of 2005. Further studies during project development would determine the specific benefits gained by implementation of this measure.

2.7.1.7 Option G: Restoration of Ship Island Breach

Implementation of this measure would provide a benefit to vegetation as a result of reforestation of the beach and dune system that once existed.

2.8 Fish and Wildlife

2.8.1 Line of Defense 1 – Barrier Island Restoration

Several measures have been developed which would allow for storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife habitats, and prevention of coastal erosion. Restoration of the barrier islands would require a large amount of high quality sand being placed on or around the sandy string of barrier islands.

2.8.1.1 Option A: Restore Island Footprint

Generally, restoration of the island footprint would entail filling of existing water bottoms to pre-Hurricane Camille conditions. The barrier islands currently provide essential fish habitat for managed fisheries, designated critical habitat for the threatened Gulf sturgeon, and designated critical habitat for piping plover. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. It is anticipated additional sand along the shoreline would provide additional opportunities for nesting for sea turtles. Additionally, the potential measure would provide additional overwintering critical habitat for the piping plover. Many other shorebird species use the barrier islands for nesting and foraging. Filling of water bottoms would remove essential fish habitat, foraging areas for sea turtles and other marine species.

The sand would be obtained from an offshore source, St. Bernard Shoals, approximately 45 miles south of the islands. Dredging will impact essential fish habitat consisting of epibenthic crustaceans and infaunal polychaetes within the immediate area. However, the impacts are primarily short-term in nature and consist of a temporary loss of benthic invertebrate populations in the areas of dredging. Adjacent benthic communities are anticipated to move into the dredged site and begin recolonization. The area is characterized as a relic sand shoal approximately at elevation -60 NGVD 88 and once dredging is complete, will remain similar in character as dredged depths would not exceed 10 feet in depth. Therefore, because similar habitat, in terms of both sediment composition and depth will be present pre- and post dredging, it is anticipated the benthic biota in the dredging areas will recover and recolonize. Further study during project development would determine the extent of impacts and benefits associated with implementation of this measure.

2.8.1.2 Option B: Replenish Sand in Littoral Zone, Inland Source

This measure would result in less direct impacts to the islands themselves by introduction of sand into the littoral zone where the islands are located. A large amount of water bottoms would be filled as a result. These areas currently provide essential fish habitat for managed fisheries and designated critical habitat for the threatened Gulf sturgeon. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. Filling of water bottoms would remove some foraging areas for sea turtles and other marine species including the Gulf sturgeon. Sand would be obtained from inland sources comprised of previous dredged river sands. Past analyses and comparisons have found the river sands are typically a finer grain size than native beach sands, which are mostly medium sized. Additionally, these comparisons determined the beach sands are slightly more rounded than river sands. One factor that would warrant further analysis is the differences in color of the two sands with the river sands having a slight brown tint compared to the beach sand samples which are described as white or light grey. It is believed the river sands would undergo bleaching from the ultraviolet radiation from the sun if the color variation was caused by a mineral staining. Adding this sand into the littoral system would diminish the differences between the natural sands by spreading it over large areas with shallow thicknesses. Although, the littoral zone placement via shallow thickness would increase the impact area to essential fish habitat, sea turtles'

foraging, and Gulf sturgeon and/or its designated critical habitat, this impact would be temporary due to the sediment placement within the littoral zone and its associated movement. No significant impacts are anticipated either due to the other large total of acreages available in the region to these species. The natural sediment transport process would blend the two sands together while removing staining from the sand grains and rounding the individual particles through abrasion. Further study during project development would determine the extent of impacts of incorporating river sands into the marine system and filling of water bottoms.

2.8.1.3 Option C: Replenish Sand in Littoral Zone, Offshore Source

This measure would result in less direct impacts to the islands themselves by introduction of sand into the littoral zone where the islands are located. A large amount of water bottoms would be filled as a result. These areas currently provide essential fish habitat for managed fisheries and designated critical habitat for the threatened Gulf sturgeon. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. Filling of water bottoms would remove foraging areas for sea turtles and other marine species including the Gulf sturgeon. Sand would be obtained from an offshore source and would consist of high quality beach sands. The natural sediment transport process would blend this sand into the existing littoral system. Further study during project development would determine the extent of impacts of filling of water bottoms and incorporation of the offshore sands.

The sand would be obtained from an offshore source, St. Bernard Shoals, approximately 45 miles south of the islands. Dredging will impact epibenthic crustaceans and infaunal polychaetes within the immediate area. However, the impacts are primarily short-term in nature and consist of a temporary loss of benthic invertebrate populations in the areas of dredging. Adjacent benthic communities are anticipated to move into the dredged site and begin recolonization. The area is characterized as a relic sand shoal approximately at elevation -60 NGVD 88 and once dredging is complete, will remain similar in character as dredged depths would not exceed 10 feet in depth. Therefore, because similar habitat, in terms of both sediment composition and depth will be present pre- and post dredging, it is anticipated the benthic biota in the dredging areas will recover and recolonize. Further study during project development would determine the extent of impacts and benefits associated with implementation of this measure.

2.8.1.4 Option D: Environmental Restoration With 2-Foot Dune

It is anticipated that implementation of this measure would provide significant benefits to fish and wildlife by restoration of existing damaged and lost habitat. Dunes provide natural island habitat and by restoration, the island dwelling species gain lost habitat. The barrier islands provide important stopover habitat for many species of migratory birds. The barrier islands currently provide essential fish habitat for managed fisheries, designated critical habitat for the threatened Gulf sturgeon, and designated critical habitat for piping plover. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. It is anticipated additional sand along the shoreline would provide additional opportunities for nesting for sea turtles. Additionally, the potential measure would provide additional overwintering critical habitat for the piping plover. Many other shorebird species use the barrier islands for nesting and foraging. Further studies during project development would determine specific benefits resulting from implementation of this measure.

2.8.1.5 Option E: Environmental Restoration With 6-Foot Dune

It is anticipated that implementation of this measure would provide significant benefits to fish and wildlife by restoration of existing damaged and lost habitat. Dunes provide natural island habitat and by restoration, the island dwelling species gain lost habitat. The barrier islands provide important

stopover habitat for many species of migratory birds. The barrier islands currently provide essential fish habitat for managed fisheries, designated critical habitat for the threatened Gulf sturgeon, and designated critical habitat for piping plover. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. It is anticipated additional sand along the shoreline would provide additional opportunities for nesting for sea turtles. Additionally, the potential measure would provide additional overwintering critical habitat for the piping plover. Many other shorebird species use the barrier islands for nesting and foraging. Further studies during project development would determine specific benefits resulting from implementation of this measure.

2.8.1.6 Option F: Environmental Restoration of Sea Grass Beds

Many marine species depend on sea grass beds for foraging opportunities and cover. Restoration of this vital habitat would provide significant benefits to fish and wildlife and their habitats. Establishment of a comprehensive program would allow for further education regarding the sustainability of the resource.

2.8.1.7 Option G: Restoration of Ship Island Breach

Generally, restoration of the island footprint would entail filling of existing water bottoms to circa 1916-17 geomorphic conditions. These areas currently provide essential fish habitat for managed fisheries, designated critical habitat for the threatened Gulf sturgeon, and designated critical habitat for piping plover. Several sea turtle species utilize the islands and adjacent water bottoms for nesting and foraging. It is anticipated additional sand along the shoreline would provide additional opportunities for nesting for sea turtles. Additionally, the potential measure would provide additional overwintering critical habitat for the piping plover. Filling of water bottoms would remove foraging areas for sea turtles and other marine species. Further study during project development would determine the extent of impacts and benefits associated with implementation of this measure.

The sand would be obtained from an offshore source, St. Bernard Shoals, approximately 45 miles south of the islands. Dredging will impact epibenthic crustaceans and infaunal polychaetes within the immediate area. However, the impacts are primarily short-term in nature and consist of a temporary loss of benthic invertebrate populations in the areas of dredging. Adjacent benthic communities are anticipated to move into the dredged site and begin recolonization. The area is characterized as a relic sand shoal approximately at elevation -60 NGVD 88 and once dredging is complete, will remain similar in character as dredged depths would not exceed 10 feet in depth. Therefore, because similar habitat, in terms of both sediment composition and depth will be present pre- and post dredging, it is anticipated the benthic biota in the dredging areas will recover and recolonize. Further study during project development would determine the extent of impacts and benefits associated with implementation of this measure.

2.9 Threatened and Endangered Species

2.9.1 Line of Defense 1 - Barrier Island Restoration

Close coordination with resource agencies has allowed for better planning and development of alternatives in order to further avoid potential significant impacts to listed species. A more detailed assessment of these threatened and endangered species issues can be found in the Environmental Appendix. Adverse impacts to threatened and endangered species were part of an initial screening process used during early planning. Further consultation with appropriate resource agencies would occur during project development and subsequent biological opinions of the agency would be issued.

Overall implementation of this measure would benefit Piping Plover and its critical habitat by the increased amount of overwintering foraging areas. Temporary impacts could occur during construction but could be avoided during the times the Piping Plover are on the overwintering grounds. Impacts associated with construction activities should be temporary and isolated to actual construction limits. Brown Pelicans could utilize the project areas, however, it is anticipated these species would avoid the construction area due to noise and activity. These impacts would be temporary and isolated to actual construction limits. Surveys to determine if nesting brown pelicans are present could be conducted to avoid any impacts. If nests cannot be avoided during construction, a take could occur. Manatees, Gulf sturgeon and Sea Turtles could be in the project area and there is potential for adverse impacts to occur. It is anticipated these species would primarily avoid the construction areas due to noise and activity resulting in less risk for harm or harassment. Methods of dredging would be utilized to avoid adverse impacts to listed species. Placement activities would be accomplished using appropriate best management practices to reduce turbidity and other potential adverse impacts to species and its critical habitat. Further consultation would be required to determine adverse impacts to critical habitat for the Gulf sturgeon. Bald Eagles (recently de-listed) should avoid the project area during construction activities due to noise and activity. Surveys to determine if nesting bald eagles are present could be conducted to avoid any impacts. If nests cannot be avoided during construction, a take, under the Bald and Golden Eagle Protection Act (BGEPA), could occur. It is anticipated whale species would avoid the project area during construction activities due to noise and activity and no collisions should occur. Further consultation would occur to determine potential impacts to listed species. Biological Assessments of particular project components would need to be evaluated under future programmatic consultations.

2.10 Water Quality

2.10.1 Line of Defense 1 - Barrier Island Restoration

Water quality within coastal Mississippi is being evaluated as part of their ongoing program and monitoring data are compared to the "*State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*" in order to make decisions on whether a water body is supporting or not supporting its designated uses such as aquatic life support, water contact recreation, fish/shellfish consumption, and drinking water. A more detailed assessment pertaining to water quality issues in coastal Mississippi can be found in the Environmental Appendix. There are specific problems in certain waterbodies throughout the study area; however, many are isolated associated with certain conditions due to industrial discharge, historical problems, and increased run-off in conjunction with development.

Restoration of the barrier islands would require a large amount of high quality sand being placed on or around the sandy string of barrier islands. Overall, this should not cause significant impacts to existing water quality within Mississippi Sound. Restoration of the barrier islands would actually ensure estuarine conditions within Mississippi Sound remain.

2.10.1.1 Option A: Restore Island Footprint

This would require direct placement of approximately 66 million cubic yards of sand dredged from St. Bernard Shoals. Approximately 31 million cubic yards would be placed within the breach (Camille Cut) on Ship Island with the remaining 20 million cubic yards to be placed along the island shorelines expanding the footprints causing many acres of waterbottoms to be filled. The sand found at St. Bernard Shoals is of a quality similar to what is found in the present day Mississippi islands and sufficient quantity to meet the need. There should be no problems associated with turbidity at the borrow site in association with the dredging. The sandy material should pose no turbidity

problems during placement activities as sand settles quickly. BMPs would be utilized in order to decrease any impacts associated with Water Quality. It is expected no impacts to water quality would result from implementation of this measure.

2.10.1.2 Option B: Replenish Sand in Littoral Zone, Inland Source

This measure would result in less direct impacts to the islands themselves by introduction of sand into the littoral zone where the islands are located. The sand would not be placed on the islands, but in areas between the islands where the currents that make up the littoral drift zone could transport the sand to the islands. This would result in a large amount of water bottoms to be filled at shallow depths, up to one-foot thicknesses. Sand would be obtained from inland sources comprised of previous dredged river sands. BMPs would be utilized to reduce turbidity associated with placement activities. It is anticipated there would be little impacts to water quality in association with implementation of this measure.

2.10.1.3 Option C: Replenish Sand in Littoral Zone, Offshore Source

This measure would result in less direct impacts to the islands themselves by introduction of sand into the littoral zone where the islands are located. The sand would not be placed on the islands, but in areas between the islands where the currents that make up the littoral drift zone could transport the sand to the islands. This would result in a large amount of water bottoms to be filled at shallow depths, up to one-foot thicknesses. Sand would be obtained from St. Bernard Shoals which is of a quality similar to what is found in the present day Mississippi islands. BMPs would be utilized to reduce turbidity associated with placement activities. It is anticipated there would be minimal impacts to water quality in association with implementation of this measure.

2.10.1.4 Option D: Environmental Restoration With 2-Foot Dune

Implementation of this measure would provide positive impacts to water quality by restoration of existing wetlands and marshes on the islands. It is anticipated there would be a benefit to water quality as a result of this measure. Although there may be a slight increase in turbidity during construction, it is anticipated this would be localized and short in duration.

2.10.1.5 Option E: Environmental Restoration With 6-Foot Dune

Implementation of this measure would provide positive impacts to water quality by restoration of existing wetlands and marshes on the islands. It is anticipated there would be a benefit to water quality as a result of this measure. Although there may be a slight increase in turbidity during construction, it is anticipated this would be localized and short in duration.

2.10.1.6 Option F: Environmental Restoration of Sea Grass Beds

Improved water quality within Mississippi Sound would help to establish sea grasses.

2.10.1.7 Option G: Restoration of Ship Island Breach

This would require direct placement of approximately 8 million cubic yards of sand dredged from St. Bernard Shoals within the breach (Camille Cut) on Ship Island causing a large amount of water bottoms to be filled. BMPs would be utilized to reduce turbidity associated with placement activities. It is anticipated there would be minimal impacts to water quality in association with implementation of this measure.

2.11 Water Supply

There should be no effect on water supply. Potential projects have been or would be designed to avoid impacts to existing public water supply infra-structure and operating facilities.

2.12 Socio-Economics

2.12.1 Line of Defense 1 - Barrier Island Restoration

Several measures have been developed which would allow for storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife habitats, and prevention of coastal erosion. Restoration of the barrier islands would require a large amount of high quality sand being placed on or around the sandy string of barrier islands. It is anticipated there would be positive effects to socio-economics as a result of the implementation of this measure.

2.12.1.1 Population

It is anticipated there would be a positive benefit associated with this measure to the population within coastal Mississippi as restoration of the barrier islands would enhance the existing natural system and allow for sustainability of this natural resource that produces much of the quality of life that currently exists today, especially prior to Hurricane Katrina.

2.12.1.2 Employment and Income

Implementation of this measure could result in a positive increase to the income of the area and its residents. This measure could also result in the creation of numerous jobs, ranging from construction to retail and others, in order to accommodate the significant infrastructure investment. These jobs could potentially be long-term in nature given the size and scope of the measure. Refer to the Economic Appendix for more details on the increases to income and employment and the full extent of impacts.

2.12.1.3 Housing

It is anticipated this measure would have no effect to current housing within coastal Mississippi. There are no residential structures located on the barrier islands.

2.12.1.4 Quality of Life

Implementation of this measure would provide for a continuation and enhancement of the existing quality of life as much of the local economy is driven by the seafood industry. This measure would provide for sustainability and enhancement of the barrier islands and prevention of coastal erosion. Stabilization of the barrier islands will ensure the future of the estuary within Mississippi Sound by ensuring no additional saltwater intrusion occurs. This will ensure the productivity of Mississippi Sound, which provides the basis of the seafood driven economy as well as additional recreational opportunities.

2.12.1.5 Schools

It is anticipated there would be no effect to schools by implementation of this measure.

2.12.1.6 Public Safety

It is anticipated there would be no negative impacts to public safety by implementation of this measure. Additionally, it is expected implementation of this measure would provide significant benefits by a reduction of damages caused by waves and storm surge.

2.12.1.7 Recreation

Within 85 miles of Gulf of Mexico coastline, coastal Mississippi has many recreational opportunities for its residents and for potential tourists. Restoration of the barrier islands will ensure water sports, fresh and saltwater fishing, camping, historic tours, and cultural sites remain available for residents and tourists. The barrier islands are popular spots for swimming, wind surfing, parasailing, motor boating, water skiing, and sailing. Data from fiscal year 2000 depicts the Gulf Islands National Seashore had 875,000 visitors, and 26,000 of these visitors stayed overnight. There are 200 varieties of saltwater fish in and around the Mississippi Sound and the Gulf of Mexico. A climate suitable for year-round fishing makes this even more popular. More than 30 public boat ramps, marina slips, and an umber of private camps and launches provide rental boats, charger boats, and bait. A wide variety of charter boats were available prior to Hurricane Katrina, for small groups of one to six passengers or for large parties. Fishing trips could be scheduled for from 4 hours up to an overnight stay. Numerous fishing tournaments are held every year, including the Mississippi Deep Sea Fishing Rodeo, which is the large event of its kind in the world (Mississippi Gulf Coast, 2001). Restoration of the barrier islands would ensure the continuation of the recreational opportunities as well as its sustainability well into the future.

2.12.1.8 Transportation and Traffic

It is anticipated there will be no effect to transportation or traffic by implementation of this measure. There are two deepwater ports and one shallow water port located within the vicinity of the barrier islands.

2.13 Land Use

2.13.1 Line of Defense 1 - Barrier Island Restoration

Several measures have been developed which would allow for storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife habitats, and prevention of coastal erosion. Restoration of the barrier islands would require a large amount of high quality sand being placed on or around the sandy string of barrier islands. It is anticipated there would be no adverse effects to current or future land use as a result any potential projects.

2.13.1.1 Option A: Restore Island Footprint

This project would require direct placement of approximately 66 million cubic yards of sand dredged from St. Bernard Shoals. Approximately 21 million cubic yards would be placed within the breach (Camille Cut) on Ship Island with the remaining 45 million cubic yards to be placed along the island shorelines expanding the footprints. Alteration of land use is expected due to the change from filling in of water bottoms being converted to sandy barrier islands resulting in expanded acreage. It is anticipated this change in land use would be insignificant as the islands would be expanded to historical sizes and the relative size of the project to the surrounding land use.

2.13.1.2 Option B: Replenish Sand in Littoral Zone, Inland Source

A large amount of water bottoms would be filled at shallow depths up to one-foot in depth in association with implementation of this measure. There would be alteration of current land use due to the changes associated with filling in of water bottoms; however, it is anticipated the difference would be insignificant due to the relative size of the proposed project to the surrounding land use.

2.13.1.3 Option C: Replenish Sand in Littoral Zone, Offshore Source

A large amount of water bottoms would be filled at shallow depths up to one-foot in depth in association with implementation of this measure. There would be alteration of current land use due to the changes associated with filling in of water bottoms; however, it is anticipated the difference would be insignificant due to the relative size of the proposed project to the surrounding land use.

2.13.1.4 Option D: Environmental Restoration With 2-Foot Dune

Implementation of this measure would provide a benefit to current land use as restoration would provide enhancement to the existing environment.

2.13.1.5 Option E: Environmental Restoration With 6-Foot Dune

Implementation of this measure would provide a benefit to current land use as restoration would provide enhancement to the existing environment.

2.13.1.6 Option F: Environmental Restoration of Sea Grass Beds

The project would result in an enhancement of the water bottoms and existing sea grass beds as a result of implementation of this measure. The project would result in a positive benefit to land use.

2.13.1.7 Option G: Restoration of Ship Island Breach

This would require direct placement of approximately 21 million cubic yards of sand dredged from St. Bernard Shoals within the breach (Camille Cut) on Ship Island causing a large amount of water bottoms to be filled. Alteration of land use is expected due to the changes associated with filling in of water bottoms being converted to sandy barrier island resulting in expanded acreage. It is anticipated this change in land use would be insignificant as the island would be expanded to its historical size and the relative size of the project to the surrounding land use.

2.14 Aesthetic Resources

As restoration occurs, aesthetics would be temporarily reduced in the immediate vicinity of the proposed project sites. Many recreational vessels utilize Mississippi Sound within the project vicinities and it is believed some residents and visitors may be disturbed by the presence of required heavy equipment during any construction phases. However, construction activities would be temporary in nature so the disturbance would be anticipated to be minimal at each potential project site. There could be times when numerous projects throughout coastal Mississippi would be occurring at once or potential project phases could be scheduled upon completion of requisite projects which would take extended amounts of time. The projects should provide residents and visitors with an overall more aesthetically pleasing view as projects are completed.

The environmental restoration projects would provide additional fish and wildlife habitat to numerous shore birds and various wildlife species which would enhance coastal Mississippi and its diverse aquatic habitats while providing future sustainability of the natural system.

2.15 Cultural Resources

Significant cultural resources as defined by the NHPA are those sites that are considered eligible for or are included in the National Register. These sites are known as historic properties. Historic properties can include buildings or other standing structures; historic or prehistoric districts (such as the historic districts in Biloxi and Ocean Springs); archaeological sites, such as Indian mounds or other remains of prehistoric life; objects, such as statues or paintings; or sunken vessels. Traditional cultural properties can also be considered significant cultural resources because of their traditional religious or cultural importance to an Indian tribe or other traditional community.

Along the Mississippi Gulf Coast, historic properties can be roughly defined within two categories. The categories are the built environment (standing structures) and archaeological sites. The vast majority of historic properties listed on the National Register are those of the built environment. To date 62 standing structures, 14 historic districts, and one ship have been listed.

In contrast, very few archaeological sites have been formally nominated to the National Register. However, numerous sites still meet the criterion of definition as historic properties. These include prehistoric earthworks and mounds, shell middens, village sites, and historic occupation areas including extinct town sites. Currently, over 200 recorded archaeological sites are considered potential historic properties.

The vast majority of historic and prehistoric sites are found along the immediate coastal strand and adjacent to estuarine systems. Preference for well-drained, sandy soils adjacent to water sources is apparent. Coast wide survey work performed by both state (Giliberti n.d.) and private researchers (Blitz and Mann 2000) have found a distinctive focus on the immediate coastal and estuarine locations. Unfortunately, the geographic placement of these resources has made them extremely vulnerable to destruction from continued occupation and development, as well as vulnerable to the effects of tropical storms and hurricanes.

Previous archaeological and architectural studies along the Mississippi Gulf Coast have documented the destruction caused by natural forces, most notably hurricanes. Standing structures are often the most dramatic and visible witnesses to this destruction. However, prehistoric and historic archaeological sites are also extremely vulnerable. Shell middens, found along the immediate shoreline and within coastal marshes and estuaries, often are flipped and re-deposited by the storm surge and wave action of hurricanes. This effectively destroys much of the value of the sites. Sites, such as Indian villages, and historic town sites, such as those along the bluff on Bay St. Louis, can also be destroyed by such wave action. In addition, post storm activities offer many more mechanisms for site destruction. These include clearing of timber by use of skidders and other heavy equipment, debris removal, and reconstruction. The destructiveness of these activities is well documented from the years following Hurricane Camille which struck the area in 1969.

The Corps, Mobile District Archaeologists, through long standing coordination relationships developed throughout the years, coordinated closely with the Mississippi Department of Archives and History staff in determining effects of the storm event. Hurricane Katrina has been documented to have destroyed a vast majority of the standing historic properties within Hancock County, and a large number of those within Harrison and Jackson Counties. The size and strength of the storm surge has also undoubtedly had as much destruction on archaeological sites. Post hurricane activities have further impacted the remaining historic properties.

Historic Fort Massachusetts is on West Ship Island, a barrier island 12 miles off the Mississippi Coast. The fort is accessible only by private boat or passenger ferry with scheduled public tours given March through October.

Fort Massachusetts was built on Ship Island for national defense. Both domestic and foreign powers recognized the strategic significance of the natural deep water harbor on the north side of the island. After lengthy debate fort construction began in the summer of 1859. Storms, disease, climate, isolation and the Civil War made construction on this remote barrier island a challenge. Construction on Fort Massachusetts halted in 1866 although the fort was not fully completed.

The fort has not only withstood actions of war but also the more subtle enemies of time and neglect. The devastating and powerful Hurricanes Camille (1969) and Katrina (2005) washed over and through the building but failed to significantly undermine the structure. However, decades of salt air and wave action began to erode the historic mortar. Employees from the Historic Preservation Training Center came to the rescue in 2001 and repaired the 135-year old brick walls. In addition the remains of the French Warehouse are located east of the fort. Various ships could be located around the barrier islands.

Protection from the immediate and post-effects of hurricanes should be considered as beneficial to cultural resources. While some historic properties may be adversely affected by protection plans, long term prevention of damage should be considered a positive measure for historic properties, in particular standing structures. Mobile District archaeologists are closely coordinating with the State of Mississippi Department of Archives and History regarding potential impacts associated with potential measures being considered in the Comprehensive Plan.

2.16 Hazardous, Toxic, and Radioactive Wastes

Quickly after Hurricane Katrina, the EPA working with the National Strike Team and other national search and rescue teams began identification and cleanup of the Household Hazardous Wastes and other hazardous type debris. The EPA established partnerships with other national and local teams involved with debris cleanup. The Corps, Mobile District team coordinated with them regularly and provided coordinates/locations of HHW and HTRW that were located during vegetative and construction type debris cleanup. The EPA working with others were charged with the responsibility of final cleanup of this type debris after the storm event.

Site inspections would be conducted at and adjacent to the various components of the Comprehensive Plan during development of specific plans and specifications in accordance with the requirements of ER 1165-2-132 entitled, HTRW Guidance for Civil Works Projects, and the American Society of Testing and Materials Standard E 1527.

2.17 Environmental Justice

EO 12898, Federal Actions to address Environmental Justice in Minority and Low-Income Populations (February 11, 1994) requires that Federal agencies conduct their programs, policies, and activities that substantially affect human health or the environment in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under such programs, policies, and activities because of their race, color, or national origin. On February 11, 1994, the President also issued a memorandum for heads of all departments and agencies, directing that EPA, whenever reviewing environmental effects of proposed actions pursuant to its authority under Section 309 of

the CAA, ensure that the involved agency has fully analyzed environmental laws, regulations, and policies.

Any potential measures would not create disproportionately high or adverse human health or environmental impacts on minority or low-income populations within the study area. Review and evaluation of the overall comprehensive plan have not disclosed the existence of identifiable minority or low-income communities that would be adversely impacted by proposed measures. Further studies during project development would determine specific impacts associated with implementation of potential measures. The following analysis will serve as a beginning point from which further analyses can be built upon during the comprehensive plan components.

Historic and Existing Conditions Data from the U.S Department of Commerce, Census of Population and Housing were used for this Environmental Justice analysis. The population in 1990 for Mississippi was 2,573,216. Minority populations included in the census are identified as Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and other Pacific Islander, Hispanic, of two or more races, and other. Mississippi is only second to the District of Columbia as having the largest Black or African American population. Poverty status, used in this coastal Mississippi report to define low-income status, is reported as the number of persons with income below poverty level. The 2005 Census defines the poverty level as $9,973 of annual income, or less, for an individual, and $19,971 of annual income, or less, for a family of four. In 2005, Mississippi ranked number one out of the 50 states for individuals living below the poverty level in the past 12 months. Unfortunately, Mississippi had 21.3% of its population living in poverty in 2005.

Coastal Mississippi has a lower percentage of minority residents than the State of Mississippi and the U.S. In 2000 (the most up-to-date data available), 79.6 percent of the population was white and 16.3 percent was black. All other racial groups combined totaled approximately 4.1 percent of the population, while 2.2 percent were of Hispanic origin. In Mississippi, 61.4 percent of the population was white, 36.3 percent was black, 2.3 percent was of another minority racial group, and 1.4 percent was of Hispanic origin. For the U.S., 75.1 percent of the population was white, 12.3 percent was black, and 12.6 percent was of other minority racial groups. Approximately 12.5 percent of the U.S. population was Hispanic.

The Census Bureau bases the poverty status of families and individuals on 48 threshold variables, including income, family size, number of family members under the age of 18 and over the age of 65, and amount spent on food. In 1997, approximately 14.6 percent of the residents were classified as living in poverty, lower than the State of Mississippi but slightly higher than the poverty rate for the U.S. as a whole.

As of 2006, the population in Mississippi was 2,910,540 – of this 135,940 individuals live in Jackson County, 193,810 live in Harrison County, and at this time a population count for Hancock County was not available. Hurricane Katrina drew focus on the number of residents unable to flee the Gulf coast due to lack of funds. There is a longstanding legacy of unfair and disproportionate harmful exposures to low income, predominantly African American communities in much of Mississippi. Predominantly in the Biloxi area but also in other coastal Mississippi communities, there was a large population of Asian Americans that depended upon fishing for their livelihood. Adverse impacts from Hurricane Katrina have resulted in a large number of these individuals leaving the area.

Environmental Justices have resulted from years of industrial activity and waste disposal practices that hit these communities harder than higher income, predominantly white communities. Impacted areas, such as superfund facilities, are located more often in low-income areas and therefore are at greater risk to post-Katrina exposure. As clean-up proceeds and rebuilding begins, every effort must be made to remedy these environmental injustices through full clean-up, fair rebuilding practices, and full partnership with affected communities. Over 30,000 families are being helped through Administration on Children and Families TANF program by the provision of short term, non-recurrent

cash benefits to families who traveled to another State from the disaster designated States. The hurricane-damaged States of Mississippi, Louisiana, and Alabama also received additional funding for the TANF program to provide assistance and work opportunities to needy families ($69 million for loan forgiveness and $25 million in contingency funds for State Welfare Programs.) Counties along the Mississippi Gulf coast lost a sizeable share of their white residents and homeowners immediately following Hurricane Katrina, while other Gulf Coast metropolitan areas, especially those that gained residents, experienced little overall shifts in their demographic profiles. Coastal counties of Mississippi, which include Gulfport-Biloxi and Pascagoula metropolitan areas, in contrast to New Orleans, were left with a population that had a larger share of minority residents, a lower level of homeownership, and no significant decline in poverty. In essence, while the poor and less well-off residents of New Orleans bore the greatest brunt of Katrina, the storm had a more egalitarian effect on the population of coastal Mississippi. Our examination of the data for other hurricane impacted areas in the Gulf Coast region reveals that while a great deal of population shifting had occurred, only minor changes have taken place in the race and ethnic, economic and socio-demographic profiles for most of these areas.

Specifically, restoration of the barrier islands would not adversely impact any minority or low-income populations because those individuals are not living within the island's vicinity. In fact, restoration of the barrier islands would indirectly benefit those individuals living on the mainland through the anticipated environmental benefits, such as fishing. Each and every measure or alternative (i.e. Forest Heights) examined in the MsCIP study was evaluated for its potential for adverse impacts to minority and/or low-income populations, in adherence with EO 12898. In no case was there any identified negative impact to any of these communities in regards to human health and environmental conditions, from any proposed actions or projects.

2.18 Protection of Children

EO 13045, Protection of Children from Environmental Health Risks and Safety Risks (April 21, 1997), recognizes a growing body of scientific knowledge that demonstrates that children may suffer disproportionately from environmental health risks and safety risks. These risks arise because children's bodily systems are not fully developed; because children eat, drink, and breathe more in proportion to their body weight; because their behavior patterns may make them more susceptible to accidents. Based on these factors, the President directed each Federal agency to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children. The President also directed each Federal agency to ensure that its policies, programs activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

It is anticipated that no disproportionate risks to children would occur as a result of implementation of the No Action Plan and any potential measures. Specifically, restoration of the barrier islands would not adversely impact children because those individuals are not living within the island's vicinity. In fact, restoration of the barrier islands would indirectly benefit those individuals living on the mainland through the anticipated environmental benefits, such as fishing. Further studies during project development phase would determine any activities that might pose any disproportionate environmental health risks or safety risks to children.

2.19 Unavoidable Adverse Environmental Effects

It is anticipated that any adverse environmental effects which could not be avoided should potential projects be implemented should be temporary and localized and would be minor individually and cumulatively.

2.20 Irreversible and Irretrievable Commitments of Resources

Any irreversible or irretrievable commitments of resources involved in any potential proposed projects have been considered and are either unanticipated at this time or will be considered to determine if any would present minor impacts.

CHAPTER 3 ENVIRONMENTAL RESTORATION ANALYSIS

A detailed analyses has been conducted for the following five environmental restoration plans to determine the impacts associated with alternatives that were considered during development of projects being tentatively selected for construction. It is expected that no further environmental analysis is required prior to the projects being constructed. Full details of all alternative plan impacts are presented below.

3.1 Environmental Effects

The following tentatively selected plan impacts are grouped together because the impacts are the same for each proposed restoration efforts.

- **Soils** - Alteration of soils is anticipated within environmental restoration projects; however, in some instances, old fill material would be removed for reestablishment of more native types soils generally found in the natural system.
- **Sediments** - Re-suspension of sediments would likely occur within specific project sites. Silt fences and other BMPs would be used to minimize the adverse impacts to the environment during construction activities to the maximum extent practicable. Containment structures, silt curtains, and other BMPs would be used to contain sediment deposition at construction and environmental restoration sites. It is expected that solids that remain suspended in the water column would migrate by littoral drift. Any impacts that might occur would typically be isolated to each construction site, minor and of short duration.
- **Geology** - There should be no effects to geology. Potential projects have been or would be designed to avoid impacts to current geological formations.
- **Climate** - There should be no effects to the existing climate.
- **Air Quality** - Currently all areas within coastal Mississippi are in attainment with the NAAQS. Air quality in the immediate vicinity of project construction would be slightly affected for a period of time by the fuel combustion and resulting engine exhausts. The standards would not be violated by the implementation of the proposed project.
- **Noise** - Noise from the construction type equipment is expected to increase during the proposed operations in the project vicinities. Noise levels will resume to existing conditions as construction activities are completed. It is anticipated there would be no significant impacts to noise during implementation of these measures.
- **Water Supply** - There should be no effect on water supply. Potential projects have been or would be designed to avoid impacts to existing public water supply infra-structure and operating facilities.
- **Socio-Economics** -

  Population - It is expected minimal impacts to population would occur by implementation.

  Employment and Income - Implementation of this measure could result in a positive increase to the income of the area and its residents. This effort could also result in the creation of jobs in order to accommodate the investment. Refer to the Economic

Appendix for more details on the increases to income and employment and the full extent of impacts.

Housing - Implementation of this measure would not impact housing within coastal Mississippi because most of the existing housing has been destroyed and only minimal impacts would occur in obtaining the property due to the hardships associated with rebuilding.

Quality of Life - Implementation of this measure could improve quality of life within coastal Mississippi as additional wetland restoration would benefit water quality, wildlife habitat, and various natural resource functions as a result of restoration activities.

Sc*hools* - Implementation of this measure would not impact schools within coastal Mississippi.

Public Safety - It is anticipated there would be minimal positive effects to public safety by implementation of this measure as wetland restoration would benefit water quality, wildlife habitat, and various natural resource functions.

Recreation - It is anticipated there would be minimal benefits to recreation associated with implementation of this measure.

Transportation and Traffic - It is anticipated there would be no impacts associated with implementation of this measure.

- **Aesthetics** - As projects would be constructed, aesthetics would be temporarily reduced in the immediate vicinity of the proposed project sites. Many recreational vessels utilize Mississippi Sound within the project vicinities and it is believed some residents and visitors may be disturbed by the presence of required heavy equipment during any construction phases. However, construction activities would be temporary in nature so the disturbance would be anticipated to be minimal at each potential restoration project site. There could be times when numerous projects throughout coastal Mississippi would be occurring at once or potential project phases could be scheduled upon completion of requisite projects which would take extended amounts of time. The restoration projects should provide residents and visitors with an overall more aesthetically pleasing view as projects are completed.

  The environmental restoration projects would provide additional fish and wildlife habitat to numerous shorebirds and various wildlife species, which would enhance coastal Mississippi and its diverse aquatic habitats while providing future sustainability of the natural system.

- **Cultural Resources** - The vast majority of historic and prehistoric sites are found along the immediate coastal strand and adjacent to estuarine systems. Preference for well-drained, sandy soils adjacent to water sources is apparent. Coast wide survey work performed by both state (Giliberti n.d.) and private researchers (Blitz and Mann 2000) have found a distinctive focus on the immediate coastal and estuarine locations. Unfortunately, the geographic placement of these resources has made them extremely vulnerable to destruction from continued occupation and development, as well as vulnerable to the effects of tropical storms and hurricanes.

  Modern development along the Mississippi coast has affected both archaeological sites and standing structures, including individual structures and historic districts in the project area. Key issues are soil disturbance and construction. Soil disturbance affects archaeological sites, and construction of new buildings and associated infrastructure can affect the view

shed and “feel” of a historic building or district or cause demolition or alteration of historic buildings.

From the early 1970s to the present, construction in the project area has greatly increased. In fact, more development and construction has occurred in the three counties that are part of the project area than anywhere else in the state. Land use studies show that between 1972 and 2000 both medium-density and high-density urban land use areas increased by more than 90 percent in the study area; overall, developed land use increased by almost 70 percent during that period (MARIS 1992, 2000; USGS 1972; USGS and USEPA 1992). This sizeable increase in developed land is caused in part by the casinos and related infrastructure, residential, and commercial construction. The development involves large areas of soil disturbance, which destroys archaeological sites.

Previous archaeological and architectural studies along the Mississippi Gulf Coast have documented the destruction caused by natural forces, most notably hurricanes. Standing structures are often the most dramatic and visible witnesses to this destruction. However, prehistoric and historic archaeological sites are also extremely vulnerable. Shell middens, found along the immediate shoreline and within coastal marshes and estuaries, often are flipped and re-deposited by the storm surge and wave action of hurricanes. This effectively destroys much of the value of the sites. Sites such as Indian villages and historic town sites such as those along the bluff on Bay St. Louis can also be destroyed by such wave action. In addition, post storm activities offer many more mechanisms for site destruction. These include clearing of timber by use of skidders and other heavy equipment, debris removal, and reconstruction. The destructiveness of these activities is well documented from the years following hurricane Camille which struck the area in 1969.

Corps, Mobile District Archaeologists, through long standing coordination relationships developed throughout the years, coordinated closely with the Mississippi Department of Archives and History staff in determining effects of the storm event. Hurricane Katrina has been documented to have destroyed a vast majority of the standing historic properties within Hancock County, and a large number of those within Harrison and Jackson Counties. The size and strength of the storm surge has also undoubtedly had as much destruction on archaeological sites. Post hurricane activities have further impacted the remaining historic properties.

Protection from the immediate and post-effects of hurricanes should be considered as beneficial to cultural resources. While some historic properties may be adversely affected by protection plans, long term prevention of damage should be considered a positive measure for historic properties, in particular standing structures. Mobile District archaeologists are closely coordinating with the State of Mississippi Department of Archives and History regarding potential impacts associated with potential measures being considered in the Comprehensive Plan. Plans are underway to develop an overall Programmatic Agreement to address potential impacts to cultural and historic resources.

- **Hazardous, Toxic, and Radioactive Wastes** - Quickly after Hurricane Katrina, the EPA working with the National Strike Team and other national search and rescue teams began identification and cleanup of the Household Hazardous Wastes and other hazardous type debris. The EPA established partnerships with other national and local teams involved with debris cleanup. The Corps team coordinated with them regularly and provided coordinates/locations of HHW and HTRW that were located during vegetative and construction type debris cleanup. The EPA working with others were charged with the responsibility of final cleanup of this type debris after the storm event.

Site inspections would be conducted at and adjacent to the various components of the Comprehensive Plan during development of specific plans and specifications in accordance with the requirements of ER 1165-2-132 entitled, HTRW Guidance for Civil Works Projects, and the American Society of Testing and Materials Standard E 1527.

Inspections would be accomplished to determine the presence or evidence of landfills, surface areas unable to support vegetation, visible sheens of petroleum product, nearby contaminated industrial facilities, or any type of visible indication that HTRW concerns exist that may impact any component of the tentatively selected plans during specific project development. Site inspections of adjacent properties, reviews of historic aerial photographs, on site interviews, and environmental database record searches would be conducted to determine any evidence of HTRW concerns that may impact any component of the tentatively selected plans during specific project development.

Based on the findings of the HTRW site assessments, specific or unusual environmental concerns that are identified that could affect construction of any proposed projects would be addressed appropriately. Additional supplemental environmental impacts statements or environmental analyses may be necessary once specific projects have been identified and development of project plans has begun. HTRW issues and concerns would be addressed during the required NEPA compliance and documentation.

- **Environmental Justice** - EO 12898, Federal Actions to address Environmental Justice in Minority and Low-Income Populations (February 11, 1994) requires that Federal agencies conduct their programs, policies, and activities that substantially affect human health or the environment in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under such programs, policies, and activities because of their race, color, or national origin. On February 11, 1994, the President also issued a memorandum for heads of all departments and agencies, directing that EPA, whenever reviewing environmental effects of proposed actions pursuant to its authority under Section 309 of the CAA, ensure that the involved agency has fully analyzed environmental laws, regulations, and policies.

  The No Action and Comprehensive plan and potential measures are not designed to create a benefit for any specific group or individual. Any potential measures would not create disproportionately high or adverse human health or environmental impacts on minority or low-income populations within the study area. Review and evaluation of the overall comprehensive plan have not disclosed the existence of identifiable minority or low-income communities that would be adversely impacted by proposed measures. Further studies during project development would determine specific impacts associated with implementation of potential measures.

  A detailed discussion on the *Historic and Existing Conditions Data from the U.S Department of Commerce, Census of Population and Housing* has been provided in Section 2.17. This analysis will serve as a beginning point from which further analyses can be built upon during the comprehensive plan components. Ultimately, the plan adopted for the Mississippi coast will not be a plan forced on them by the Corps or other Federal agencies, but a plan coordinated, discussed, and finally adopted by the numerous entities and individuals that will live with that plan, the residents and local government of coastal Mississippi.

- **Protection of Children** - The EO 13045, Protection of Children from Environmental Health Risks and Safety Risks (April 21, 1997), recognizes a growing body of scientific knowledge that demonstrates that children may suffer disproportionately from environmental health risks and safety risks. These risks arise because children's bodily systems are not fully developed;

because children eat, drink, and breathe more in proportion to their body weight; because their behavior patterns may make them more susceptible to accidents. Based on these factors, the President directed each Federal agency to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children. The President also directed each Federal agency to ensure that its policies, programs activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

It is anticipated that no disproportionate risks to children would occur as a result of implementation of the No Action Plan and any potential measures. Further studies during project development phase would determine any activities that might pose any disproportionate environmental health risks or safety risks to children.

- **Unavoidable Adverse Environmental Effects** - It is anticipated that any adverse environmental effects which could not be avoided should potential projects be implemented should be temporary and localized and would be minor individually and cumulatively.

- **Irreversible and Irretrievable Commitments of Resources** - Any irreversible or irretrievable commitments of resources involved in any potential proposed projects have been considered and are either unanticipated at this time or will be considered to determine if any would present minor impacts.

The following section provided completed detailed analysis of the alternatives considered for each restoration project during development of each proposed tentatively selected plan.

3.2 Admiral Island

Tidal marshes in this area were ditched in the 1960s causing changes in the natural hydrology and subsequent changes in the species composition. Hurricane Katrina left extensive debris fields and sedimentation in the area destroying many native trees and vegetation. Due to the loss of native species this area has a severe infestation of the invasive Chinese Tallow Tree, which is invading the marshes and adjacent flatwoods.

3.2.1 Vegetation

3.2.1.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition.

3.2.1.2 Plan 1 – Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.

There will be a benefit to vegetation as this plan will restore hydrology, remove exotics allowing native plants to become better established, and the planting density is such that ensures high rates of survival and increases percent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future.

3.2.1.3 Plan 2 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

There will be a benefit to vegetation as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return.

3.2.1.4 Plan 3 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 2 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return.

3.2.1.5 Plan 4 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is such that ensures high rates of survival and increases per-cent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future.

3.2.1.6 Plan 5 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return.

3.2.1.7 Plan 6 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent

cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return.

3.2.2 Fish and Wildlife

3.2.2.1 No Action

The invasive species would continue to thrive threatening to take over the site reducing available native forage for fish and wildlife species to use the area. Lack of available habitat could cause fish and wildlife species to move from the area seeking more suitable habitat.

3.2.2.2 Plan 1 – Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.

There will be a benefit to fish and wildlife species, including essential fish habitat for managed species, as this plan would restore hydrology, remove exotics allowing native plants to become better established, and the planting density is such that ensures high rates of survival and increases percent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future. This will provide valuable forage and cover for fish and wildlife species.

3.2.2.3 Plan 2 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

There will be a benefit to fish and wildlife species, including essential fish habitat for managed species, as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return and to provide necessary habitat for fish and wildlife species.

3.2.2.4 Plan 3 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 2 meter spacing.

Implementation of this plan would provide a benefit to fish and wildlife species, including essential fish habitat for managed species, as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Increased maintenance activities could disrupt established use patterns by species and increased spacing would reduce the overall quality of the habitat to support foraging and cover.

3.2.2.5 Plan 4 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.

Implementation of this plan would provide a benefit to fish and wildlife species, including essential fish habitat for managed species, as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat

affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. Lack of natural hydrology would impact fish and wildlife species that would naturally use an intact habitat and could also limit resources available for their survival. The planting density is such that ensures high rates of survival and increases percent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future. This will provide valuable forage and cover for fish and wildlife species.

3.2.2.6 Plan 5 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 1 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. Lack of natural hydrology would impact fish and wildlife species, including essential fish habitat for managed species, that would naturally use an intact habitat and could also limit resources available for their survival. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return and to provide necessary habitat for fish and wildlife species.

3.2.2.7 Plan 6 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. Lack of natural hydrology would impact fish and wildlife species, including essential fish habitat for managed species, that would naturally use an intact habitat and could also limit resources available for their survival. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Increased maintenance activities could disrupt established use patterns by species and increased spacing would reduce the overall quality of the habitat to support foraging and cover.

3.2.3 Threatened and Endangered Species

As these vital resources are restored, it is anticipated that various threatened and endangered species would begin to utilize those valuable habitats. Birds, such as piping plovers and brown pelicans, and sea turtles would likely begin to utilize the filled breached area at Ship Island and nourished mainland beaches. Protected species, such as the red-cockaded woodpeckers, Mississippi sandhill cranes, gopher tortoises and the Eastern indigo snakes, would likely benefit from the restored wet pine Savannah habitats.

3.2.3.1 No Action

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.2.3.2 Plan 1 – Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.2.3.3 Plan 2 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.2.3.4 Plan 3 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 2 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.2.3.5 Plan 4 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.2.3.6 Plan 5 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 1 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.2.3.7 Plan 6 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.2.4 Water Quality

3.2.4.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. Continued degradation of the site would further reduce any water quality functions that currently exist.

3.2.4.2 Plan 1 – Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.

There will be a benefit to water quality as this plan will restore hydrology, remove exotics allowing native plants to become better established, and the planting density is such that ensures high rates of survival and increases per-cent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.2.4.3 Plan 2 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

There will be a benefit to water quality as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Once complete, the project would mature over a longer period of time; however, the project would provide for improved water quality functions. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.2.4.4 Plan 3 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 2 meter spacing.

Implementation of this plan would provide a benefit to water quality as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Although the project would provide benefits to water quality, the amount of time necessary would increase and a longer period of time would be needed in order for the wetland to reach maturity. The sustainability of the project remains unknown and it may become necessary for the introduction of additional native plants to provide the optimum percent cover necessary to reach a fully functional wetland.

3.2.4.5 Plan 4 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.

Implementation of this plan would provide a benefit to water quality as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is such that ensures high rates of survival and increases percent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future. The reduced hydrology will reduce the overall water quality functions of the wetlands as compared to filling in the ditches proposed in plans 1 - 3.

3.2.4.6 Plan 5 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 1 meter spacing.

Implementation of this plan would provide a benefit to water quality as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Once complete, the project would mature over a longer period of time; however, the project would provide for improved water quality functions. The reduced hydrology will reduce the overall water quality functions of the wetlands as compared to filling in the ditches proposed in plans 1 - 3.

3.2.4.7 Plan 6 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

Implementation of this plan would provide a benefit to water quality as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. The sustainability of the project remains unknown and it may become necessary for the introduction of additional native plants to provide the optimum percent cover necessary to reach a fully functional wetland. The reduced hydrology will reduce the overall water quality functions of the wetlands as compared to filling in the ditches proposed in plans 1 - 3.

3.2.5 Land Use

3.2.5.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition; however there should be no change to current land use as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

3.2.5.2 Plan 1 – Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.

There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

3.2.5.3 Plan 2 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

3.2.5.4 Plan 3 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 2 meter spacing.

There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

3.2.5.5 Plan 4 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.

There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

3.2.5.6 Plan 5 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

3.2.5.7 Plan 6 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

3.3 Dantzler Environmental Restoration

The area was planted in plantation pines during the 1960s and ditches and stormwater lines were constructed in the 1970s in anticipation of residential development of the site. Long term exclusion of fire and the invasion of non-native species, Cogongrass and Chinese Tallow Trees have severely degraded the site.

3.3.1 Vegetation

3.3.1.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community.

3.3.1.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.

Implementation of this plan will benefit vegetation. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain.

3.3.1.3 Plan 2 – Maintain Savannah Vegetation by Mowing Annually, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.

Implementation of this plan will benefit vegetation. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease composition for native species.

3.3.2 Fish and Wildlife

3.3.2.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession, creating a mixed pine/hardwood forest community thus shifting the fish and wildlife species that would normally use the historical pine savannah habitat.

3.3.2.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. Many fish and wildlife species depend on these disappearing habitats. Adequate restoration and fire management is necessary to ensure continued existence of species dependent on pine savannah habitats.

3.3.2.3 Plan 2 – Maintain Savannah Vegetation by Mowing Annually, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease competition for native species. Mowing activities could impact ground nesting birds as well as other terrestrial mammals. Mowing creates additional ground litter that could inhibit daily activities of some species although maintenance of early successional habitat will benefit most species.

3.3.3 Threatened and Endangered Species

3.3.3.1 No Action

The invasive species would continue to thrive threatening to take over the site further degrading available habitat for use by the Mississippi Sandhill Crane.

3.3.3.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.

Implementation of this plan will benefit the Mississippi Sandhill Crane by restoration of the savannah, the main habitat used by the species for nesting and foraging. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. The Alabama Red-bellied turtle has been documented in using channels within Mary Walker Bayou, adjacent to the project site. It is anticipated the species could use the project site for nesting. The Mississippi Sandhill Crane depends on this type habitat for its continued existence which has experienced declines due to development within coastal Mississippi.

3.3.3.3 Plan 2 – Maintain Savannah Vegetation by Mowing Annually, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.

Implementation of this plan will benefit the endangered Mississippi Sandhill Crane and Alabama Red-bellied Turtle. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease competition for native species. Mowing activities could impact ground nesting birds such as the Mississippi Sandhill Crane. Mowing creates additional ground litter that could limit foraging efficiency of the Mississippi Sandhill Crane. The Alabama Red-bellied turtle has been documented in using channels within Mary Walker Bayou, adjacent to the project site. It is anticipated this species could use the project site for nesting.

3.3.4 Water Quality

3.3.4.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community.

3.3.4.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. It is anticipated that burning activities could have short term impacts to water quality due to runoff during rain events. This should be localized and short term in nature. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.3.4.3 Plan 2 – Maintain Savannah Vegetation by Mowing Annually, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease competition for native species. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.3.5 Land Use

3.3.5.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and creating a mixed pine and hardwood community. There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

3.3.5.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.

There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

3.3.5.3 Plan 2 – Maintain Savannah Vegetation by Mowing Annually, 100% Removal of exotics and plantation pines over the project life, Fill in 100% artificial ditches.

There would be no impacts to current land use as a result of construction of this alternative as the site is currently owned by the State of Mississippi and consists of a degraded wetland.

3.4 Turkey Creek Environmental Restoration

The site is primarily comprised of a pine savannah wetland. Several miles of ditches have been excavated throughout the site. Additionally, an elevated railway berm fragments the wetland habitat substantially altering hydrology of the wetlands located to the north.

3.4.1 Vegetation

3.4.1.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community.

3.4.1.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.

Implementation of this plan will benefit vegetation. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain.

3.4.1.3 Plan 2 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.

Implementation of this plan will benefit vegetation. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease composition for native species.

3.4.1.4 Plan 3 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.

Implementation of this plan will benefit vegetation. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain.

3.4.1.5 Plan 4 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.

Implementation of this plan will benefit vegetation. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease composition for native species.

3.4.1.6 Plan 5 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.

Implementation of this plan will benefit vegetation. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain.

3.4.1.7 Plan 6 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.

Implementation of this plan will benefit vegetation. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease composition for native species.

3.4.2 Fish and Wildlife

3.4.2.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession, creating a mixed pine/hardwood forest community thus shifting the fish and wildlife species that would normally use the historical pine savannah habitat.

3.4.2.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. Many fish and wildlife species depend on these disappearing habitats. Adequate restoration and fire management is necessary to ensure continued existence of species dependent on pine savannah habitats. This plan would restore the entire area north and south of the railroad berm which would provide a contiguous fire maintained landscape. Larger blocks of habitat are more easily managed using fire and less fragmented landscapes provide more benefits to fish and wildlife species. Unfortunately the railroad berm presents a barrier to hydrology, fire and fish and wildlife species. To accommodate the barrier, additional culverts would be required as well as additional fire breaks for prevention of damages to the railroad berm by fire. Wildlife crossings would aid in dispersal of fish and wildlife species and would reduce train/wildlife collisions.

3.4.2.3 Plan 2 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease competition for native species. Mowing activities could impact ground nesting birds as well as other terrestrial mammals. Mowing creates additional ground litter that could inhibit daily activities of some species although maintenance of early successional habitat will benefit most species. This plan would restore the entire area north and south of the railroad berm which would provide a contiguous habitat which would reduce fragmentation and the need for travel corridors. Unfortunately the railroad berm presents a barrier to hydrology and fish and wildlife species. To accommodate the barrier, additional

culverts would be required as well as wildlife crossings. Wildlife crossings would aid in dispersal of fish and wildlife species and would reduce train/wildlife collisions.

3.4.2.4 Plan 3 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. Many fish and wildlife species depend on these disappearing habitats. Adequate restoration and fire management is necessary to ensure continued existence of species dependent on pine savannah habitats. This plan would only restore the area south of the railroad berm which would provide a contiguous fire maintained landscape. Larger blocks of habitat are more easily managed using fire and less fragmented landscapes provide more benefits to fish and wildlife species.

3.4.2.5 Plan 4 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease competition for native species. Mowing activities could impact ground nesting birds as well as other terrestrial mammals. Mowing creates additional ground litter that could inhibit daily activities of some species although maintenance of early successional habitat will benefit most species. This plan would restore the entire area south of the railroad berm which would provide a large contiguous habitat. Larger blocks of habitat are more easily managed and less fragmented landscapes provide more benefits to fish and wildlife species.

3.4.2.6 Plan 5 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. Many fish and wildlife species depend on these disappearing habitats. Adequate restoration and fire management is necessary to ensure continued existence of species dependent on pine savannah habitats. This plan would only restore the area north of the railroad berm which would provide a much smaller fire maintained landscape. Restoration of this habitat would provide benefits to fish and wildlife species even though the overall area is relatively smaller.

3.4.2.7 Plan 6 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing

brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease competition for native species. Mowing activities could impact ground nesting birds as well as other terrestrial mammals. Mowing creates additional ground litter that could inhibit daily activities of some species although maintenance of early successional habitat will benefit most species. This plan would restore the entire area north of the railroad berm which would provide a much smaller area for use as habitat. Restoration of this habitat would provide benefits to fish and wildlife species even though the overall area is relatively smaller.

3.4.3 Threatened and Endangered Species

3.4.3.1 No Action

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.4.3.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.4.3.3 Plan 2 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.4.3.4 Plan 3 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.4.3.5 Plan 4 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.4.3.6 Plan 5 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.4.3.7 Plan 6 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.4.4 Water Quality

3.4.4.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community.

3.4.4.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. It is anticipated that burning activities could have short term impacts to water quality due to runoff during rain events. This should be localized and short term in nature. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.4.4.3 Plan 2 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease composition for native species. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.4.4.4 Plan 3 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. It is anticipated that burning activities could have short term impacts to water quality due to runoff during rain events. This should be localized and short term in nature. Once complete, the project would continue to mature resulting in additional

water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.4.4.5 Plan 4 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease composition for native species. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.4.4.6 Plan 5 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. It is anticipated that burning activities could have short term impacts to water quality due to runoff during rain events. This should be localized and short term in nature. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi. This plan would restore the entire area north of the railroad berm which would provide a much smaller area providing water quality functions. Restoration of the water quality functions would replace lost functions even though the overall area is relatively smaller.

3.4.4.7 Plan 6 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease composition for native species. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi. This plan would restore the entire area north of the railroad berm which would provide a much smaller area providing water quality functions. Restoration of the water quality functions would replace lost functions even though the overall area is relatively smaller.

3.4.5 Land Use

3.4.5.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native

species composition. The area undergoes succession and creating a mixed pine and hardwood community. The No Action alternative being implemented would not preclude future development from occurring on the site as the site is owned by a private citizen.

3.4.5.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.

Implementation of this plan would result in slight changes to current land use by restoration efforts. The site would continue to exist as a wetland with increased functions.

3.4.5.3 Plan 2 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site.

Implementation of this plan would result in slight changes to current land use by restoration efforts. The site would continue to exist as a wetland with increased functions.

3.4.5.4 Plan 3 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.

Implementation of this plan would result in slight changes to current land use by restoration efforts. The site would continue to exist as a wetland with increased functions.

3.4.5.5 Plan 4 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area south of the railway berm.

Implementation of this plan would result in slight changes to current land use by restoration efforts. The site would continue to exist as a wetland with increased functions.

3.4.5.6 Plan 5 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.

Implementation of this plan would result in slight changes to current land use by restoration efforts. The site would continue to exist as a wetland with increased functions.

3.4.5.7 Plan 6 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area north of the railway berm.

Implementation of this plan would result in slight changes to current land use by restoration efforts. The site would continue to exist as a wetland with increased functions.

3.5 Bayou Cumbest Environmental Restoration

The site consists of existing tidal marsh as well as filled and developed residential areas causing changes in the natural hydrology and subsequent losses and fragmentation to marsh. Hurricane Katrina left extensive debris fields and sedimentation in the area destroying many native trees and vegetation. Due to the loss of native species this area has a severe infestation of the invasive

Chinese Tallow Tree, Cogongrass, and Phragmites which are invading the marshes and adjacent flatwoods.

3.5.1 Vegetation

3.5.1.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition.

3.5.1.2 Plan 1 – Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.

There will be a benefit to vegetation as this plan will restore hydrology, remove exotics allowing native plants to become better established, and the planting density is such that ensures high rates of survival and increases per-cent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future.

3.5.1.3 Plan 2 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

There will be a benefit to vegetation as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return.

3.5.1.4 Plan 3 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 2 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return.

3.5.1.5 Plan 4 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is such that ensures high rates of survival and increases percent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future.

3.5.1.6 Plan 5 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return.

3.5.1.7 Plan 6 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return.

3.5.2 Fish and Wildlife

3.5.2.1 No Action

The invasive species would continue to thrive threatening to take over the site reducing available native forage for fish and wildlife species to use the area. Lack of available habitat could cause fish and wildlife species to move from the area seeking more suitable habitat.

3.5.2.2 Plan 1 – Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.

There will be a benefit to fish and wildlife species, including essential fish habitat for managed species, as this plan would restore hydrology, remove exotics allowing native plants to become better established, and the planting density is such that ensures high rates of survival and increases percent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future. This will provide valuable forage and cover for fish and wildlife species.

3.5.2.3 Plan 2 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

There will be a benefit to fish and wildlife species, including essential fish habitat for managed species, as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return and to provide necessary habitat for fish and wildlife species.

3.5.2.4 Plan 3 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

Implementation of this plan would provide a benefit to fish and wildlife species, including essential fish habitat for managed species, as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Increased maintenance activities could disrupt established use patterns by species and increased spacing would reduce the overall quality of the habitat to support foraging and cover.

3.5.2.5 Plan 4 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.

Implementation of this plan would provide a benefit to fish and wildlife species, including essential fish habitat for managed species, as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. Lack of natural hydrology would impact fish and wildlife species that would naturally use an intact habitat and could also limit resources available for their survival. The planting density is such that ensures high rates of survival and increases percent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future. This will provide valuable forage and cover for fish and wildlife species.

3.5.2.6 Plan 5 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. Lack of natural hydrology would impact fish and wildlife species, including essential fish habitat for managed species, that would naturally use an intact habitat and could also limit resources available for their survival. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return and to provide necessary habitat for fish and wildlife species.

3.5.2.7 Plan 6 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

Implementation of this plan would provide a benefit to vegetation as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. Lack of natural hydrology would impact fish and wildlife species, including essential fish habitat for managed species, that would naturally use an intact habitat and could also limit resources available for their survival. The planting density is not at optimum level for expedited reestablishment of native species.

This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Increased maintenance activities could disrupt established use patterns by species and increased spacing would reduce the overall quality of the habitat to support foraging and cover.

3.5.3 Threatened and Endangered Species

3.5.3.1 No Action

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species, except for the Alabama Red-bellied Turtle as noted above.

3.5.3.2 Plan 1 – Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.5.3.3 Plan 2 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.5.3.4 Plan 3 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.5.3.5 Plan 4 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.5.3.6 Plan 5 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.5.3.7 Plan 6 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.5.4 Water Quality

3.5.4.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition.

3.5.4.2 Plan 1 – Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.

There will be a benefit to water quality as this plan will restore hydrology, remove exotics allowing native plants to become better established, and the planting density is such that ensures high rates of survival and increases per-cent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.5.4.3 Plan 2 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

There will be a benefit to water quality as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Once complete, the project would mature over a longer period of time; however, the project would provide for improved water quality functions. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.5.4.4 Plan 3 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 2 meter spacing.

Implementation of this plan would provide a benefit to water quality as this plan will restore hydrology, and remove exotics allowing native plants to become better established. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Although the project would provide benefits to water quality, the amount of time necessary would increase and a longer period of time would be needed in order for the wetland to reach maturity. The sustainability of the project remains unknown and it may become necessary for the introduction of additional native plants to provide the optimum percent cover necessary to reach a fully functional wetland.

3.5.4.5 Plan 4 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.

Implementation of this plan would provide a benefit to water quality as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is such that ensures high rates of survival and increases percent cover. Planting of native species at such a high density ensures the native species will outcompete any exotic species that could be introduced or by seed germination in the future. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.5.4.6 Plan 5 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

Implementation of this plan would provide a benefit to water quality as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Once complete, the project would mature over a longer period of time; however, the project would provide for improved water quality functions. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.5.4.7 Plan 6 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

Implementation of this plan would provide a benefit to water quality as this plan will partially restore hydrology, and remove exotics allowing native plants to become better established. Old fill material would be removed somewhat affecting the hydrologic regime. Due to the persistence of artificial ditches and channels, hydrology would not be completely restored at the site. The planting density is not at optimum level for expedited reestablishment of native species. This will reduce the percent cover which could allow for exotics to reestablish in the future. A higher degree of maintenance would be necessary over the life of the project to ensure exotic species do not return. Although the project would provide benefits to water quality, the amount of time necessary would increase and a longer period of time would be needed in order for the wetland to reach maturity. The sustainability of the project remains unknown and it may become necessary for the introduction of additional native plants to provide the optimum percent cover necessary to reach a fully functional wetland.

3.5.5 Land Use

3.5.5.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The site would remain a severely damaged residential community which may experience moderate rebuilding efforts in the future.

3.5.5.2 Plan 1 – Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at .5 meter spacing.

There would be a significant change in current land use as the existing site consists of a severely damaged residential community. Construction of this alternative would result in the removal of the residences and restoration of the area into a fully functional wetland.

3.5.5.3 Plan 2 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

There would be a significant change in current land use as the existing site consists of a severely damaged residential community. Construction of this alternative would result in the removal of the residences and restoration of the area into a fully functional wetland.

3.5.5.4 Plan 3 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

There would be a significant change in current land use as the existing site consists of a severely damaged residential community. Construction of this alternative would result in the removal of the residences and restoration of the area into a fully functional wetland.

3.5.5.5 Plan 4 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at .5 meter spacing.

There would be a significant change in current land use as the existing site consists of a severely damaged residential community. Construction of this alternative would result in the removal of the residences and restoration of the area into a fully functional wetland.

3.5.5.6 Plan 5 - Excavation of old fill material, Removal of exotics and maintenance over project life, Filling in 100% artificial ditches, Native Vegetation Plantings at 1 meter spacing.

There would be a significant change in current land use as the existing site consists of a severely damaged residential community. Construction of this alternative would result in the removal of the residences and restoration of the area into a fully functional wetland.

3.5.5.7 Plan 6 - Excavation of old fill material, Removal of exotics and maintenance over project life, Native Vegetation Plantings at 2 meter spacing.

There would be a significant change in current land use as the existing site consists of a severely damaged residential community. Construction of this alternative would result in the removal of the residences and restoration of the area into a fully functional wetland.

3.6 Franklin Creek Environmental Restoration

The site was identified as an interim project that consists of residential relocations which provides an opportunity for environmental restoration. The site currently consists of degraded pine flatwoods with numerous areas of fill as a result of residential development and the existing railroad which creates a hydrologic barrier between two separate areas.

3.6.1 Vegetation

3.6.1.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community.

3.6.1.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.

Implementation of this plan will benefit vegetation. Restoration of hydrology by excavation of old roadbeds and any additional fill will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. Installation of culverts increases hydrologic connections between the two separate areas which will improve native vegetation.

3.6.1.3 Plan 2 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.

Implementation of this plan will benefit vegetation. Restoration of hydrology by excavation of old roadbeds and any additional fill will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease competition for native species. Installation of culverts increases hydrologic connections between the two separate areas which will improve native vegetation.

3.6.1.4 Plan 3 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.

Implementation of this plan will benefit vegetation. Partial restoration of hydrology by removal of old fill will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain.

3.6.1.5 Plan 4 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.

Implementation of this plan will benefit vegetation. Partial restoration of hydrology by removal of old fill will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease composition for native species.

3.6.2 Fish and Wildlife

3.6.2.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession, creating a mixed pine/hardwood forest community thus shifting the fish and wildlife species that would normally use the historical pine savannah habitat.

3.6.2.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. Many fish and wildlife species depend on these disappearing habitats. Adequate restoration and fire management is necessary to ensure continued existence of species dependent on pine savannah habitats. This plan would restore the entire area north and south of the railroad berm which would provide a contiguous fire maintained landscape. Larger blocks of habitat are more easily managed using fire and less fragmented landscapes provide more benefits to fish and wildlife species. Unfortunately the railroad berm presents a barrier to hydrology, fire, and fish and wildlife species. To accommodate the barrier, additional culverts would be required as well as additional fire breaks for prevention of damages to the railroad berm by fire. Wildlife crossings would aid in dispersal of fish and wildlife species and would reduce train/wildlife collisions.

3.6.2.3 Plan 2 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease competition for native species. Mowing activities could impact ground nesting birds as well as other terrestrial mammals. Mowing creates additional ground litter that could inhibit daily activities of some species although maintenance of early successional habitat will benefit most species. This plan would restore the entire area north and south of the railroad berm which would provide a contiguous habitat which would reduce fragmentation and the need for travel corridors. Unfortunately the railroad berm presents a barrier to hydrology and fish and wildlife species. To accommodate the barrier, additional culverts would be required as well as wildlife crossings. Wildlife crossings would aid in dispersal of fish and wildlife species and would reduce train/wildlife collisions.

3.6.2.4 Plan 3 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out

and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. Many fish and wildlife species depend on these disappearing habitats. Adequate restoration and fire management is necessary to ensure continued existence of species dependent on pine savannah habitats. This plan would only restore the area south of the railroad berm which would provide a contiguous fire maintained landscape. Larger blocks of habitat are more easily managed using fire and less fragmented landscapes provide more benefits to fish and wildlife species.

3.6.2.5 Plan 4 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.

Implementation of this plan will benefit fish and wildlife species. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease competition for native species. Mowing activities could impact ground nesting birds as well as other terrestrial mammals. Mowing creates additional ground litter that could inhibit daily activities of some species although maintenance of early successional habitat will benefit most species. This plan would restore the entire area south of the railroad berm which would provide a large contiguous habitat. Larger blocks of habitat are more easily managed and less fragmented landscapes provide more benefits to fish and wildlife species.

3.6.3 Threatened and Endangered Species

3.6.3.1 No Action

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.6.3.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.6.3.3 Plan 2 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.6.3.4 Plan 3 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.6.3.5 Plan 4 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.

It is anticipated there will be no impacts to threatened and endangered species as the project area does not offer suitable habitat for any of the listed species.

3.6.4 Water Quality

3.6.4.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area would undergo succession and create a mixed pine/hardwood community.

3.6.4.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. It is anticipated that burning activities could have short term impacts to water quality due to runoff during rain events. This should be localized and short term in nature. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.6.4.3 Plan 2 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease composition for native species. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.6.4.4 Plan 3 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation but more importantly the fire regime will clear out and open up the under and mid-stories which will allow native grasses to become established. Removal of exotic species will allow for native species to remain. It is anticipated that burning activities could have short term impacts to water quality due to runoff during rain events. This should be localized and short term in nature. Once complete, the project would continue to mature resulting in additional

water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.6.4.5 Plan 4 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.

Implementation of this plan will benefit water quality. Restoration of hydrology by filling in of ditches will help reestablish native vegetation. Mowing will help maintain succession by removing brushy under and mid-stories but may not completely encourage establishment of native species as most are fire dependent for establishment. Removal of exotic species will decrease composition for native species. Once complete, the project would continue to mature resulting in additional water quality functions over time. It is expected the wetlands would be sustainable over an indefinite period of time replacing vital lost water quality functions throughout coastal Mississippi.

3.6.5 Land Use

3.6.5.1 No Action

The invasive species would continue to thrive threatening to take over the site. The area would continue to experience changes in hydrology due to excessive sedimentation and changes in native species composition. The area undergoes succession and creating a mixed pine and hardwood community. The No Action plan would result in no changes in current land use; although prior to implementation of the Interim Project, the area consisted primarily of a residential community.

3.6.5.2 Plan 1 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.

Implementation of this plan would result in significant changes to current land use as the project consists of a prior developed residential community.

3.6.5.3 Plan 2 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over entire site, Add culverts under existing railroad berm.

Implementation of this plan would result in significant changes to current land use as the project consists of a prior developed residential community.

3.6.5.4 Plan 3 – Maintain Savannah Vegetation by Prescribed Burning on a 3-5 year cycle, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.

Implementation of this plan would result in significant changes to current land use as the project consists of a prior developed residential community.

3.6.5.5 Plan 4 – Maintain Savannah Vegetation by Mowing annually, Fill in 100% artificial ditches, Excavate and remove existing roadbeds and any additional fill material over area southeast of railroad berm.

Implementation of this plan would result in significant changes to current land use as the project consists of a prior developed residential community.

1.4 Environmental Restoration Being Considered for Construction

1.4.1 Admiral Island Restoration Benefits

Admiral Island, Hancock County

The Admiral Island restoration area contains 123 acres to be restored to 62 acres of emergent tidal marsh and 61 acres of scrub shrub habitats (Figure 5.6.1-2). The tidal marshes in this area were ditched during the 1960s causing changes in the natural hydrology and subsequent changes in the species composition. Hurricane Katrina left extensive debris fields and sedimentation in the area and destroyed many native trees and vegetation. Due to the loss of native species this area has a severe infestation of the invasive Chinese Tallow tree, which is invading the marshes and the adjacent flatwoods. For increased habitat diversity, the team proposed to leave some of the higher elevations as is and plant shrub/scrub species in order to enhance environmental benefits at the restoration site. The diverse habitat allows for a variety of fish and wildlife to utilize the area which increases the environmental benefits.

Objective:

1. Restore the natural hydrology.
2. Restore native wetland plant communities.
3. Provide storm surge protection.
4. Provide fish and tidal wildlife habitat.
5. Prevent saltwater intrusion

Measures:

1. Excavation of old fill material (includes 90-95% removal of existing exotic species in excavated areas) (Mandatory).



Figure 5.6.1-2. Admiral Island Restoration Site

This measure, in conjunction with measure 3, affects the hydrologic regime variable, which under existing conditions receives a score 0.25, on the assumption that greater than half the site has been filled above the normal tidal flooding zone. This measure by itself would raise the hydrologic regime variable to a 0.75.

2. 100% removal of exotics from non-excavated areas and maintain removal of exotic plant species in all areas over project lifetime. (Mandatory in all plans).

This measure affects the “percent cover by invasive or exotic species” variable, and would raise the variable score to 1.0 under all plans

3. Filling in 100% of existing artificial ditches/channels.

   If this measure is performed in addition to the mandatory measure 1, the hydrologic regime variable score would increase to 1.0 as there would be no more hydrologic alterations to the site.

4. Native Vegetation Planting

Alternatives:

a) 0.5 meter spacing

b) 1 meter spacing

c) 2 meter spacing

This measure affects the “percent cover by woody plant species”, “wildlife habitat diversity”, “vegetation height”, “wetland indicator status” and “mean percent cover emergent plant species” variables. The relevant vegetation variables are assumed to reach their highest potential score at year 5 under 0.5 meter spacing, year 7 with 1.0 meter spacing, and year 10 with 2.0 meter spacing, and then sustained at that level for the project life (50 years). Variable subindex scores are treated as increasing linearly from their value under the no-action plan up to their highest potential value obtained at year 5, 7, or 10, depending on the planting spacing, and then remaining constant thereafter (Tables 5.6.1-4 and 5.6.1-5).

Table 5.6.1-4.
Measures

Plan 1. 1,2,3,4a	Plan 2. 1,2,3,4b	Plan 3. 1,2,3,4c
Plan 4. 1,2,4a	Plan 5. 1,2,4b	Plan 6. 1,2,4c

Table 5.6.1-5.
Summary of AAFU Benefits From Various Restoration Plans

Site	Restoration Acres	Plan	AAFU Benefit
Admiral Island	62	No-action plan	0
Admiral Island	62	Plan 1	61
Admiral Island	62	Plan 2	60
Admiral Island	62	Plan 3	59
Admiral Island	62	Plan 4	51
Admiral Island	62	Plan 5	50.5
Admiral Island	62	Plan 6	49

The management measures were combined to create six plans that were analyzed to determine the cost-effectiveness of each. Economically ineffective plans are identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the six plans analyzed, two plans were eliminated because they produced less benefit at greater cost than a subsequent plan.

The recommended plan consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas, planting native vegetation at a

density of 1.0 meter, and filling existing artificial ditches. The planting of native vegetation consist of *S. alteniflora, J. roemerianus, and S. patens*.

Benefits are measured in terms of AAFU. The HGM approach was used to assess wetland function similar to Bayou Cumbest. Table 5.6.1-6 shows the total functional units under each implemented plan and the AAFU net benefit. To calculate the AAFU net benefit, it is assumed that benefits will be maximized at year 5 with 0.5 meter spacing of vegetation, at year 7 with 1.0 meter spacing of vegetation, and at year 10 with 2.0 meter spacing of vegetation. These benefits are estimated to be sustainable over the life of the project. Net AAFU benefits are calculated as the difference between the total functional units for the ecosystem restoration plan and the total functional units for the no action plan. The recommended plan was selected based on the criteria used for Bayou Cumbest.

1.4.2 BAYOU CUMBEST RESTORATION BENEFITS

Environmental Benefits of Bayou Cumbest Restoration

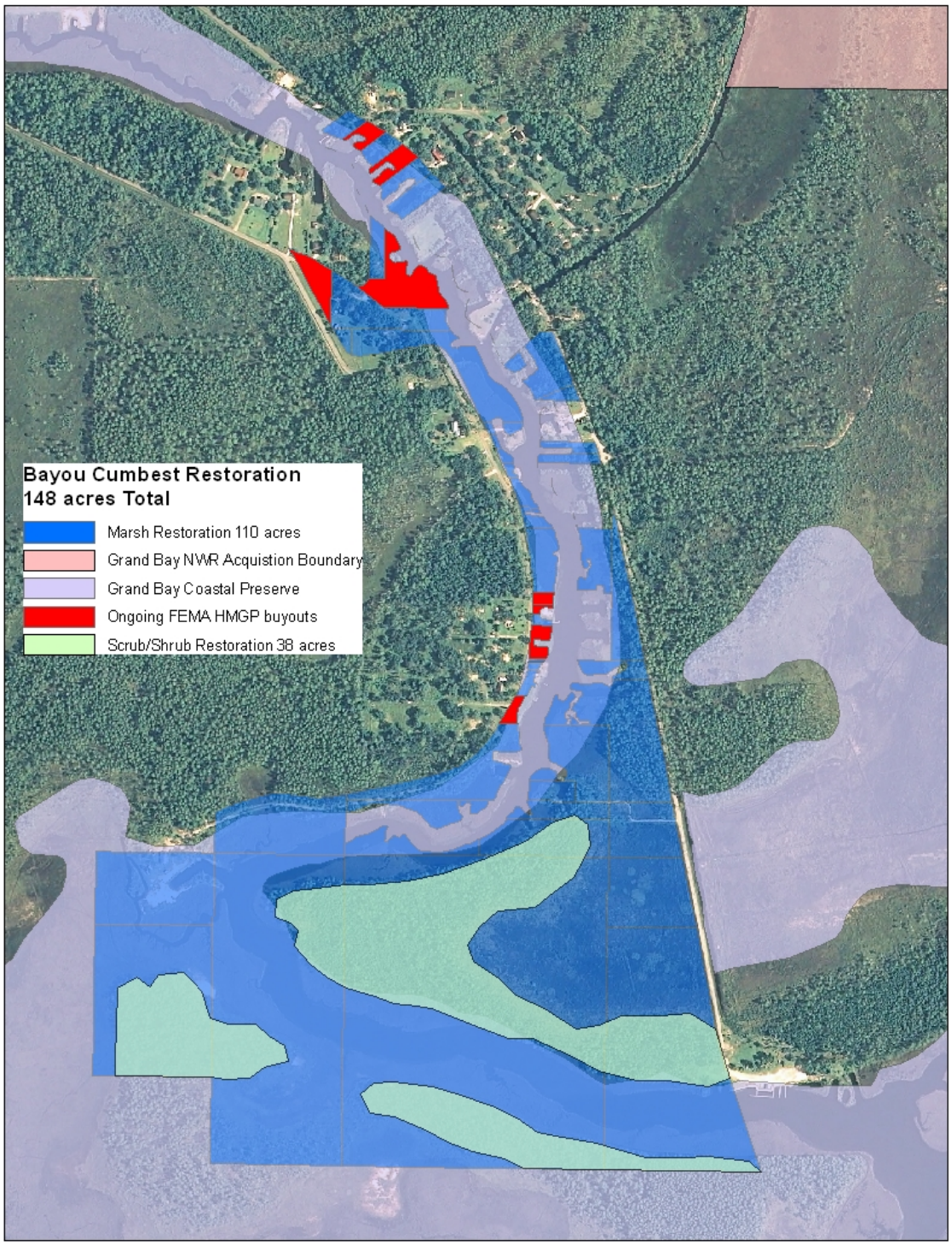


Figure 1. Bayou Cumbest restoration site.

The Bayou Cumbest restoration area (Figure 1) contains 148 acres, of which 110 acres would be restored to tidal marsh and the remaining 38 acres would remain scrub/shrub

wetland habitat. The area presently consists of previously filled areas, some tidal marsh, and scrub shrub.

Objective:
1. Restore marsh to historical (pre-development ~1950's) conditions.
2. Provide storm surge protection.
3. Restore native tidal wetland plant community.
4. Provide fish and tidal wildlife habitat.
5. Prevent saltwater intrusion

Assumptions:
1. Mandatory buy-outs.
2. 100% removal of existing structures

Measures:
1. Excavation of old fill material (includes 90-95% removal of existing exotic species in excavated areas) (Mandatory)

This measure, in conjunction with measure 3, affects the hydrologic regime variable, which under existing conditions receives a score 0.50, on the assumption that approximately half the site has been filled above the normal tidal flooding zone. This measure by itself would raise the hydrologic regime variable to a 0.75.

2. 100% removal of exotics from non-excavated areas and maintain removal of exotic species (Chinese Tallow, Phragmites, Cogon Grass) in all areas over project lifetime. (Mandatory in all plans).

This measure affects the "percent cover by invasive or exotic species" variable, and would raise the variable score to 1.0 under all plans

3. Filling in 100% of existing artificial ditches/channels

If this measure is performed in addition to the mandatory measure 1, the hydrologic regime variable score would increase to 1.0 as there would be no more hydrologic alterations to the site.

4. Native Vegetation Planting
Alternatives

a) 0.5 meter spacing
b) 1 meter spacing
c) 2 meter spacing

This measure affects the "percent cover by woody plant species", "wildlife habitat diversity", "vegetation height", "wetland indicator status" and "mean percent cover emergent plant species" variables. The relevant vegetation variables are assumed to reach their highest potential score at year 5 under 0.5 meter spacing, year 7 with 1.0 meter spacing, and year 10 with 2.0 meter spacing, and then sustained at that level for the

project life (50 years). Variable subindex scores are treated as increasing linearly from their value under the no-action plan up to their highest potential value obtained at year 5, 7, or 10, depending on the planting spacing, and then remaining constant thereafter.

Plans:
Plan 1: 1,2,3,4a
Plan 2: 1,2,3,4b
Plan 3: 1,2,3,4c
Plan 4: 1,2,4a
Plan 5: 1,2,4b
Plan 6: 1,2,4c

Benefits:

Table 1 shows the average annual functional unit (AAFU) benefit under each plan.

Table 1.
Summary of Average Annual Functional Unit Benefits From Various Restoration Plans

Site	Restoration Acres	Plan	Average Annual Functional Unit Benefit[1]
Bayou Cumbest	110	No-action plan	0
Bayou Cumbest	110	plan 1	191
Bayou Cumbest	110	plan 2	188
Bayou Cumbest	110	plan 3	184
Bayou Cumbest	110	plan 4	172
Bayou Cumbest	110	plan 5	169
Bayou Cumbest	110	plan 6	164

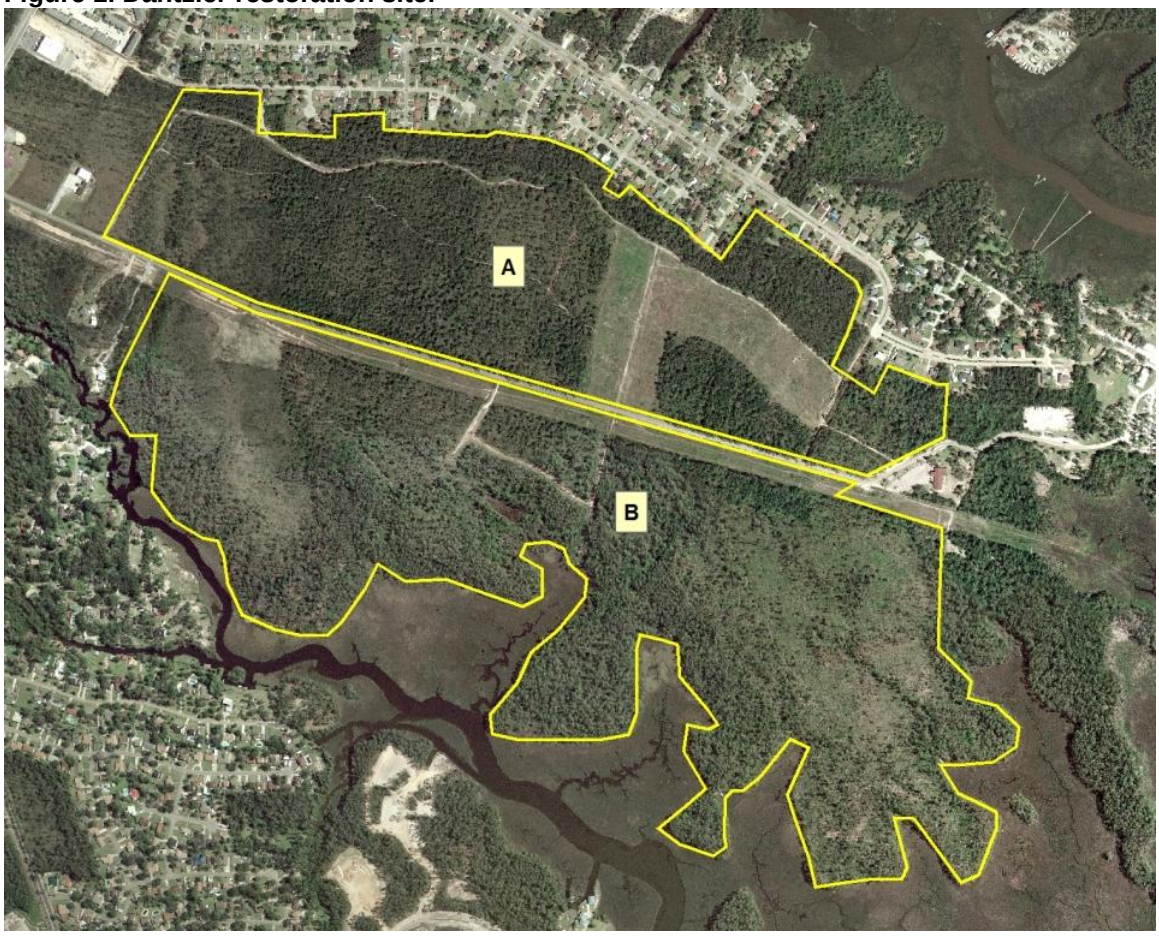
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Shafer, D. J., T. H. Roberts, M. S. Peterson, and K. Schmid. (in press). "A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing the Functions of Tidal Fringe Wetlands Along the Mississippi and Alabama Gulf Coast." U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

1.4.3 DANTZLER RESTORATION BENEFITS

Environmental Benefits of Dantzler restoration

Source: Corps
Figure 1. Dantzler restoration site.



Source: Corps

The Dantzler restoration area (Figure 1) contains 385 acres to be restored to wet pine savanna. The restorable area is split by a road, 151 of the acres are north of the road and the remaining 234 acres are south of the road. This area was planted in plantation pine during the 1960s and ditches and stormwater lines were constructed in the early 1970s in anticipation of residential development of the site. The long-term exclusion of fire and the invasion of non-native species such as Cogongrass and Chinese Tallowtree have severely degraded the site.

Objective:

1. Restore the natural hydrology.
2. Restore natural fire regime.
3. Restore native wetland plant communities.
4. Provide storm surge protection.
5. Provide fish and tidal wildlife habitat.

Assumptions:

Measures:

1. Maintain native savanna vegetation. (Mandatory)
    Alternative:
        a. prescribed burning on a 3-5 year cycle.
        b. mowing annually.

This measure affects the "area of contiguous fire-maintained landscape", as well as all plant related variables used in the model. It is assumed that these variables will recover to a score of 1.0 under the burn alternative. Under the mowing alternative, the "area of contiguous fire-maintained" landscape variable will score a 0.0 but the plant related variables will still score a 1.0, similar to burning.

2. 100% removal of exotics and plantation pine; maintain removal of exotic plant species in all areas over project lifetime. (Mandatory in all plans).

This measure affects the "percent cover by invasive or exotic species" variable, and would raise the variable score to 1.0 under all plans

3. Filling in 100% of existing artificial ditches. (Mandatory)
If this measure is performed in addition to the mandatory measure 1, the hydrologic regime variable score would increase to 1.0 as there would be no more hydrologic alterations to the site.

Plans:
Plans 1-2: Restoring areas both north and south of road (areas A and B)
Plan 1: 1a,2,3
Plan 2: 1b,2,3
Plans 3-4: Restoring only area north of road (Area A)
Plan 3: 1a,2,3
Plan 4: 1b,2,3
Plans 5-6: Restoring only area south of road (Area B)
Plan 5: 1a,2,3
Plan 6: 1b,2,3

Benefits:
Table 1 shows the average annual functional unit (AAFU) benefit under each plan.

Table 1.
Summary of Average Annual Functional Unit Benefits From Various Restoration Plans

Site	Restoration Acres	Plan	Average Annual Functional Unit Benefit
Dantzler	385	No-action plan	0

Dantzler	385	plan 1	1,244
Dantzler	385	plan 2	943
Dantzler	151	plan 3	488
Dantzler	151	plan 4	370
Dantzler	234	plan 5	756
Dantzler	234	plan 6	573

References

Shafer, D. J., T. H. Roberts, M. S. Peterson, and K. Schmid. (in press). "A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing the Functions of Tidal Fringe Wetlands Along the Mississippi and Alabama Gulf Coast." U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

1.4.4 Franklin Creek Restoration Benefits

Environmental Benefits from Franklin Creek Restoration

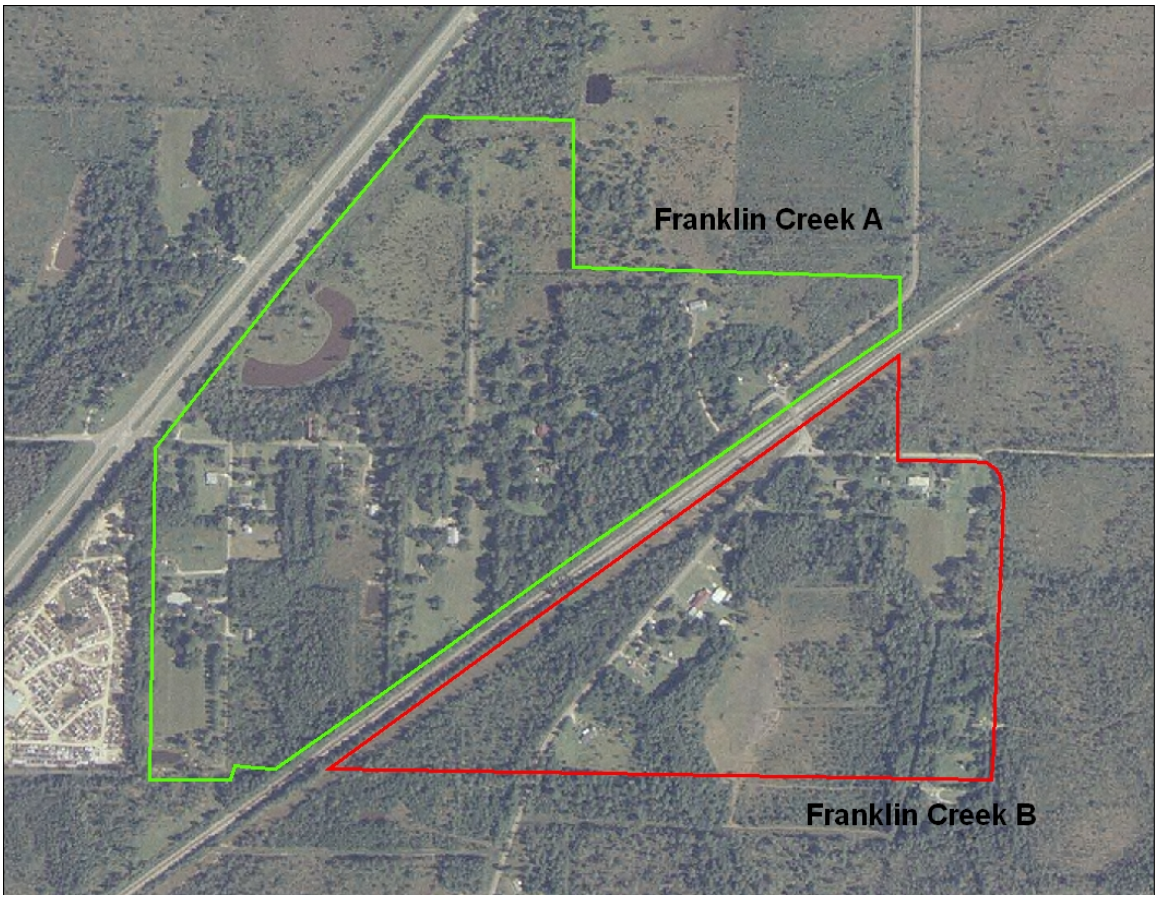


Figure 1. Franklin Creek restoration site, broken into assessment areas north (green border) and south (red border) of the railroad.

The Franklin Creek project site is located in eastern Jackson County and has been funded for homeowners assistance and relocation as part of the MsCIP Interim Report. The project consists of 149 acres located north and south of the CSX railroad.

Restoration Options: Franklin Creek (Pine Savanna)

Objectives:
1. Restore native vegetation
2. Restore natural hydrology
3. Restore fish and wildlife habitat
4. Provide storm water storage protection.

Assumptions:
1. Mandatory buy-outs.

Measures:

Listed below are the proposed restoration measures and their expected effect on variables used in the HGM model.

1. Filling in ditches (Mandatory)

This measure affects the "Outflow of Water" variable, which measures the removal of water by ditches or drains. The variable score would increase from 0.1 to 1.0 under this measure.

2. Maintain vegetation (Mandatory)
Alternatives

a. Burn (3 year cycle)
b. Mow (annual)

This measure affects the "area of contiguous fire-maintained landscape", as well as all plant related variables used in the model. It is assumed that these variables will recover to a score of 1.0 under the burn alternative. Under the mowing alternative, the "area of contiguous fire-maintained landscape variable will score a 0.05 but the plant related variables will still score a 1.0, similar to burning.

3. Excavate and remove existing roadbeds and any additional fill (Mandatory)

This measure affects the "surface water storage" variable, which measures the presence of excavation or fill at the site. This variable score would increase from 0.1 to 1.0 in areas with existing roadbeds/fill.

4. Add culverts (Mandatory)

This measure increases the hydrologic connection between the two existing wetland areas separated by an elevated railway. The wetlands are primarily precipitation driven resulting in sheet flow drainage. Additional culverts will result in increased sheet flow drainage reducing standing surface water in the northern wetland area.

Plans:
Plans 1-2 - Restoring areas A and B
Plan 1: 1, 2a, 3, 4
Plan 2: 1, 2b, 3, 4

Plans 3-4 Restoring just area B
Plan 3: 1, 2a, 3
Plan 4: 1, 2b, 3

Benefits:

Table 1 shows the total functional units of the site under each plan, and the average annual functional unit (AAFU) benefit. It is assumed here that functional units will remain the same under existing conditions and the no-action plan. To calculate the AAFU, it is assumed all benefits are immediately accrued following plan

implementation, and that the benefits are sustainable over the life of the project. Therefore, the AAFU was simply calculated as the difference between the total functional units for the restoration plan the total functional units for the no-action plan.

Table 1.
Summary of Functional Unit Benefits From Various Restoration Plans

Site	Restoration Acres	Plan	Average Annual Functional Unit Benefit
Franklin Creek	149	No-action plan (plans 1-2)	0
Franklin Creek	56	No-action plan (plans 3-4)	0
Franklin Creek	149	plan 1	516
Franklin Creek	149	plan 2	399
Franklin Creek	56	plan 3	194
Franklin Creek	56	plan 4	150

References

Rheinhardt, R. D., Rheinhardt, M. C., and Brinson, M. M. (2002). "A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains," ERDC/EL TR-02-9, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

1.4.5 Turkey Creek Restoration Benefits

Environmental Benefits from Turkey Creek Restoration

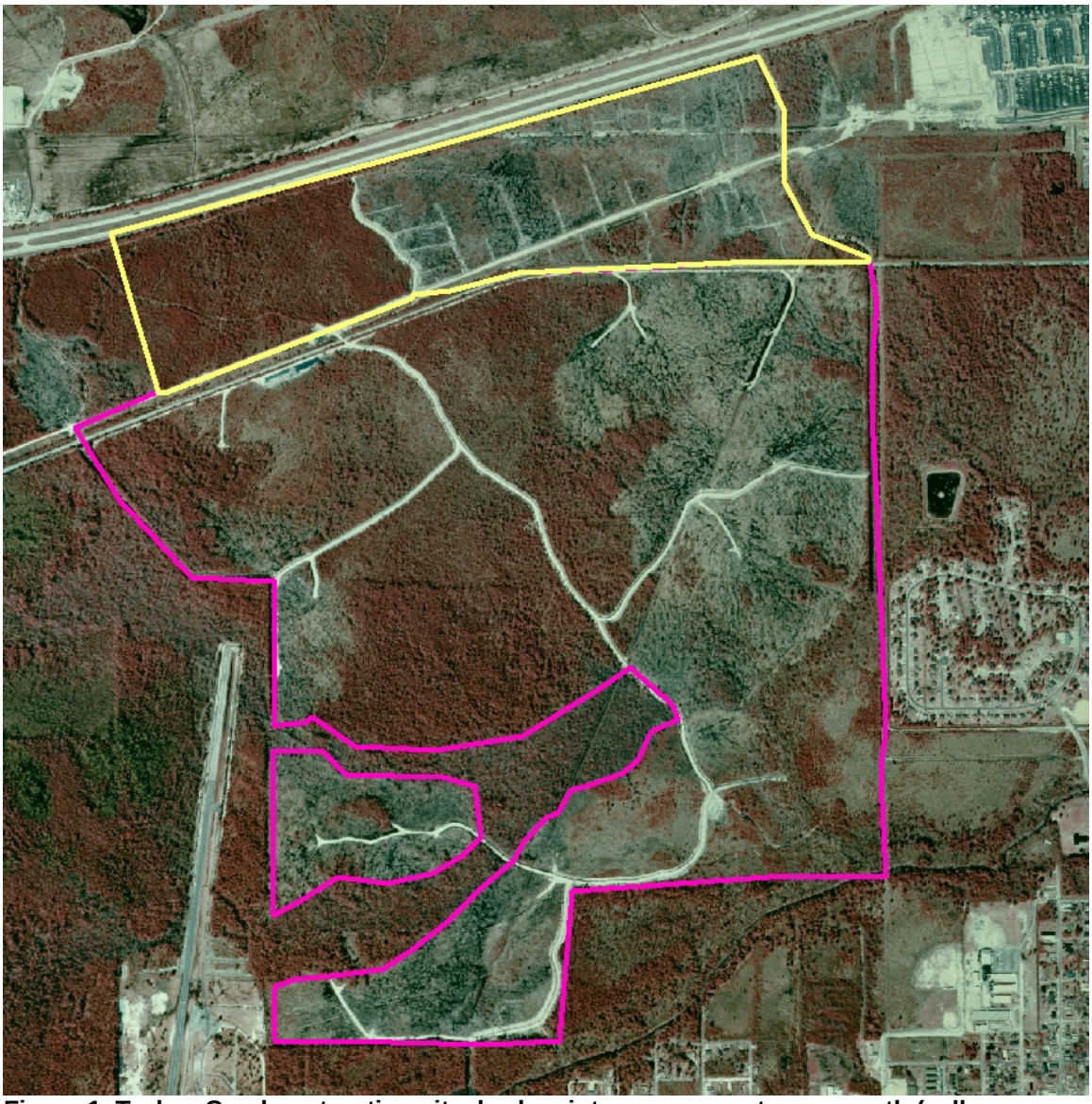


Figure 1. Turkey Creek restoration site, broken into assessment areas north (yellow border) and south (pink border) of the railroad.

The Turkey Creek site had an HGM assessment performed in 2000, using the Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains (Rheinhardt et al 2002). Results from this earlier assessment are being used to establish baseline (current) conditions at the site. The site has been divided into 8 separate assessment areas (figure 1), as there were different baseline conditions for each area. The same HGM model is also being used to measure functional unit benefits at the site resulting from different restoration plans.

Restoration Options: Turkey Creek (Pine Savanna)

Objectives:
1. Restore native vegetation
2. Restore natural hydrology
3. Restore fish and wildlife habitat
4. Provide storm water storage protection.

Assumptions:
1. Mandatory buy-outs.

Measures:
Listed below are the proposed restoration measures and their expected effect on variables used in the HGM model.

1. Filling in ditches (Mandatory)

This measure affects the "Outflow of Water" variable, which measures the removal of water by ditches or drains. The variable score would increase from 0.1 to 1.0 under this measure.

2. Maintain vegetation (Mandatory)
Alternatives

a. Burn (3 year cycle)
b. Mow (annual)

This measure affects the "area of contiguous fire-maintained landscape", as well as all plant related variables used in the model. It is assumed that these variables will recover to a score of 1.0 under the burn alternative. Under the mowing alternative, the "area of contiguous fire-maintained landscape variable will score a 0.0 but the plant related variables will still score a 1.0, similar to burning.

3. Excavate and remove existing roadbeds and any additional fill (Mandatory)

This measure affects the "surface water storage" variable, which measures the presence of excavation or fill at the site. This variable score would increase from 0.1 to 1.0 in areas with existing roadbeds/fill.

Plans:
Plans 1-2 - Restoring areas north and south of railroad
Plan 1: 1, 2a, 3
Plan 2: 1, 2b, 3

Plans 3-4 Restoring just areas south of railroad
Plan 3: 1, 2a, 3
Plan 4: 1, 2b, 3

Plans 3-4 Restoring just areas north of railroad
Plan 5: 1, 2a, 3
Plan 6: 1, 2b, 3

Benefits:

Table 1 shows the total functional units of the site under each plan, and the average annual functional unit (AAFU) benefit. It is assumed here that functional units will remain the same under existing conditions and the no-action plan. To calculate the AAFU, it is assumed all benefits are immediately accrued following plan implementation, and that the benefits are sustainable over the life of the project. Therefore, the AAFU was simply calculated as the difference between the total functional units for the restoration plan the total functional units for the no-action plan.

Table 1.
Summary of Functional Unit Benefits From Various Restoration Plans

Site	Restoration Acres	Plan	Total Functional Units	Average Annual Functional Unit Benefit
Turkey Creek	879	Existing Condition (plans 1-2)	1,222	-
Turkey Creek	689	Existing Condition (plans 3-4)	1,012	-
Turkey Creek	190	Existing Condition (plans 5-6)	210	-
Turkey Creek	879	No-action plan (plans 1-2)	1,222	0
Turkey Creek	689	No-action plan (plans 3-4)	1,012	0
Turkey Creek	190	No-action plan (plans 5-6)	210	0
Turkey Creek	879	plan 1	3,268	2,046
Turkey Creek	879	plan 2	2,574	1,352
Turkey Creek	689	plan 3	2,577	1,565
Turkey Creek	689	plan 4	2,037	815
Turkey Creek	190	plan 5	691	481
Turkey Creek	190	plan 6	537	327

References

Rheinhardt, R. D., Rheinhardt, M. C., and Brinson, M. M. (2002). "A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains," ERDC/EL TR-02-9, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

1.4.6 Deer Island Restoration Benefits

FUNCTIONAL HABITAT INDEX

Future Without Project Condition

Functions	Shore line Birds	Migratory Birds	Native Fish	Sport Fish	Macro Invertebrates & Primary Producers	Bivalves	Future Without Project	
							Functional Habitat Index (FHI)	FHI 525 acres
Restoration of Emergent Beach and Dune System	-	-	-	-	-	-	-	0.0
Restoration of Maritime Forest Habitat	-	-	-	-	-	-	-	0.0
Soft Substrate	-	-	-	-	-	-	-	0.0
Reestablishment of pre-disturbance shoreline	-	-	-	-	-	-	-	0.0
Reduced Wave Energy along Grand Bayou and the Southern Shoreline	-	-	-	-	-	-	-	0.0
Shoreline Stabilization	-	-	-	-	-	-	-	0.0
Roosting Habitat	-	-	-	-	-	-	-	0.0
Nesting Habitat	-	-	-	-	-	-	-	0.0
Native Vegetation Propagation	0.05	0.05	-	-	-	-	0.10	52.5
Shoreline Foraging Habitat	-	-	0.05	0.05	-	-	0.10	52.5
Erosion Control	-	-	-	-	-	-	-	0.0
Sediment Stabilization	-	-	-	-	-	-	-	0.0
Water Quality	-	-	-	-	-	-	-	0.0
Hard Substrate-ocean bottom or submerged rip-rap	-	-	-	-	-	-	-	0.0
Direct Benefit = 0.10								
Indirect Benefit = 0.05							**Total FHI = 0.20**	**105**

Total Table FHI = 105

FUNCTIONAL HABITAT INDEX

Restoration of Grand Bayou (Proposed-Profile 1) and The West End Breach (Proposed) and Entire Southern Shoreline

Functions	Shore line Birds	Migratory Birds	Native Fish	Sport Fish	Macro Invertebrates & Primary Producers	Bivalves	Proposed Alternative		Future Without	
							Functional Habitat Index (FHI)	FHI 525 acres	Future w/o FHI	FHI 0 acres
Restoration of Emergent Beach and Dune System	0.10	0.10	0.05	0.05	0.05	-	0.35	183.75	-	0.0
Restoration of Maritime Forest Habitat	0.10	0.10	-	-	0.05	-	0.25	131.25	-	0.0
Soft Substrate	0.05	0.05	0.10	0.10	0.05	0.05	0.40	210	-	0.0
Reestablishment of pre-disturbance shoreline	0.05	0.05	-	-	-	-	0.10	52.5	-	0.0
Reduced Wave Energy along Grand Bayou and the Southern Shoreline	0.10	0.10	0.05	0.05	0.05	0.05	0.40	210	-	0.0
Shoreline Stabilization	0.05	0.05	0.05	0.05	-	-	0.20	105	-	0.0
Roosting Habitat	0.10	0.10	-	-	-	-	0.20	105	-	0.0
Nesting Habitat	0.10	0.10	-	-	-	-	0.20	105	-	0.0
Native Vegetation Propagation	0.10	0.10	0.05	0.05	0.10	-	0.40	210	0.10	0.0
Shoreline Foraging Habitat	0.10	0.10	0.10	0.10	0.05	0.05	0.50	262.5	0.10	0.0
Erosion Control	0.05	0.05	0.05	0.05	0.05	0.10	0.35	183.75	-	0.0
Sediment Stabilization	0.05	0.05	0.05	0.05	0.05	0.10	0.35	183.75	-	0.0
Water Quality	-	-	0.05	0.05	0.05	0.05	0.20	105	-	0.0
Hard Substrate-ocean bottom or submerged rip-rap	-	-	0.05	0.05	-	0.10	0.20	105	-	0.0
Direct Benefit = 0.10										
Indirect Benefit = 0.05							**Total FHI = 4.1**	**2152.5**	**0.20**	**0.0**

Total Table FHI = 2152.5

1.4.7 Barrier Islands Restoration Benefits

Littoral Zone Placement & Fill of Breach Between West & East Ship Islands

	Habitat Units									
Assessment Variables	*Shorebirds*	*Waterfowl*	*Migratory Birds*	*Raptors*	*Beach Fauna*	*Dune Flora and Fauna*	*Oysters*	*Estuarine Fish*	*Threatened and Endangered Species*	***Functional Habitat Unit***
Island Persistence	10	8	10	8	10	10	10	10	10	86
Shoreline Stabilization	10	8	8	8	10	10	10	6	10	80
Reproduction Habitat	10	0	0	0	8	10	10	10	10	58
Feeding Habitat	10	6	10	8	8	10	10	10	10	82
Roosting Habitat	10	6	8	6	10	10	10	10	10	80
Wintering Habitat	10	6	8	6	10	10	10	10	10	80
Dune Habitat	10	10	10	10	10	10	10	10	10	90
Beach Habitat	10	10	10	10	10	10	10	10	10	90
Water Column Habitat	8	8	8	8	8	8	10	10	10	78
Water-Land Interface Habitat	10	10	10	10	10	10	10	10	10	90
Fishery Habitat	10	10	10	10	10	10	10	10	10	90
Oyster Habitat	6	6	6	6	6	8	10	8	8	64
									TOTAL FHI	**968**

NO ACTION

	Habitat Units									
Assessment Variables	*Shorebirds*	*Waterfowl*	*Migratory Bi*	*Raptors*	*Beach Fa*	*Dune Flora and Fauna*	*Oysters*	*Estuarine Fish*	*Threatened and Endangered Species*	***Functional Habitat Unit***
Island Persistence	0	0	0	0	0	0	0	0	0	***0***
Shoreline Stabilization	0	0	0	0	0	0	0	0	0	0
Reproduction Habitat	0	0	0	0	0	0	0	0	0	0
Feeding Habitat	0	0	0	0	0	0	0	0	0	0
Roosting Habitat	0	0	0	0	0	0	0	0	0	0
Wintering Habitat	0	0	0	0	0	0	0	0	0	0
Dune Habitat	0	0	0	0	0	0	0	0	0	0
Beach Habitat	0	0	0	0	0	0	0	0	0	0
Water Column Habitat	2	2	2	2	2	2	2	2	2	18
Water-Land Interface Habitat	0	0	0	0	0	0	0	0	0	0
Fishery Habitat	2	2	2	2	2	2	2	2	2	18
Oyster Habitat	2	2	2	2	2	2	2	2	2	18
									TOTAL FHI	**54**

1.4.8 Bayou Cumbest Submerged Aquatic Vegetation Benefits

Species of fishes commonly found in Submerged Aquatic Vegetation Habitats in the Grand Bay National Estuarine Research Reserve.

Scientific Name	Common Name
Anchoa mitchilli	Bay anchovy
Archosargus probatacephalus	Sheepshead
Bairdiella chrysoura	Silver perch (drum family)
Brevoortia patronus	Gulf menhaden
Chasmodes saburrae	Florida blenny
Citharichthys spilopterus	Bay whiff (flounder)
Ctenogobius boleosoma	Darter goby
Cynoscion nebulosus	Spotted seatrout
Eucinostomus argenteus	Spot-fin mojarra
Lagodon rhomboides	Pinfish
Leiostomus xanthurus	Spot
Lucania parva	Rainwater killifish
Lutjanus grisues	Grey snapper (mangrove snapper)
Menidia beryllina	Inland silverside
Mugil cephalus	Striped mullet
Mycteroperca microlepis	Gag grouper
Oligoplites saurus	Leatherjack
Orthopristis chrysoptera	Pigfish
Sphoeroides parvus	Least puffer
Sphyraena guachancho	Guaguanche (barracuda family)
Sygnathus louisianae	Chain pipefish
Sygnathus scovelli	Gulf pipefish
Symphurus plagiusa	Black cheeked tonguefish
Synodus foetens	Inshore lizardfish

SECTION 2
ENVIRONMENTAL AGENCY SUPPORT DOCUMENTS

FISH AND WILDLIFE COORDINATION ACT REPORT AND BIOLOGICAL OPINIONS

1 PLANNING AID ASSISTANCE LETTER

DRAFT

The U.S. Army Corps of Engineers (Corps), Mobile District is currently coordinating the identified proposals with the U.S. Fish and Wildlife Service (USFWS), Jackson, Mississippi. The USFWS has provided its Planning Aid Assistance (PAL) letter dated June 12, 2007 concerning the Mississippi Coastal Improvements Program (MsCIP) effort.

DRAFT

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Mississippi Field Office
6578 Dogwood View Parkway, Suite A
Jackson, Mississippi 39213

June 12, 2007

Dr. Susan Rees
U.S. Army Corps of Engineers
Mobile District
109 St. Joseph St.
Mobile, AL 36602

Dear Dr. Rees:

As you are aware, the U.S. Fish and Wildlife Service (Service) has agreed to be a cooperating agency during the environmental review process of the Mississippi Coastal Improvements Program (MsCIP). In this capacity, we have assisted in drafting the Environmental Impact Statement (EIS) and Environmental Appendix. We have provided input on modeling schemes and selection of potential restoration sites to the Engineering Research and Development Center in Vicksburg, Mississippi. We have also made recommendations regarding potential impacts to wetlands, National Wildlife Refuge lands, Coastal Barrier Resources Act (CBRA) units, and fish and wildlife resources.

This planning aid letter (PAL) is provided to give additional information regarding federally listed species and their habitats that may be adversely affected by some of the program activities. This PAL is submitted under the Endangered Species Act (ESA)(87 Stat. 884, as amended 16 U.S.C. 1531 et seq.) and the Fish and Wildlife Coordination Act (16 U.S.C. 661-667e) but does not constitute the report of the Secretary of the Interior as required by Section 2(b) of the Act.

The program purpose, as authorized by the Department of Defense Appropriations Act 2006 (P.L. 109-148) dated December 30, 2005, is to conduct an analysis and design for comprehensive improvements or modifications to existing improvements in the coastal area of Mississippi in the interest of hurricane and storm damage reduction, prevention of salt water intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resource purposes.

The Service has determined that the following federally listed species and/or their habitats could be located within the project area and should be considered:

The threatened gopher tortoise (*Gopherus polyphemus*) inhabits well-drained sandy soils, especially in areas of longleaf pine. The gopher tortoise digs a burrow used as a shelter

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and nesting area. Groups of these tortoises dig burrows in the same location forming a colony. In addition, the threatened eastern indigo snake (*Drymarchon corais couperi*) is known to inhabit gopher tortoise burrows.

The endangered red-cockaded woodpecker (*Picoides borealis*) (RCW) is a species of southern pine forests. RCW's excavate nesting cavities in mature pine trees (60+ years old). The preferred nesting habitat is open, park-like, mature pine woodlands with few or no hardwood trees present. A mated pair of birds and all helper birds forms a clan. A cluster of cavity trees where the clan nests and roosts is called a colony. All cavity trees, active and inactive, are important to the colony and should therefore be avoided. Preferred feeding habitats are pine stands with trees 23 cm (9in.) and greater in diameter. Therefore, pine stands with this diameter and greater within a half-mile of a colony should be considered foraging habitat and should not be disturbed. These areas may or may not include a significant hardwood component.

The endangered plant, Louisiana quillwort (*Isoetes louisianensis*), is a nonflowering grasslike plant that lives in or near shallow, blackwater streams in riparian woodland and bayhead forests of pine flatwoods and upland pine forests. Mature plants are six to ten inches high, mostly evergreen, with spore-bearing structures below the ground.

The black pine snake (*Pituophis melanoleucus* ssp. *lodingi*) a candidate species, prefers uplands with well-drained sandy soils in areas of longleaf pine and hardwood tree species.

The endangered Alabama red-bellied turtle *(Pseudemys alabamensis)* is found in the lower Pascagoula River and its tributaries: Bluff Creek and the Escatawpa River. It is also found in Old Fort Bayou, the Tchoutacabouffa River, the Biloxi River, and the Back Bay of Biloxi. Destruction of nesting areas along river banks and feeding areas of submerged aquatic vegetation, and reduced water quality have impacted this species. Red-bellied turtles in Mississippi are somewhat different from those in Alabama, having fewer or less conspicuous head-stripes, a narrower head, less-conspicuous cusps (particularly on hatchlings), darker background color on the carapace and skin, and a relatively longer, narrower shell.

The federally listed threatened Louisiana black bear (*Ursus a. luteolus*) occurs primarily in bottomland hardwood and floodplain forests along the Mississippi River and the southern part of the state. Although the bear is capable of surviving under a range of habitat types, some necessary habitat requirements include hard mast, soft mast, escape cover, denning sites, forested corridors, and limited human access. Forest management practices, agricultural, commercial and industrial development, and highways can cause adverse impacts to bear habitat by increasing human disturbance, fragmenting forests, and removing den trees.

The threatened bald eagle (*Haliaeetus leucocephalus*) is the only species of sea eagle regularly occurring on the North American continent. The bald eagle is predominantly a winter migrant in the southeast; however, increasing occurrences of nesting have been

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observed. The bald eagle nests in the transitional area between forest and water. They construct their nests in dominant living pines or bald cypress trees. Eagles often use alternate nests in different years with nesting activity beginning between September and January of each year. Young are usually fledged by midsummer.

The endangered Mississippi gopher frog (*Rana sevosa*), requires two distinct habitats: temporary pools for breeding and upland foraging sites with a subterranean refuge (tortoise burrows, crawfish burrows, or stumpholes). The only population currently known to exist is located in Harrison County, Mississippi.

The threatened Gulf sturgeon (*Acipenser oxyrhynchus desotoi*) is found in the Pearl, Leaf, and Pascagoula Rivers. Gulf sturgeons are primitive, anadromous fish that annually migrate from the Gulf of Mexico into freshwater streams. Subadults and adults spend eight to nine months each year in rivers. Although Gulf sturgeon activity is not well documented, the species has been found in the Pearl River as far north as the Jackson metropolitan area. The decline of the Gulf sturgeon is primarily due to limited access to migration routes and historic spawning areas, habitat modification, and water quality degradation. Critical Habitat has been designated along the Mississippi Gulf Coast, and the Pearl, Leaf, and Pascagoula Rivers.

The threatened yellow-blotched map turtle (*Graptemys flavimaculata*) is found in the Chickasawhay, Leaf, and Pascagoula Rivers. The yellow-blotched map turtle prefers river stretches with moderate currents, abundant basking sites, and sand bars. Stream modification has significantly contributed to the decline of the species.

The endangered Brown pelican *(Pelecanus occidentalis*) nests mostly on offshore islands, but has been known to nest in onshore estuaries. Nesting areas are usually in low shrubs, trees or on the ground, and contain groups of 25-250 birds. They also congregate to feed near coastal wharves and pilings. Disturbance of nesting areas should be avoided.

The threatened Piping Plover *(Charadrius melodus)* does not nest in Mississippi but winters along the coastal beaches and barrier islands. These feeding areas have been threatened by urban development. Hence, Critical Habitat has been designated along several areas of the Mississippi Gulf Coast.

The endangered Mississippi Sandhill Crane *(Grus canadensis pulla*) is found only in a small area west of the Pascagoula River in Jackson County. Critical Habitat has been established on and adjacent to the Mississippi Sandhill Crane National Wildlife Refuge.

Kemp's ridley, Green, and Loggerhead sea turtles are also listed species found along the coast of Mississippi. The Service has jurisdiction over these species whenever there may be impacts to nesting sea turtles.

Once final project proposals are available, areas of potential habitat for listed species should be surveyed to determine presence or absence. The results of the survey will be

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included in a Biological Assessment to be provided to the Service as part of ongoing consultation under the ESA.

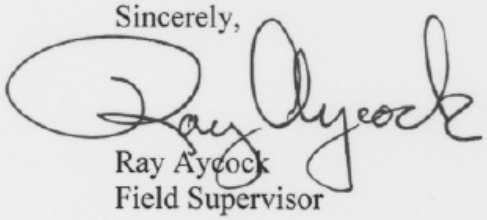
In addition, we recommend that your agency coordinate with National Marine Fisheries Service (NMFS), which also has jurisdiction for listed marine species, including sea turtles and gulf sturgeon.

We are aware that the Corps is considering structural, non-structural, and environmental approaches to the MsCIP program. Although we understand the need for structural measures in certain circumstances, we recommend that environmental and non-structural measures be utilized wherever practicable. However, minimization and avoidance of impacts should be considered on all project elements.

Upon receipt of the Draft Integrated Comprehensive Report/EIS, the Service will provide comments and recommendations on the projects. We understand that many of the projects plans will be conceptual in nature and therefore, our recommendations will only be as specific as the plans allow.

The Service looks forward to continuing to work with the Corps on the MsCIP program. Should you have any further questions or concerns, please contact Paul Necaise at 228-493-6631 or Sabrina Chandler at 601-321-1135.

Sincerely,



Ray Aycock
Field Supervisor

cc: NMFS, Panama City, FL
MSDMR, Biloxi, MS
MDEQ, Jackson, MS
EPA, Atlanta, GA
NPS, Gulf Breeze, FL

1

FISH AND WILDLIFE COORDINATION REPORT

DRAFT

The Corps, Mobile District is coordinating with the USFWS concerning the MsCIP effort. The USFWS provided its final Draft Fish and Wildlife Coordination Act Report on June 12, 2008. The Corps utilized the USFWS' recommendations, shown below, in the developments of the MsCIP effort. In fact, the Corps had assistance from the USFWS staff member in the actual preparation of this MsCIP documentation.

1. Incorporate sediment control measures during construction including timely revegetation of disturbed areas.
2. Maintain disturbed areas with the use of native vegetation if at all possible. Clean equipment prior to transport to prevent contamination by exotic species such as cogon grass to other sites.
3. Place restrictive easements or covenants on all preserved and restored project areas to prevent future development.
4. Account for secondary development and indirect effects associated with projects during advanced design and feasibility studies.
5. Environmental and non-structural measures should be utilized in place of hard structures wherever practicable.
6. Minimization and avoidance of impacts should be considered on all project elements.
7. Consultation as required by Section 7 of the Endangered Species Act will be completed as necessary.

The USFWS will provide its Final Fish and Wildlife Coordination Act Report upon publication of the Final MsCIP Report.

DRAFT

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Mississippi Field Office
6578 Dogwood View Parkway, Suite A
Jackson, Mississippi 39213

June 12, 2008

Colonel Byron Jorns
District Engineer, Mobile District
U.S. Army Corps of Engineers
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Jorns:

Enclosed is our final draft Fish and Wildlife Coordination Act (FWCA) report for the Mississippi Coastal Improvements Program (MsCIP), Hancock, Harrison, and Jackson Counties, Mississippi. The Mississippi Department of Wildlife, Fisheries, and Parks and National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA-NMFS) have participated in the environmental planning phase of this program.

The program is authorized to conduct an analysis and design for comprehensive improvements or modifications to existing improvements in the coastal area of Mississippi in the interest of hurricane and storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resources. Numerous projects are being recommended under various authorities. Many projects require further design and study.

Our report concluded that implementation of this program will impose both adverse and favorable impacts to fish and wildlife resources. Once more detailed information is available, addendums to the report will be incorporated. We have provided preliminary measures and recommendations that could reduce impacts to fish and wildlife resources. In accordance with provisions of the FWCA, this report should be attached to and made an integral part of your final Comprehensive Report. Thank you for the opportunity to comment on this program.

Sincerely,

Ray Aycock
Field Supervisor

Cc: Environmental Protection Agency, Atlanta, GA
Miss. Dept. of Wildlife, Fisheries, and Parks, Jackson, MS
Miss. Dept. of Environmental Quality, Jackson, MS
Miss. Dept. of Marine Resources, Biloxi, MS
National Marine Fisheries Service, Panama City, FL
National Park Service, Gulf Breeze, FL

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FISH AND WILDLIFE COORDINATION ACT REPORT

MISSISSIPPI COASTAL IMPROVEMENTS PROGRAM (MsCIP)

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June 2008

Executive Summary

The purpose of the Mississippi Coastal Improvements Program (MsCIP) is to identify risk reduction measures that can be integrated to form a system that will address the Congressional mandates authorized in response to Hurricane Katrina by Public Law 109-148 (30 December 2005). The scope of the proposed project is to address the full range of structural, non-structural, and ecosystem restoration measures available to provide short term, as well as, comprehensive solutions. The study area includes the three coastal counties along the northern Gulf of Mexico within the State of Mississippi: Hancock, Harrison, and Jackson. Also included in the project is the offshore ecosystem of the Mississippi Sound and its barrier islands.

Proposed projects include numerous environmental restoration projects, restoration of the barrier islands, beach and dune construction, submerged aquatic vegetation restoration, freshwater diversions, ring levees, elevated roadways, seawalls, inland barriers and surge gates, residential buyouts and relocations, and retreat and/or relocation of critical facilities. These projects would have both adverse and favorable impacts to fish and wildlife resources. However, in order to provide an adequate evaluation of impacts for some projects, more information and further study is needed. Supplemental Environmental Impact Statements (EIS) will be provided to address impacts in those cases. Additional Fish and Wildlife Coordination Act (FWCA) reports will be prepared based on those Supplemental EIS's. Our preliminary recommendations are:

1. Incorporate sediment control measures during construction including timely revegetation of disturbed areas with native plant species.
2. Maintain disturbed areas with the use of native vegetation if at all possible. Clean equipment prior to transport to prevent contamination by exotic species such as cogon grass to other sites.
3. Place restrictive easements or covenants on all preserved and restored project areas to prevent future development.
4. Account for secondary development and indirect effects associated with projects during advanced design and feasibility studies.
5. Environmental and non-structural measures should be utilized in place of hard structures wherever practicable.
6. Minimization and avoidance of impacts should be considered on all project elements.
7. Consultation as required by section 7 of the Endangered Species Act will be completed as necessary.

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Introduction

This final draft Fish and Wildlife Coordination Act (FWCA) report provides planning input and recommendations for the U.S. Army Corps of Engineers Mississippi Coastal Improvements Program (MsCIP) in, Hancock, Harrison, and Jackson Counties, Mississippi. The proposed project is authorized in response to Hurricane Katrina by Public Law 109-148 (30 December 2005) to:

> "Conduct an analysis and design for comprehensive improvements or modifications to existing improvements in the coastal area of Mississippi in the interest of hurricane and storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resources…"

This FWCA report is to accompany your Integrated Comprehensive Report/Environmental Impact Statement (EIS) and is submitted in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended: 16 U.S.C. 661 *et seq.*) and the Endangered Species Act (16 U.S.C. 1531 *et seq.)*. This final draft report constitutes the report of the Secretary of the Interior as required by Section 2(b) of the Act. Additional FWCA reports will be provided to evaluate Supplemental EIS's where they may be warranted.

The purpose of the proposed program is to identify risk reduction measures that can be integrated to form a system that will address the interests expressed in the authorization. The scope of the proposed project includes the full range of structural, non-structural, and ecosystem restoration measures available to provide short term, as well as, comprehensive solutions.

The U.S. Fish and Wildlife Service (Service) is a cooperating agency for this project and has had a representative co-located with the U.S. Army Corps of Engineers (Corps), Mobile District throughout the planning process. Other cooperating agencies include over 30 Federal, State, and local governments, Non-Governmental Organizations (NGO's), and business and industries, as well as several private citizens. An environmental team was established to formulate environmental restoration projects and complete the EIS portion of the Comprehensive Report. Representatives on the environmental team include individuals from National Marine Fisheries Service (NOAA-NMFS), National Park Service (NPS), U.S. Geological Survey (USGS), Environmental Protection Agency (EPA), Mississippi Department of Environmental Quality (MDEQ), Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP), and Mississippi Department of Marine Resources (MDMR, the local sponsor). Since April 2006, the Corps Mobile District has hosted 12 formal public and agency meetings, a 2-day Regional coordination meeting, a Public Scoping workshop, 3 online meetings, a Public Hearing workshop, and numerous internal meetings in which the Service participated as a full member of the MsCIP planning team. The Corps also launched a website enabling user downloads, project team collaboration, and improved communication and coordination among agencies and the public.

Public Law 109-148 also authorized the Corps to provide interim recommendations for near term improvements. The Corps solicited project proposals from agencies and the public, by which they identified 180 projects that could be classified as hurricane and storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, or prevention of coastal erosion. Those projects were evaluated, screened, and refined into a list of 15 projects that could be recommended for construction. These 15 projects were included in the MsCIP interim report that was submitted to Congress in August 2006. Together these projects will restore 35 miles of beach and dune systems; protect/enhance 3,300 acres of coastal wetlands; restore 2.5 miles of seawall systems; restore flood storage capacity and circulation in 11 miles of streams/canals; potentially reduce storm damage to over 41,000 structures, and provide $11 million in annual recreation benefits. Congress appropriated

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$107,000,000 for these recommendations as part of an emergency supplemental bill on May 25, 2007.

The numerous meetings and coordination workshops have allowed the Corps to eliminate some projects based on lack of support or major impacts. The project components found within Chapter 8 of the current Integrated Comprehensive Report/EIS (ICR/EIS) are a result of this input. This report will address those remaining projects in this report.

The Service provided the Corps with a Planning Aid Letter (PAL) dated June 12, 2007 with initial recommendations as well as a list of federally protected threatened and endangered (T&E) species that may be impacted by the proposed project. The Service recommended in the PAL that environmental and non-structural measures be utilized wherever practicable, and that minimization and avoidance of impacts should be considered on all project elements.

A draft FWCA was provided on November 20, 2007 and provided additional recommendations. That report was written based on an earlier version of the ICR/EIS that did not contain all of the components that would be recommended for construction. This final draft FWCA addresses all of the components that will be recommended for construction. Additional components that are mentioned, but will not be recommended for construction in the ICR/EIS will be evaluated and presented in future Supplemental EIS's which will require an additional FWCA report.

Description of Study Area

The study area includes the three coastal counties along the northern Gulf of Mexico within the State of Mississippi: Hancock, Harrison, and Jackson. Also included in the project is the offshore ecosystem of the Mississippi Sound and its barrier islands. Areas in Louisiana and Alabama that would be affected by actions considered for improvements to the Mississippi coast will be discussed, if applicable.

The 75-mile coastal area is bounded on the west by the Pearl River, on the east by the Alabama state line, and to the south by the Gulf of Mexico. The Mississippi Sound is a partially protected body of water averaging 8 to 10 miles wide separated from the Gulf of Mexico by a series of barrier islands (Cat, Ship, Horn, and Petit Bois Island). The Gulf Intra-coastal Waterway encompasses deep water in the Mississippi Sound a few miles from the mainland shore. The mainland shore is broken by the entrances to Bay of St. Louis between Bay St. Louis and Pass Christian, and Biloxi Bay between Biloxi and Ocean Springs. U.S. Highway 90 traverses the area a few miles inland except in Harrison County, where it closely borders the coastline. Two major rivers empty into Mississippi Sound. The Pearl River, which forms the boundary between Mississippi and Louisiana, and the Pascagoula River, which travels North to South through Jackson County and enters the sound at Pascagoula. Major towns along the coast are, from west to east, Waveland, Bay St. Louis, Pass Christian, Long Beach, Gulfport, Biloxi, Ocean Springs, and Pascagoula. This area ranges in elevation from sea level to about 30 feet. The essentially flat to gently undulating, locally swampy Coastal Lowlands are underlain by alluvial, deltaic, estuarine, and coastal deposits and merge with the fluvial-deltaic, plains of the streams of the area. This portion of Coastal Mississippi has been classified as an alluvial coast, and terraced, deltaic plain. This area is illustrated in Figure 1.

Coastal Mississippi was the point of impact of the greatest tidal surge that has hit the mainland of the United States (U.S.) in its recorded history. Hurricane Katrina affected over 90,000 square miles (m2) of the Gulf Coast region. It caused nearly complete destruction of several large coastal communities while seriously damaging numerous others. The destruction was on a scale unmatched by any natural disaster in U.S. history. Losses to Coastal Mississippi were unprecedented and have presented a high cost to the nation with a complete fisheries failure being declared by the Commerce Secretary. Hurricane Katrina produced marine debris covering valuable productive water

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bottoms, exacerbated coastal erosion, loss to maritime forests, degraded water quality, increased pollution, created widespread debris fields throughout coastal wetlands, degraded coastal preserve lands owned and maintained by the State of Mississippi, increased risks to infrastructure and human life, danger to fish and wildlife including T&E species and their critical habitats, and the loss of an entire way of life. Losses to many commercially important fisheries stock, foraging areas, and nurseries have been felt economically throughout the region. Spawning, breeding, and foraging grounds of fish and shellfish were severely impacted resulting in rising prices, and once readily available resources are in limited supply. The ability of wetlands to enhance protection from future storm surges, coastal erosion, and flooding has been greatly reduced. Human activities can also inhibit the natural processes of coastal lands. Urban and residential development is often conducted without an adequate understanding of coastal geology and processes. There have been an increased number of wetland fill permits due to the apparent need for housing in the area, post-Katrina, that can also impact the coastal area's natural defenses against storm surge. As a result, they can lead to cumulative degradation of coastal resources. Cooperative scientific investigations are starting to provide the crucial information needed to minimize the unintended effects of human disturbances along coasts.

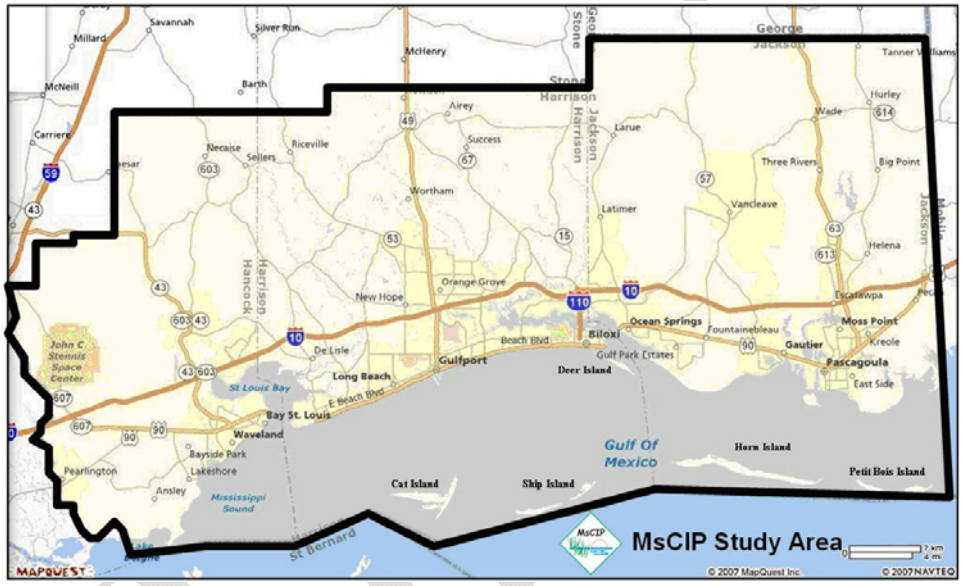


Figure 1. MsCIP Study Area

Fish and Wildlife Concerns and Planning Objectives

The primary responsibility of the Service is the identification of fish and wildlife habitats and identification of preservation and restoration opportunities for the Mississippi Gulf Coast. Specifically the Service has identified the following needs of the Study Area:

1. Preservation of wetlands and associated fish and wildlife resources found within the Mississippi Gulf coastal area.

2. Restoration of the hydrology and vegetation found within the degraded portions of the Mississippi Gulf coastal area.

3. Minimization of structural measures by optimizing environmental and non-structural measures, such as wetland restoration, residential buyouts and floodproofing.

Evaluation Methodology

Projects were evaluated for wetland impacts (acres) and restoration benefits in the form of Functional Capacity Indices (FCI) and Functional Habitat Indices (FHI). The FCI for each function is readily used to evaluate impacts, compare project alternatives, and help design and evaluate mitigation plans. Sites proposed for residential buyout and/or relocation and environmental restoration were selected using the Spatial Decision Support System (SDSS). More information on the SDSS tool can be found in the Environmental Appendix of the Comprehensive Report. This information is summarized in Table 1 below.

Table 1. Summary of models used in evaluation and analysis of environmental project proposals included in the MsCIP Comprehensive Plan

Model	Description/Purpose	Use in MsCIP
Spatial Decision Support System	GIS based decision system to identify & evaluate potential sites	Selection of potential Wetland restoration sites
AL/MS Gulf Coast Tidal Fringe HGM Model	Perform functional assessment of tidal fringe wetlands	Evaluate positive/negative impacts to tidal fringe wetlands
MS Wet Pine Savannah HGM Model	Perform functional assessment of wet pine savannah habitats	Evaluate positive/negative impacts to wet pine savannah habitats
Functional Habitat Index Spreadsheet	Assess the environmental values of beach and dune habitat	Evaluate positive/negative impacts to beach and dune habitats

The methodology used for riparian and coastal wetlands is the Hydrogeomorphic Model (HGM) developed by EPA, NOAA-NMFS, Corps, and Service personnel, and is calibrated for wetlands ecosystems found in coastal Mississippi, as used in many prior studies (Shafer et al. 2007). HGM is a science-based quantitative and replicable methodology that establishes functions and values at a variety of sites and reference points that are then used to establish functional values for sites within the area be analyzed. HGM was applied at a landscape-level, using numerous reference sites in the area in the establishment of without-project conditions. The HGM model was used for the functional assessment of Tidal Fringe wetlands and Wet Pine Savannahs within the study area. Because HGM has not been calibrated for use in Maritime Forest or beach and dune analysis in this area, an alternative methodology was used for the small number of these sites. The methodology chosen for this application was FHI.

Fish and Wildlife Resources

Although no site specific sampling of terrestrial or aquatic resources has been completed for this study, fish and wildlife resource estimates are based upon past reports and data pertinent to the study area. Existing fish and wildlife resources along the Mississippi Gulf Coast are a product of the area's response to human alteration and impact.

Many species of invertebrates and vertebrates make up the fauna population along the Mississippi Gulf Coast. Invertebrate populations in Mississippi Sound and the nearshore area of the Gulf of Mexico transfer energy through the coastal food web. Microscopic estuarine zooplankton live throughout the water column with limited mobility. Zooplankton includes such organisms as copepods, protozoans, chaetognaths, pteropods, tunicates, ctenophores, and siphonophores. Larval stages of benthic forms and eggs and larval stages of many fish species are often interspersed throughout zooplankton. Many important commercial fish species feed upon zooplankton.

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Vittor and Associates (1982) investigated the macrofauna of Mississippi Sound and selected areas in the Gulf of Mexico. Over 532 taxa from offshore Mississippi and Alabama and 437 taxa from the Mississippi Sound were identified. Densities of individuals varied from 910 to 19,536 individual/ yard^2 for the offshore and 1,200 to 38,863 individual/ yard^2 for the Sound area. Abundance of macrofauna is temporal with greatest densities occurring from fall to spring.

Oyster production in Mississippi depends on public reefs managed by the Mississippi Department of Marine Resources (DMR). The State of Mississippi accounts for about 13% to 17% of Gulf oyster landings. Reefs are located along the coast across the entire state with the largest reefs near the western boundary. According to W.J. Demoran (1979), there were 9,934 acres of oysters. At that time, that number included 582 acres of planted oyster beds. Additional acreage has been planted. A few small areas of oyster bottom have been leased for private development; however, production from these areas has been negligible. There have been considerable annual variations in size of productive areas due to natural environmental fluctuations, such as freshwater flow into the oyster beds. Many of Jackson County's most productive areas have been closed to harvest due to increased pollution associated with coastal development.

Many commercially important species of crustaceans are harvested in Mississippi Sound and the nearshore of the Gulf of Mexico. Brown shrimp (*Penaeus aztecus*) is the main shrimp species harvested by commercial fishermen in the Gulf of Mexico and is the most important commercial species in the Mississippi Sound and Mobile Bay area. White shrimp (*Litopenaeus setiferus*) and blue crab (*Callinectes sapidus*) are also harvested within the study area. In addition to those commercial species, there is a very diverse community of crustaceans within Mississippi Sound and adjacent waters including a wide variety of forms and habitat preferences. Epibenthic crustaceans dominate the diet of flounder, catfish, croaker, porgy, and drum. Christmas and Waller (1973) reported 138 fish species in 98 genera and 52 families taken from areas across Mississippi Sound. The major fisheries landed along the Mississippi Gulf coast are anchovies, menhaden, mullet, croakers, shrimp, and oyster. Jackson County, primarily the ports of Pascagoula and Moss Point, receives greater than 85% of all Mississippi landings, including all industrial fish (menhaden), 95% of the mullet, trout, and red snapper, and 74% of the croaker landed (Corps 1992).

Coastal wetlands of Mississippi Sound, St. Louis Bay, Biloxi Bay, Pascagoula Bay, and the tidal Pascagoula River provide the resource base for commercial and marine recreational fishing and tourism in Mississippi. The dockside value of commercial fish landings in Mississippi neared $42 million in 1995. Recreational fisheries also play an important role in the state's economy. In 1991, 500,000 people spent more than $236 million fishing in Mississippi's waters, generating almost $14 million in state sales tax, resulting in $131 million in earnings, and supporting more than 8,000 jobs. Approximately one-quarter of the recreational fishing occurs in coastal waters. Communities such as Moss Point, Pascagoula, Gautier, Ocean Springs, Biloxi, Long Beach, Gulfport, Pass Christian and Bay St. Louis all depend on fishing to support their local economies.

Coastal Mississippi habitats support an array of reptiles, amphibians, birds, and mammals. There is a great diversity of reptiles including 23 species of turtles, 10 species of lizards, 39 species of snakes, and the American alligator. Eighteen species of salamanders and 22 species of frogs and toads are indigenous to the coastal region.

Mammals occur within all habitats of the coastal system, using underground burrows, the soil surface, vegetative strata, the air, and the water for feeding, resting, breeding, and bearing and rearing young. There are 57 species of mammals found in the area (Corps 2005). Several species of mammals include the raccoon, river otter, gray fox, striped skunk, mink, white-tailed deer, bottlenose dolphin, beaver, possum, and nine-banded armadillo. A number of whales are known to occur offshore and occasionally are sighted within the Mississippi Sound.

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Over 300 species of birds have been reported as migratory or permanent residents within the area. Several of these species also breed there. Shorebirds and wading birds include osprey, great blue heron, great egret, piping plover, sandpiper, gulls, brown and white pelicans, American oystercatcher, and terns. These birds eat a great variety of foods and exhibit a diversity of nesting behaviors.

Loss of these habitats is increasing throughout coastal Mississippi largely due to development and habitat degradation. Urban encroachment on fish and wildlife habitats has created direct and indirect affects. Impacts to habitats can include direct loss due to construction, but also come from the inability to properly manage existing habitats. Fire management is a necessary tool in wet pine savannahs, a dominant habitat type across the local landscape. Increased wildland-urban interface (WUI), where forests meet development, prohibits the use of prescribed fire in many cases due to liability associated with fire.

Fish and wildlife habitats within the project area are diverse. Wet pine savannah is a dominant wetland type with the Mississippi Coastal area. A dominant upland habitat type is mixed pine-hardwood forest. Remaining habitats include: fresh and saltwater tidal marsh, non-tidal freshwater marsh, beach and dune, riparian forest, and bottomland hardwood forest. The Service Mitigation Policy (CFR 46(15):7644-7663; Appendix I) classifies wet pine savannah, fresh and saltwater tidal marsh, non-tidal freshwater marsh, bottomland hardwoods, and beach and dune habitats as a Resource Category 2. These habitats are “of high value for evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section.” The mitigation goal for a Resource Category 2 habitat is “no net loss of in-kind habitat value.” Mixed-pine hardwood and riparian forests are classified as a Resource Category 4. These habitats are “of medium to low value for evaluation species.” The mitigation goal for Resource Category 4 habitat is “minimization of loss of habitat value.”

Invasive exotic species are also of increasing concern especially in coastal areas. Chinese tallow tree (*Sapium sebiferum*) and Cogongrass (*Imperata cylindrica)* are two major pest plant problems that land managers face. Faunal invasives also persist along the coast. Wild hogs (*Sus scrofa*) and red imported fire ants are two examples of invasive fauna that impact native species and their habitats.

Threatened and Endangered Species

There are nineteen (19) species listed under the Endangered Species Act within the project study area (Table 2). These species include both aquatic and terrestrial fauna, as well as one plant species. National Marine Fisheries Service has jurisdiction over off shore species and critical habitat, including sea turtles, Gulf sturgeon, and some whale species.

Due to the scope of this project and associated unknown factors, consultation as required by section 7 of the Endangered Species Act (16 U.S.C. 1531 *et seq.*) will be addressed at least initially through this report. It is the opinion of the Service that some of the “Tentatively Selected Comprehensive Plan Components” may warrant Formal Consultation once more specific plans are available for each project and supplemental EIS documents are prepared. Therefore, the Service reserves the right to request formal consultation if necessary. Affects to T&E species and other fish and wildlife resources associated with each component are listed in the section titled “Description of Project Impacts.”

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Table 2.
Threatened and Endangered Species with Associated Habitat Descriptions

Common Name	Scientific Name	Status	County	Habitat
Alabama red-bellied turtle	Pseudemys alabamensis	E	Harrison, Jackson	Submerged aquatic vegetation in brackish coastal rivers; freshwater reaches
Bald eagle	Haliaeetus leucocephalus	Delisted*	Hancock, Harrison, Jackson	Shorelines near open water
Black pine snake	Pituophis melanoleucus ssp. lodingi	C	Harrison, Jackson	Fire-dependent, upland longleaf pine forests
Brown pelican	Pelecanus occidentalis	E	Hancock, Harrison, Jackson	Feeds over water in coastal areas, nests on small islands.
Gopher tortoise	Gopherus polyphemus	T	Hancock, Harrison, Jackson	Fire-dependent, upland longleaf pine forests
Green sea turtle	Chelonia mydas	T	Hancock, Harrison, Jackson	Shallow coastal waters with SAV and algae, nests on open beaches.
Gulf sturgeon,	Acipenser oxyrhynchus desotoi	TCH	Hancock, Harrison, Jackson	Migrates from large coastal rivers to coastal bays and estuaries
Inflated Heelsplitter	Potamilus inflatus	T	Hancock	Soft, stable substrata in slow to moderate currents of tributaries and large rivers
Kemp's Ridley sea turtle	Lepidochelys kempii	E	Hancock, Harrison, Jackson	Nearshore and inshore coastal waters, often in salt marshes
Loggerhead sea turtle	Caretta caretta	T	Hancock, Harrison, Jackson	Open ocean; also inshore areas, bays, salt marshes, ship channels, and mouths of large rivers
Louisiana black bear	Ursus americanus luteolus	T	Hancock, Harrison, Jackson	Bottomland hardwood forest; frequently ranges into other habitats
Louisiana quillwort	Isoetes louisianensis	E	Hancock, Harrison, Jackson	Small blackwater streams with sand and gravel substrate and forest cover
Mississippi gopher frog	Rana capito sevosa	E	Harrison, Jackson	Fire-dependent, upland longleaf pine forests; open, ephemeral upland pools
Mississippi sandhill crane	Grus canadensis pulla	ECH	Jackson	Wet pine savannah
Pearl darter (Pascagoula River System)	Percina aurora	C	Jackson	Rivers and large creeks with sand and gravel bottoms and flowing water.
Piping Plover	Charadrius melodus	TCH	Hancock, Harrison, Jackson	Barrier islands and coastal beaches
Red-cockaded woodpecker	Picoides borealis	E	Harrison, Jackson	Fire-dependent, upland longleaf pine forests
West Indian or Florida Manatee	Trichechus manatus	E	Hancock, Harrison, Jackson	Fresh and salt water in large coastal rivers, bays and estuaries.
Yellow-blotched map turtle	Graptemys flavimaculata	T	Jackson	Rivers and large creeks with habitat suitable for basking

E = endangered T= threatened C= candidate CH= designated critical habitat
*The Bald Eagle continues to be protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act

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Coastal Barrier Resources Act

The Coastal Barrier Resources Act (CBRA) of 1982 established the John H. Chafee Coastal Barrier Resources System (CBRS), comprised of undeveloped coastal barriers along the Atlantic, Gulf, and Great Lakes coasts. The law encourages the conservation of hurricane prone, biologically rich coastal barriers by restricting Federal expenditures that encourage development, such as Federal flood insurance through the National Flood Insurance Program. CBRA is a free-market approach to conservation. These areas can be developed, but Federal taxpayers do not underwrite the investments. CBRA saves taxpayer dollars and encourages conservation at the same time. CBRA has saved over $1 billion and will save millions more in the future. Approximately 3.1 million acres of land and associated aquatic habitat are part of the CBRS. The Fish and Wildlife Service maintains the repository for CBRA maps enacted by Congress that depict the CBRS. The Service also advises Federal agencies, landowners, and Congress regarding whether properties are in or out of the CBRS, and what kind of Federal expenditures are allowed in the CBRS.

The Coastal Barrier Resources Act and its amendments prohibit most new Federal expenditures that tend to encourage development or modification of coastal barriers. The laws do not restrict activities carried out with private or other non-Federal funds and only apply to the areas that are within the defined John H. Chafee Coastal Barrier Resource System (CBRS).

Examples of prohibited Federal assistance within System units include subsidies for road construction, channel dredging, and other coastal engineering projects. Federal flood insurance through the National Flood Insurance Program is available in a CBRS unit if the subject building was constructed (or permitted and under construction) before the CBRS unit's effective date. If an existing insured structure is substantially improved or damaged, the Federal flood insurance policy will not be renewed.

Federal monies can be spent within System units for certain exempted activities, after consultation with the U.S. Fish and Wildlife Service. Examples of such activities include emergency assistance, military activities essential to national security, exploration and extraction of energy resources, preservation of fish and wildlife resources, and maintenance of existing Federal navigational channels.

The Coastal Barrier Improvement Act of 1990 expanded the CBRS and created a new category of lands known as otherwise protected areas (OPAs). OPA designations add a layer of Federal protection to coastal barriers already held for conservation or recreation, such as national wildlife refuges, national parks and seashores, state and county parks, and land owned by private groups for conservation or recreational purposes, and discourage development of privately owned inholdings. The only Federal funding prohibition within OPAs is Federal flood insurance. The CBRS currently includes 271 OPAs which add up to approximately 1.8 million acres of land and associated aquatic habitat. These units are designated by the letter ‘P’ found at the end of the unit identifier.

There are seven CBRA units within the MsCIP project area (Table 3). Petit Bois, Horn, and Ship Islands which are part of the Gulf Islands National Seashore (GUIS) are all considered one unit (MS-01P). This unit falls into the category of OPAs, thus the letter ‘P’ found at the end of the unit identifier. The remaining island within GUIS is Cat Island which has a separate designation. Those portions of Cat Island that are owned and managed by the National Park Service are designated as unit R03. Note that even though Cat Island could be designated as an OPA this designation was not made due to the fact that the remainder of the island is under private ownership which is not considered a part of CBRA.

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Table 3.
Coastal Barrier Resources Act units
within the Mississippi Coastal Improvement Program Area

Unit Identifier	County	Description
MS-01P	Jackson	Gulf Islands
MS-01P	Jackson	Gulf Islands
MS-01P	Jackson	Gulf Islands
MS-01P	Jackson	Gulf Islands
MS-01P	Harrison	Gulf Islands
R01	Jackson	Round Island
R01A	Jackson	Belle Fontaine Point
MS-02	Jackson	Marsh Point
R02	Harrison	Deer Island
R03	Harrison	Cat Island
MS-04	Hancock	Heron Bay Point

Description of Tentatively Selected Comprehensive Plan Components

Components of MsCIP can be grouped into five categories. Only those components that are recommended for construction authorization will be addressed within this Report. Other components that require additional engineering and design or study will be addressed in FWCA reports that will correspond with Supplemental EIS's provided by the Corps upon authorization. Categories of selection of recommended measures are listed below.

- Projects recommended for construction authorization
- Projects recommended for additional pre-construction engineering and design
- Studies recommended for finalization under programmatic plan authorization
- Studies recommended for additional feasibility-level study
- Studies recommended for inclusion as requiring advanced design studies

It is important to note that many measures that may be recommended will be grouped in categories that include projects that will require minimal additional information during preparation of plans and specifications. Many measures will be recommended as potential actions that will need advance design prior to development of plans and specifications and others will establish a framework in which future projects will be identified under continuing authorities that would require specific Project Information Reports (PIR) after development of plans and specifications. There are certain measures that will require additional studies to determine problems and opportunities in order to address any concerns.

As a result of the numerous categorizations of potential projects that might come forth from the MsCIP Comprehensive Report, further environmental considerations and analyses will be required for some projects. There will be additional coordination and consultation on supplemental EIS's for projects that would result in significant impacts to the environment and further environmental assessments for projects that are less complex in nature with less significant impacts associated with them.

This final draft FWCA report serves as coordination of the current draft EIS, and will serve as the basis from which further required environmental analyses and documentation could be tiered.

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Comprehensive plan components have been tentatively selected and are determined to be 'keystone' pieces on which later recommendations would be built. These plan elements have been determined to be engineeringly feasible, environmentally acceptable and beneficial, and cost effective. Each of the tentatively selected plan components have been designed to function as stand alone units that will act independently should additional time be required for design or other components be determined to not be cost effective. Descriptions of tentatively selected components of the comprehensive plan can be found in Chapter 8 of the Main Report.

Description of Project Impacts

Hurricane and Storm Damage Reduction Plan Components

The plan components described below will singly or in combination assist in the reduction of risk to the maximum extent practicable. Other options, both structural and nonstructural, present opportunity for additional risk reduction but are not able to be evaluated in the Comprehensive report at a level required to determine feasibility, acceptability, or cost effectiveness. Potential impacts associated with each project are presented below, however due to the vast number of properties involved and the uncertainties associated with some project footprints, specific affects may not be available at this time.

1. Hurricane Risk Reduction Education

This component is not likely to adversely affect fish and wildlife resources, including T&E species.

2. Hurricane and Storm Warning

This component is not likely to adversely affect fish and wildlife resources, including T&E species.

3. Hurricane Evacuation Planning

This component is not likely to adversely affect fish and wildlife resources, including T&E species.

4. Floodplain Management

Better management of the floodplain could benefit fish and wildlife resources by restricting impacts of associated with development within the floodplain. This component could also benefit wetlands by reducing the amount hazardous waste, un-anchored structural components, and other infrastructure that is allowed within the floodplain, as well as reduce the amount of fill necessary for development in these areas. This component is not likely to adversely affect fish and wildlife resources, including T&E species.

5. Building Code Update

Updated building codes could reduce the number of structures that would be destroyed during a hurricane or storm event. Fewer structures impacted would reduce the amount of storm debris and hazardous materials that would likely impact surrounding wetlands and other fish and wildlife habitats. This component is not likely to adversely affect fish and wildlife resources, including T&E species.

6. Zoning Code Update

Updated zoning regulations support both the floodplain management and building code update components, by further prohibiting certain types of development and structures from high hazard areas. This component is not likely to adversely affect fish and wildlife resources, including T&E species.

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7. Long-term Critical Infrastructure and Services Relocation (LOD 5)

This component would encourage relocation or designation of critical infrastructure outside of the Maximum Probable Intensity (MPI) boundary. This line is drawn based on elevation related to the maximum storm surge inundation depth and can be used as a guide for local county and municipal governments when locating critical facilities. As facilities are relocated and constructed northward of this planning line, losses to existing habitats would occur. Potential impacts could also result from secondary development associated with relocation of infrastructure into undeveloped areas. This component could impact T&E species, specifically the threatened gopher tortoise; however this possibility cannot be assessed at this time and would have to be evaluated on a case by case basis. Due to the vast number of properties involved and the uncertainties associated with project footprints, specific impacts to fish and wildlife resources cannot be determined at this time. Future studies during project development would determine specific impacts associated with implementation of this measure.

8. Homeowner Assistance and Relocation Program (HARP)

The most effective alternative for reducing the risk from future hurricane surge events is to relocate all structures and population centers from the high risk zones. Formulation of alternatives included those which would provide for minimum level of risk reduction (approximate base flood elevation) up to those that would provide for risk reduction from increasing levels of inundation. In addition a smaller alternative concentrating on voluntary acquisition in the high to moderately high hazard areas is being evaluated.

Temporary and minimal effects could occur during implementation of this measure; however, properties that would be purchased as part of a buy-out program would be restored to historical conditions providing potential benefits to fish and wildlife and their habitats. Floodproofing may temporarily impact fish and wildlife species during construction, but should have no long term impacts once projects are completed. Potential impacts could also result from secondary development associated with relocation of infrastructure into undeveloped areas. This component could impact T&E species, specifically the threatened gopher tortoise; however this possibility cannot be assessed at this time and would have to be evaluated on a case by case basis. Due to the vast number of properties involved and the uncertainties associated with project footprints, specific impacts to fish and wildlife resources cannot be determined at this time. Future studies during project development would determine specific impacts associated with implementation of this measure.

9. Moss Point Municipal Relocation Component

Since relocation of facilities is proposed only within the incorporated limits, there are no negative impacts anticipated as a result of this project. Fish and wildlife resources could benefit from additional greenspace that will be created along the riverfront as a result of this relocation proposal. This component is not likely to adversely affect fish and wildlife resources, including T&E species.

10. Waveland Floodproofing

Temporary and minimal impacts may be encountered during construction of floodproofing components; however no major negative impacts are anticipated as this project will involve currently developed areas within an existing footprint. This component is not likely to adversely affect fish and wildlife resources, including T&E species.

11. Forrest Heights Hurricane and Storm Damage Reduction Component

Due to a pre-existing disturbed condition created by the presence of the residential development and partial levee system currently in place, this component would result in minimal impacts to fish and

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wildlife species from levee expansion. Continued maintenance of the levee reduces natural habitats that are currently available for numerous wildlife species. This component is not likely to adversely affect fish and wildlife resources, including T&E species. It would however require fill of 19.85 acres of non-tidal wetlands due to expansion of the levee footprint. The entire footprint of the levee at elevation 21 feet would total 23 acres. The 19.85 acres of wetlands are classified as wet pine savannah habitats.

12. Evaluation of Structural Measures

While large structural solutions such as surge gate barriers did not garner much local support, there were viable alternatives, such as smaller ring levees that have the potential of providing cost effective solutions. Possible ring levee alternatives are being evaluated as part of this study including ring levees at: Belle Fontaine, Gulf Park Estates, Pascagoula/Moss Point, Pearlington, Gautier, Ocean Springs, and Bay St. Louis. The development of cost effective, acceptable alternatives however will require additional study and coordination. Because these components will undergo further study and coordination, only a brief overview of potential impacts has been provided below. All of these structural measures will likely impact fish and wildlife resources and potentially affect T&E species.

Ring Levees

Approximately 265 acres of wetland vegetation could be lost based on some alignments (Lin and Shafer 2007). Although impacts to fish and wildlife resources would depend on the exact footprint of the levee, adverse impacts are not expected due to continuous coordination throughout the planning process. The Belle Fontaine ring levee comes close to falling within CBRA Unit R01A, however, through early consultation with the engineering team this was addressed as a potential conflict and should be revisited if there are changes to the alignment.

Line of Defense 4 – Inland Barrier and Surge Gates

The general alignment of the inland barrier would be along the path of the existing railway that crosses the coast of Mississippi. This railway is located atop of a constructed berm. In order to protect much of the developed areas around Biloxi and St. Louis Bays, the inland barrier would need to cross the mouths of these bays which would necessitate construction of structural surge barriers.

Hancock County Inland Barrier (LOD 4)

Impacts to fish and wildlife resources could be avoided or minimized by alternate alignments and/or elevations of the proposed structure. Native vegetation under the levee footprint would be lost, and the levee itself would likely be vegetated with non-native species for stabilization of the structure. Approximately 300 acres of wetlands would be impacted based on some potential alignments and/or elevations (Lin and Shafer 2007). Specific losses would be field verified prior to construction and during project development to determine wetland functions lost. Specific impacts to fish and wildlife species would not be evaluated until final plans are available. Surveys of potential habitats for threatened and endangered species would be required in order to determine impacts to listed species.

St. Louis Bay Surge Barrier

Further studies would be needed during project development to determine the full extent of impacts, to fish and wildlife species, submerged aquatic vegetation (SAV), and other estuarine organisms associated with implementation of this measure.

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Harrison County Inland Barrier (LOD 4)

Impacts to fish and wildlife resources could be avoided or minimized by alternate alignments and/or elevations of the proposed structure. Native vegetation under the levee footprint would be lost, and the levee itself would likely be vegetated with non-native species for stabilization of the structure. Approximately 45 acres of wetlands would be impacted based on some potential alignments and/or elevations (Lin and Shafer 2007). Specific losses would be field verified prior to construction and during project development to determine wetland functions lost. An alternate alignment along Menge Ave. in Gulfport would eliminate the need for the Biloxi Bay Surge Barrier. The Service recommends that the Menge Ave. alignment be used in order to avoid the need for that component. Specific impacts to fish and wildlife species would not be evaluated until final plans are available. Surveys of potential habitats for threatened and endangered species would be required in order to determine impacts to listed species.

Biloxi Bay Surge Barrier

Further studies would be needed during project development to determine the full extent of impacts, to fish and wildlife species, SAVs, and other estuarine organisms associated with implementation of this measure. An alternate alignment of the Harrison County Inland Barrier (LOD 4) along Menge Ave. in Gulfport would eliminate the need for this component. The Service recommends that the Menge Ave. alignment be used in order to avoid the need for this component.

Jackson County Inland Barrier (LOD 4)

Impacts to fish and wildlife resources could be avoided or minimized by alternate alignments and/or elevations of the proposed structure. Native vegetation under the levee footprint would be lost, and the levee itself would likely be vegetated with non-native species for stabilization of the structure. Approximately 79 acres of wetlands would be impacted based on some potential alignments and/or elevations (Lin and Shafer 2007). Specific losses would be field verified prior to construction and during project development to determine wetland functions lost. Specific impacts to fish and wildlife species would not be evaluated until final plans are available. Surveys of potential habitats for threatened and endangered species would be required in order to determine impacts to listed species.

Ecosystem Restoration Plan Components

1. Turkey Creek

The Turkey Creek Restoration project will restore 689 acres of wet pine savannah habitat in a severely impaired watershed within an urbanized area in North Gulfport. This area suffers from altered hydrology and habitat degradation through lack of fire and an abundance of invasive exotic species. By restoring this habitat, this watershed will regain much needed flood storage capacity and regain its natural wetland function, and will also be protected from development. The HGM approach was used to measure benefits resulting in a total of 2,577 functional units with a net AAFU benefit of 1,565. There will be temporary, localized impacts to fish and wildlife species during construction, but the benefits gained greatly outweigh these impacts. This component is not likely to adversely affect fish and wildlife resources, including T&E species.

2. Dantzler

This 385 acre site owned by the State of Mississippi and managed by the Department of Marine Resources is located in central Jackson County near the Pascagoula River and the Mississippi Sandhill Crane National Wildlife Refuge (NWR). The site currently consists of plantation pine and

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includes drainage ditches and stormwater lines that were added in anticipation of residential development, and therefore does not provide the benefits that a naturally functioning wet pine savannah should. Hurricane Katrina also introduced an enormous amount of debris to this site. By thinning the pines, removing invasive species, filling ditches to restore hydrology, and implementing a natural fire regime this site could benefit the endangered Mississippi Sandhill Crane found on adjacent Refuge lands. The HGM approach was used to measure benefits resulting in a total of 604 functional units with a net AAFU benefit of 1,244. There will be temporary, localized impacts to fish and wildlife species during construction, but the benefits gained greatly outweigh these impacts. This component is not likely to adversely affect fish and wildlife resources, including T&E species.

3. Franklin Creek

This project is located near the communities of Orange Grove and Pecan in eastern Jackson County, MS. This area has already been funded for acquisition and demolition of 30 structures as part of the MsCIP Interim Report. This restoration will supplement that project by restoring 149 acres of former residential development to wet pine savannah. This site is located adjacent to the Grand Bay NWR /National Estuarine Research Reserve (NERR) and would compliment the management of those protected areas and add to available fish and wildlife habitat in the area. The HGM approach was used to measure benefits resulting in a total of 596 functional units with a net AAFU benefit of 516. There will be temporary, localized impacts to fish and wildlife species during construction, but the benefits gained greatly outweigh these impacts. This component is not likely to adversely affect fish and wildlife resources, including T&E species.

4. Bayou Cumbest

The Bayou Cumbest restoration area contains approximately 348 acres to be restored to tidal marsh and scrub/shrub habitats. This site currently consists of residential development severely damaged by Hurricane Katrina as well as abundant fill material which inhibits the natural ebb and flow of the wetlands in the area. This restoration project would benefit fish and wildlife species as this plan would restore hydrology, remove exotics, and allow for more contiguous suitable habitat. This will provide valuable forage and cover for fish and wildlife species. This project would also remove structures that currently fragment adjacent undeveloped habitat. This site is adjacent to the Grand Bay NWR/NERR and is also near the site of the proposed submerged aquatic vegetation pilot project discussed below. This component is not likely to adversely affect fish and wildlife resources, including T&E species.

5. Admiral Island

The Admiral Island restoration project consists of 123 acres of state owned property managed by the Mississippi Department of Marine Resources (DMR). This site has been degraded over the years and suffered major damage from Hurricane Katrina. The restoration of this site would benefit fish and wildlife resources as this plan would restore hydrology, remove exotics species, and clean up profuse debris that was deposited as a result of Hurricane Katrina. This will provide valuable forage and cover for fish and wildlife species. This component is not likely to adversely affect fish and wildlife resources, including T&E species.

6. Submerged Aquatic Vegetation (SAV) Pilot project

Implementation of this pilot project would provide much needed research and information necessary to restore SAVs and determine the effectiveness of subsequent restoration projects and experimental techniques. Additionally, the project will provide an opportunity to replace SAVs lost as a result of Hurricane Katrina. The functions and resultant values help to sustain productive foraging and refugia habitat for various lifestages of aquatic species. Many fish and wildlife species depend

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on these seagrasses during different stages of their life cycles. This project would benefit fish and wildlife resources by restoring a quickly diminishing, but necessary, habitat.

7. Additional Ecosystem Restoration Studies

Development of the Spatial Decision Support System (SDSS) tool allowed the MsCIP environmental team, including the Service and DMR, to identify and prioritize potential wetland restoration areas throughout coastal Mississippi (Lin 2007). The SDSS produced numerous areas that qualified for restoration, based on the fact that most of them have been impacted and/or destroyed nationally, regionally, and locally by development and/or natural events. These sites were determined unable to repair themselves therefore, requiring human intervention to restore their historical values and functions. Restoration and protection of these sites are essential to healthy fish and wildlife populations all along the Mississippi Gulf coast. Thirty-eight (38) additional sites were evaluated, screened and selected from the results of the SDSS tool and have been proposed for restoration. These sites will be prioritized and specific details will be developed and integrated into a programmatic type authority. Habitats that would be restored through this component range from emergent aquatic vegetation to wet pine savannah to bayhead swamps and beach and dune systems. Some of the proposed projects fall within CBRA units, however these projects would likely be exempt from CBRA prohibitions based on Section 6 of the Act which allows federal funding for projects that would enhance or preserve fish and wildlife resources. This component is not likely to adversely affect fish and wildlife resources, including T&E species. However, complete site assessments should be conducted prior to work to ensure no federally protected species, such as Louisiana quillwort, are present.

8. Violet Freshwater Diversion Project Engineering and Design

The Mississippi Department of Marine Resources (DMR) has been working with the Mississippi congressional delegation in order to address impacts from saltwater intrusion and degradation of the oyster resources found within the Mississippi Sound, primarily those associated with Hancock County. Through collaboration with Louisiana, the two states have agreed on a mutually beneficial proposal for a diversion at or near Violet, Louisiana. Modeling efforts have been ongoing and although a version of the project has been authorized through the Water Resources and Development Act of 2007 (WRDA), no specific plans have been agreed upon. The project may impact the federally listed Pallid and Gulf sturgeon however the extent of those impacts will remain unknown until specific details are available and adequate studies performed. Other fish and wildlife resources may also be affected by the implementation of this project. Further research would be required to determine exact impacts associated with this component.

9. Escatawpa River Diversion – Grand Bay Marsh Ecosystem Restoration

Human disturbances have impacted the Grand Bay marsh ecosystem by altering historic sheet water flows into the area, as well as the natural migration of the Pascagoula and Escatawpa Rivers. These rivers flow into marshes and other wetlands that make up the Grand Bay NWR/NERR. Lack of sheet water flow into the area has caused a loss of valuable pine savannah wetlands that under optimum conditions would provide abundant habitat for numerous fish and wildlife species. Saltwater intrusion due to lack of freshwater input into the system has also degraded available fish and wildlife habitats. Shoreline erosion has also contributed to the increased salinity in the area, as well as a loss of fish and wildlife habitats with the total erosion of landmasses such as the Grand Batture Islands. This project may impact federally listed species however the extent of those impacts will remain unknown until specific details are available and adequate studies performed. Other fish and wildlife resources may also be affected by the implementation of this project. Further research would be required to determine exact impacts associated with this component.

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10. Coastwide Beach and Dune Ecosystem Restoration

The man-made beaches that exist along the Mississippi Gulf coast have become the winter home to more than just the human population. These beaches and dune systems were designated critical habitat for the threatened Piping plover in 2002. These birds only overwinter along these beaches, while many other species of shorebirds depend on these habitats for nesting and other life stages. Most of the dunes that previously existed along these beaches were destroyed by Hurricane Katrina along with much of the beach, leaving numerous species of wildlife without adequate foraging and nesting habitat. Because restoration of these beaches would greatly benefit the fish and wildlife species that depend on them, the temporary and minimal impacts associated with construction should not adversely impact these species. However, time of year and duration of each project should be considered when planning these projects to avoid impacts to fish and wildlife species. Borrow areas should also be evaluated prior to excavation to avoid impacting areas such as mud flats, on which these birds also depend for forage areas.

11. Comprehensive Barrier Island Restoration

The Service agrees that the selected alternative Barrier Island Comprehensive plan (G) described in Section 8.1.2.11.2 of the Main Report would be the most efficient and least damaging alternative. However this alternative will impact fish and wildlife resources and habitats in the vicinity of the project area. These impacts are both positive and negative. The barrier islands are designated critical habitat for wintering Piping Plovers. Direct sand placement in Camille cut and reintroduction of sandy sediments to the littoral zones of Ship, Horn, and Petit Bois Islands could provide additional wintering habitat for this threatened shorebird. However, this option would alter waters within the project area, which are designated critical habitat for the threatened Gulf sturgeon. Federally protected sea turtles also inhabit the area and have the potential to nest on the islands. Sea turtles fall under the jurisdiction of the Service when onshore during nesting. NOAA-NMFS has jurisdiction over listed species and critical habitat offshore. Because restoration and enhancement of these islands would greatly benefit the fish and wildlife species that depend on them, the temporary and minimal impacts associated with construction should not adversely impact terrestrial species found within the project area. However, time of year and duration of each project should be considered when planning these projects to avoid impacts to fish and wildlife species. Changes to water bottoms and introduction of sediments into the system will likely affect aquatic species, such as the Gulf sturgeon. A final project proposal would be required to perform an adequate evaluation of impacts to listed species and habitats.

12. Deer Island Ecosystem Restoration

Deer Island is located within the boundaries of Harrison County, Mississippi near the mouth of the Biloxi Bay and the City of Biloxi, and falls within CBRA unit R02. It is managed by DMR as a coastal preserve. The lands within the interior are privately owned while the State of Mississippi owns much of the property considered tidal wetlands. This island has suffered damage from many storms which was exacerbated by Hurricane Katrina. A breach from previous storms was significantly widened, coastal marshes were impacted by debris and sedimentation, and the maritime forest was killed by saltwater overtopping and wind damage. The island, prior to Hurricane Katrina, was the subject of a restoration project through the beneficial use of dredged material, and the restoration area seems to have faired well under the circumstances. A second restoration effort is currently underway to repair the breach on the western end as well as selective restoration to critical areas on the southern shoreline. Deer Island contains a diversity of habitats valuable to wildlife which would be protected from erosion by the proposed restoration plan. This project would likely be exempt from CBRA prohibitions based on Section 6 of the Act which allows federal funding for projects that would enhance or preserve fish and wildlife resources. This option could alter waters within the project area, which are designated critical habitat for the threatened Gulf sturgeon. Changes to

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waterbottoms and introduction of sediments into the system could affect aquatic species, such as the Gulf sturgeon.

Summary of Impacts

Impacts and effects listed for each component are preliminary in nature and could change with new information as projects go through the planning process. Further study would be required for some of the proposed components. The Service may issue addendums to this FWCA to address concerns, in addition to requesting further consultation under section 7 of the ESA, if warranted. Additional FWCA reports will be issued in the event of Supplemental Environmental Impacts Statements.

Fish and Wildlife Conservation Measures

The Service has provided preliminary conservation measures for mitigation of losses and/or restoration of fish and wildlife resources below. More specific measures may be provided in addendums to this report once specific plans are available and plans and/or alternatives are selected.

The Service and the Corps, working together during the MsCIP planning process, have managed to avoid many potential fish and wildlife resource conflicts within project proposals (i.e., National Wildlife Refuges and Coastal Barrier Resources Act (CBRA) units). The Corps invited the Service to participate in the planning process as a full member of the project planning team. The Service applauds the Corps, Mobile District, for the opportunity to actively participate and provide input throughout the process.

Although many major wetland areas were avoided during the planning process, some impacts to wetlands, primarily associated with levee construction, still remain. Overall preliminary estimates suggest that up to approximately 726 acres could be impacted if all projects were constructed at the maximum proposed footprint. The Service suggests avoiding, minimizing, or rectifying this acreage by constructing projects that have the least impact while continuing to meet objectives set forth in the Congressional mandate. The wetland areas that may potentially be impacted by proposed projects are designated as Resource Category 2 under the Service Mitigation Policy. The mitigation goals for Resource Category 2 are physical modification of replacement habitat to convert it to the same type lost; restoration or rehabilitation of previously altered habitat; increased management of similar replacement habitat so that the in-kind value of the lost habitat is replaced, or; a combination of these measures. Specific losses should be field verified prior to construction and during project development to determine functions of wetlands lost. Restoration and enhancement of fish and wildlife habitats within the project area could reduce these impacts, as well as provide benefits to the resource. In addition, restoration and protection of habitats along the Mississippi Gulf Coast could increase overall fish and wildlife resources within the area and improve water quality.

Care should be taken to ensure use of native species to re-vegetate disturbed areas. Precautions should also be taken to prevent the distribution of invasive exotics such as cogon grass (*Imperata cylindrica*) during ground disturbing activities. Cogon grass in rampant across vitually every habitat on the Mississippi Gulf Coast and can outcompete native vegetation if not controlled or prohibited from spreading.

Proposed surge barriers could induce major impacts to fish and wildlife resources. These projects should be adequately studied to determine potential impacts throughout the entire basin.

Secondary development and indirect effects could be associated with several project proposals and would have to be evaluated and in the case of impacts, mitigation would be necessary. By

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encouraging development in previously undeveloped areas, impacts to fish and wildlife resources and federally listed species (gopher tortoise), as well as the ability to properly manage habitats (prescribed fire), are likely.

The Service recommends that the Planning division and the Regulatory division within the Corps, Mobile District continue to coordinate their activities as they relate to MsCIP. Areas delineated by the SDSS for environmental restoration and/or buyouts should not be eligible for permits for authorized fill under Section 404 of the Clean Water Act. Coordination such as this could potentially be considered a flood damage reduction measure.

RECOMMENDATIONS

Based on information currently available the Service makes the following recommendations to minimize impacts to fish and wildlife resources:

1. Incorporate sediment control measures during construction including timely revegetation of disturbed areas with native plant species.

2. Maintain disturbed areas with the use of native vegetation if at all possible. Clean equipment prior to transport to prevent contamination by exotic species such as cogon grass to other sites.

3. Place restrictive easements or covenants on all preserved and restored project areas to prevent future development.

4. Account for secondary development and indirect effects associated with projects during advanced design and feasibility studies.

5. Environmental and non-structural measures should be utilized in place of hard structures wherever practicable.

6. Minimization and avoidance of impacts should be considered on all project elements.

7. Consultation as required by section 7 of the Endangered Species Act will be completed as necessary.

Summary of Findings and Service Position

The Service has determined based on preliminary information, that the Mississippi Coastal Improvements Program would have both adverse and favorable impacts to existing fish and wildlife resources. The majority of the tentatively selected components are environmentally sound projects that would provide a benefit to fish and wildlife resources and preserve habitat by preventing potential future development. These projects also meet the objectives of flood damage reduction and hurricane and storm damage reduction.

Non-structural programs such as buyouts would also likely benefit fish and wildlife resources. However, relocation programs that would encourage development in previously undeveloped areas could create direct and indirect adverse impacts to fish and wildlife resources as well as T&E species. Nevertheless, these relocations would likely have a less damaging effect than other structural options. Major impacts associated with relocations could be avoided by wise selection of relocation areas.

It is unknown at this time how projects such as freshwater diversions and surge barriers will impact fish and wildlife resources. Projects such as these will require much more study than what has been afforded by Congress. These projects will be evaluated once more information is available.

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It is the opinion of the Service that some of the "Tentatively Selected Comprehensive Plan Components" may warrant Formal Consultation once more specific plans are available for each project and supplemental EIS documents are prepared. Therefore, the Service reserves the right to request formal consultation if necessary.

The Service recommends that structural measures be avoided such as surge barriers, inland levees, and ring levees. The need for these projects could be avoided by the use of more efficient, less damaging non-structural alternatives, such as environmental restoration and relocations.

This final draft Fish and Wildlife Coordination Act Report will be programmatic in nature. Consequently, once formal project proposals are received and supplemental EIS's as required for some projects are received, they will be addressed in additional FWCA reports. These additional reports will contain all requirements for the Secretary of the Interior as required by Section 2(b) of the Act.

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BIOLOGICAL ASSESSMENT AND BIOLOGICAL OPINIONS

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The Corps coordinated with both the USFWS and National Marine Fisheries Service, Protected Resource Division concerning the anticipated formal consultation and subsequent preparation of a Biological Assessment under Section 7 of the Endangered Species Act. Both agencies concurred that the MsCIP Programmatic Integrated Programmatic Environmental Impact Statement (EIS) would serve also as the Biological Assessment (BA). This decision was reached by the agencies due to the prepared MsCIP Programmatic Integrated EIS document already containing all necessary information required in the BA already. The USFWS provided a letter, dated June 24, 2008, stating its use of the MsCIP Programmatic Integrated EIS as a supplement for the Corps' BA. Future BAs and Biological Opinions could be possibly required on projects being tentatively selected for additional study.

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Mississippi Field Office
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June 24, 2008

Dr. Susan I. Rees
Mississippi Coastal Improvements Program
U.S. Army Corps of Engineers
Mobile District
PO BOX 2288
Mobile, AL 36628-0001

Dear Dr. Rees:

The U.S. Fish and Wildlife Service (Service) has been coordinating with you and your team to accomplish the mandates authorized by Congress through the Mississippi Coastal Improvements Program (MsCIP). The MsCIP team, of which the Service has been a full member, is currently working to complete an Integrated Comprehensive Report/ Environmental Impact Statement (ICR/EIS). This report will address numerous projects that have been proposed and evaluated as a means of helping the Mississippi Gulf Coast not only recover from Hurricane Katrina, but also become better prepared and to be more resilient in the event of future storms.

The Service provided a final draft Fish and Wildlife Coordination Act (FWCA) Report (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) to the Corps on June 12, 2008. This FWCA Report not only provided recommendations for projects, but also addressed potential impacts to threatened and endangered species that are protected by the Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq.*). Due to the broad scope of MsCIP and associated unknown factors, consultation as required by section 7 of the ESA was addressed initially through the FWCA report. Once a Final ICR/EIS has been provided, the Service believes that document will be sufficient for continuation of consultation.

We believe that this is the most efficient way to achieve our common goals of recovery and resiliency throughout the entire Mississippi Gulf Coast. Thank you for the opportunity to work with you on this very important program.

Sincerely,

Ray Aycock

Ray Aycock
Field Supervisor

SECTION 3
ENVIRONMENTAL COMPLIANCE DOCUMENTATION

3.1 Section 404(b)(1) Evaluation Report for the Mississippi Coastal Improvements Program (MsCIP), Hancock, Harrison, and Jackson Counties, Mississippi

SECTION 404(b)(1) EVALUATION REPORT
FOR THE
COASTAL MISSISSIPPI IMPROVEMENTS PROGRAM (MsCIP)
HURRICANE RESTORATION EFFORT

HANCOCK, HARRISON, AND JACKSON COUNTIES, MISSISSIPPI

I. **PROJECT DESCRIPTION**:

A. **Location**. The Hurricanes of 2005 created unprecedented destruction within the Gulf Region of the United States (U.S.) of America. Beginning with Hurricane Cindy on July 6th 2005, which made landfall near Waveland, Mississippi, peaking with Hurricane Katrina, which made landfall on the 29th of August on the Louisiana-Mississippi border, and ending with Hurricane Rita on the 24th of September, which also caused additional damage to the coastline of Mississippi, this series of tremendous storms caused unparalleled devastation to homes and businesses, industry, livelihoods, regional economies, environmental resources, and most importantly, dealt a life-changing blow to the people that call this region home.

Hurricane Katrina made landfall on August 29, 2005 near Buras-Triumph, Louisiana. Hurricane force winds extended outward 120 statute miles. Landfall of this storm placed Coastal Mississippi in the northeast quadrant, the most destructive quadrant. Destruction spans along all three coastal counties – Hancock, Harrison, and Jackson. Most, if not all, of the infrastructure was destroyed by the hurricane south of Highway 90. South of Interstate-10 had massive flooding and infrastructure damage. Hurricane Katrina destroyed coastal regions of Louisiana, Mississippi, and Alabama making it the most destructive and costliest natural disaster in the history of the U.S. Coastal Mississippi was the point of impact of the greatest tidal surge that has hit the mainland of the U.S. in its recorded history.

B. **General Description**. The U.S. Army Corps of Engineers (Corps), Mobile District has been authorized by Congress to investigate expedited studies of flood and storm damage reduction. These studies will address hurricane and storm damage reduction, flood control, and ecological restoration as well as other related water resource purposes. With the assistance of Federal, State of Mississippi, and local government agencies, private entities, and other interest groups, the Corps, Mobile District developed measures and specific projects that contribute to the reduction of storm surge, preservation of fish and wildlife, prevention of saltwater intrusion, prevention of coastal erosion, and reduction of coastal flooding. The MsCIP Comprehensive Plan and Integrated Programmatic EIS develop measures and projects for tentatively selected in the following categories:

- Construction;
- Preconstruction Engineering Design for Specific Features;
- Additional Feasibility Studies; and
- Advanced Design Studies for Innovative Concepts.

The potential measures and projects are addressed in the MsCIP Comprehensive Report and Integrated Programmatic EIS. The Corps, Mobile District will coordinate with Federal, state, and local agencies during the required environmental compliance process. This Section 404(b)(1) Evaluation Report addresses potential water quality impacts that could potentially result from

constructing the following measures and/or projects in Coastal Mississippi. Each of the measures and/or projects has been fully discussed in the MsCIP Comprehensive Report and Integrated Programmatic EIS to address the potential environmental impacts associated with their implementation. There may be additional analyses required prior to construction of specific components of tentatively selected measures and projects. This would entail development of additional Section 404(b)(1) Evaluations that would assess potential environmental impacts associated with the specific proposed action within a measure or project. All of the potential measures and projects are located in Coastal Mississippi either in Hancock, Harrison, or Jackson County and are referenced in the attached MsCIP Comprehensive Report and Integrated Programmatic EIS.

C. **Authority and Purpose**. The MsCIP was authorized by Congress in the Department of Defense Appropriations Act, 2006 (Public Law 109-359) 30 December 2005. A description of the analysis and design authority contained in the aforementioned act reads as follows:

> *For an additional amount for "investigations" to expedite studies of flood and storm damage reduction related to the consequences of hurricanes in the Gulf of Mexico and Atlantic Ocean in 2005, $37,300,000, to remain available until expended: Provided, That using $10,000,000 of the funds provided, the Secretary shall conduct an* ***analysis and design*** *for comprehensive improvements or modifications to existing improvements in the coastal area of Mississippi in the interest of hurricane and storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resource purposes* ***at full Federal expense****: Provided further, That the Secretary shall recommend a cost-effective project, but* ***shall not perform an incremental benefit-cost analysis*** *to identify the recommended project, and shall not make project recommendations based upon maximizing net national economic development benefits: Provided further, That interim* ***recommendations for near term improvements shall be provided within 6 months*** *of enactment of this Act* ***with final recommendations within 24 months of enactment****: (****emphasis added)***

The National Environmental Policy Act (NEPA) of 1969 excuses or excludes the Corps from the preparation of any formal environmental analysis with respect to actions that result in minor or no environmental effects, which are known as "categorical exclusions." An intermediate level of analysis, an Environmental Assessment (EA), is prepared for an action that is not clearly categorically excluded, but does not clearly require an EIS [40 Code of Federal Regulations (CFR) §1501.3 (a) and (b)]. Based on the EA, the Corps either prepares an EIS, if one appears warranted, or issues a "Finding of No Significant Impact" (FONSI), which satisfies the NEPA requirement. This document is prepared according to the Engineer Regulation (ER) 200-2, *Procedures for Implementing NEPA, and the Council on Environmental Quality (CEQ) Regulations (40 CFR § 1508.27) for Implementing the Procedural Provisions of NEPA (40 CFR § 1500-1508).*

D. **General Description of Dredged or Fill Material**.

(1) **General Characteristics of Material.** Materials used for barrier island restoration and beach/dune nourishment actions would consist of fine to medium grained sand that would be compatible with existing sediments. Material with a mixture of silts, sands and some clay component will be used where sediment is required for marsh/scrub/shrub restoration. Levee construction will require the use of clay fill material. The material will be obtained from either commercial sources, trucked in, and/or existing borrow areas near the project sites. The substrate that will be used as a restoration site for submerged aquatic vegetation (SAV) at Bayou Cumbest would consist of primarily sands with some silts. The freshwater diversion substrate would be similar to that of the marsh restoration and SAVs.

(2) **Quantity of Material**. For the barrier island restoration efforts, it is estimated that a total of up to approximately 31 million cubic yards (cys) of sandy material may be required for the filling of Ship Island Breach. A quantity of sandy material yet to be determined could be used as a feeder source to supplement natural migration of material within the littoral zone. Exact quantities are dependent upon which measure that would be implemented. The volume of material dredged and excavated in association with the ring levee around Forest Heights is yet to be determined. Quantities associated with environmental restoration sites (i.e. filling and excavation) are calculated to rough order of magnitude. No additional fill material would be required for the restoration of SAV.

(3) **Source of Material**. Sand used for barrier island restoration would be obtained from the St. Bernard Shoals, a natural sand deposit located in the Gulf of Mexico south of Mississippi and Louisiana or from river sources (i.e. upland dredged material disposal sites) located along the Black Warrior – Tombigbee River system and the Tennessee – Tombigbee Waterway would be further evaluated for compatibility with existing barrier island beach sand composition, including acceptable grain size, color, and texture. Sources required for ecosystem restoration have yet to be determined. No sources will be used for the SAV restoration.

E. **Description of the Proposed Discharge Site**.

(1) **Location**. The locations of any discharge areas associated with measures and projects described herein are addressed in Section B (General Description) of this report.

(2) **Size**. The sizes of the potential discharge areas associated with measures vary with each component of a measure and/or specific projects. The sizes of these sites may range from approximately 25 acres up to approximately 500 acres.

(3) **Type of Site**. Site types for the variety of projects described herein consist the barrier islands, open-water of Mississippi Sound and the coastal mainland of the State of Mississippi. The types of sites consists of beach and dunes, marine, estuarine, and freshwater marsh, SAVs, wet pine savannah, upland forests, urbanized areas (i.e. residential and commercial), fringes, rivers, and bays.

(4) **Type of Habitat**. The types of habitats consists of beach and dunes, coastal maritime forests, marine, estuarine, and freshwater marsh, scrub/shrub, SAVs, wet pine savannah, urbanized areas (i.e. residential and commercial), fringes, and bays.

(5) **Timing and Duration of Discharge**. Timing and duration of the proposed actions are dependent upon approval and funding of the projects. Beach projects along the mainland could take up to 2 years. Restoration of the barrier islands could take up to 15 years for completion. Ring levee construction would take up to 1 year for completion. The non-structural and environmental component features timeframe will vary from 180 days to several years.

F. **Description of Disposal Method**. Methods of placement and disposal for these projects will utilize a variety of dredges including hydraulic cutterhead, hopper, and mechanical, deep draft, scow, and various shallow draft barges. In addition, track hoes, bulldozers, dump trucks, backhoes, marsh buggies, and other similar earthmoving construction equipment will be utilized dependent on the scope of each project.

II. **Factual Determinations (Section 230.11)**:

A. **Physical Substrate Determinations**.

(1) **Substrate Elevation and Slope**. The barrier islands restoration project would consist of beach/dune restoration projects and would be designed to sustain elevations and slopes consistent with similar habitat types in the vicinity that has been sustained under the typical energy climate. Potential marsh and coastal maritime forest restoration components on the barrier islands will also be further evaluated in accordance with and conformity with the Organic Act, National Park Service (NPS) mission, and NPS management policies. The beach could be constructed to between approximately 0 to 2-foot elevation with a 1:10 slope on the foreshore. Dune elevations along the mainland could be constructed to a maximum height of 6 feet with 1:3 slope. Marsh habitat would be constructed between -0.5 and 2-foot while the scrub/shrub would be constructed to between approximately 4 to 6 feet. The ring levee around Forest Heights would be constructed up to a 12- or 16-foot elevation. The ecosystem restoration projects would be constructed at the appropriate elevations to ensure hydrology at the site. The SAV restoration project would be constructed at about -5 to -10 feet water depth.

(2) **Sediment Type**. Materials used for the beach restoration actions will consist of fine to medium grained sand that is compatible (grain size, color, and texture) with existing beach sediments. Sandy material with a small silty component will be used where sediment is required for marsh restoration. Materials dredged from drainage channels and canals will likely contain soft, fine-grained, organic silts and clays with some fraction of sand. This material will be disposed in approved upland sites.

(3) **Dredged/Fill Material Movement**. Fill material would be pumped or trucked directly onto the beach sites. It is expected that a readjustment phase will occur and sand materials redistributed to form a more natural profile. Restoration areas will utilize material that may contain a higher percentage of fine grained materials. Silt fences/curtains and other best management plans (BMPs) will be utilized to reduce material movement during heavy equipment operations. It is believed that no adverse impacts would occur from movement of materials.

Physical Effects on Benthos. No impacts to benthos are anticipated in the upland areas. There would be temporary disruption of the aquatic community as a result of the proposed projects being constructed. Areas where sand and sediments are laid directly upon the bottom open-water habitat to create marsh or restore barrier islands and/or beaches may result in destruction of sessile benthic fauna. Non-motile benthic fauna within the project sites would be lost as a result of the organisms not being able to penetrate through the thick layer of material that will be used to construct the tidal marsh and sand placement for restoration. This loss of sessile benthic fauna would be minor due to the tidal marsh area and other restoration area sites encompassing only a small percentage of the entire Mississippi Sound. Benthic fauna, such as crabs, are anticipated to re-colonize the area upon restoration and in addition, should provide aquatic habitat for various motile and non-motile benthic fauna. The intertidal zone and sub-tidal zones along the restored beaches should provide rapid recovery of and recruitment of benthos. The marsh would provide additional nursery area along the outer fringes suitable for fishes following the proposed activities. Non-motile benthic fauna within the project area may be destroyed by the proposed operations, but should repopulate within several months after construction activities are completed.

Physical Effects on Wetlands. Restoration projects would restore damaged and filled wetlands providing an overall benefit to wetlands. Implementation of the proposed levee at Forest Heights would not require fill in wetlands. It is anticipated that relocation of city facilities in Moss Point and homeowner assistance relocations would be located in uplands and any required fill material would be obtained from upland sources.

(4) **Other effects**. No other effects are anticipated.

(5) **Actions Taken to Minimize Impacts (Subpart H)**. Actions will be taken to minimize impacts to all project areas during the construction activities. BMPs and/or silt curtains will be used at the construction sites, where applicable, to minimize turbidity and curtail material migration. Borrow material used in construction will be utilized in such a manner to minimize impacts to surrounding areas.

B. **Water Column Determinations**.

(1) **Salinity**. Projects that are being tentatively selected for construction should have minimal impacts to salinity as a result of its implementation. In fact, the filling of Ship Island breach is anticipated to have a positive benefit to salinity in Mississippi Sound.

(2) **Water Chemistry (pH, etc.)**. All sediment and material used in the construction of the identified projects will be clean materials removed from sources of contamination and considered contaminant free. Such material will have no effect on surrounding water chemistry.

(3) **Clarity**. Construction activities in association with beach nourishment and dune construction and tidal marshes will reduce water clarity due to elevated suspended sediments in the water column; however, BMPs and/or silt curtains will be used, where applicable, to minimize impacts to the project area. Minor increases in turbidity may be experienced in the immediate vicinity of the project areas during construction operations. However, these increases will be temporary and would return to pre-project conditions shortly after completion. In fact, several components of the proposed project may improve water clarity because particles tend to settle out of the water column at tidal marsh areas.

(4) **Color**. No effect.

(5) **Odor**. No effect.

(6) **Taste**. No effect

(7) **Dissolved Gas Levels**. Temporary decreases in dissolved oxygen will likely result from some of the construction activities, but this will only be of a short duration. The construction activities and the return water are not anticipated to adversely impact dissolved gas levels.

(8) **Nutrients**. Slight increases in nutrient concentrations may occur from the proposed construction activities; however, these concentrations would be rapidly dispersed. These described increases would have no significant effect to the water column. Further studies prior to construction and implementation of certain measures would be conducted to determine possible impacts.

(9) **Eutrophication**. The projects tentatively selected for construction would have minimal impacts to eutrophication effects.

C. **Water Circulation, Fluctuation, and Salinity Gradient Determinations**:

(1) **Current Patterns and Circulation**.

(a) **Current Patterns and Flow**. Restoration of the barrier islands would be modeled to determine effects of filling the breach between East and West Ship Islands, creating a feeder source of sand to supplement littoral drift and migration, and filling of water bottoms in order for expansion of the island footprints. The subsequent return water flow is also not anticipated to affect current

patterns and flow in the vicinity of the mainland. The environmental restoration sites would restore historic water flow patterns. Levee construction would likely divert water away from the urbanized areas. The non-structural plan would also help restore historic water flow patterns by removing structures all together or raising them from their base elevation.

(b) **Velocity**. No Effect.

(2) **Stratification**. No Effect.

(3) **Hydrologic Regime**. Environmental restoration would result in a benefit to the hydrologic regime as the lost hydrology is restored to historical wetlands.

(4) **Normal Water Level Fluctuations**. No Effect.

(5) **Salinity Gradient**. Salinity in Mississippi Sound is highly variable due to the inflow of freshwater from surrounding rivers and the tidal influence from the Gulf of Mexico. Restoration of barrier islands would affect salinity gradient and further analysis would be conducted to determine the effects of these measures.

D. **Suspended Particulate/Turbidity Determination**:

(1) **Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Placement Site**. The placement of fill material at the proposed project sites within Mississippi Sound and within the vicinity of the barrier islands would reduce light penetration through the water column, thereby reducing photosynthesis and surface water temperatures. Although it is expected an initial high volume loss of sand from the restoration projects at the barrier islands would occur, it is expected that sand movement would decrease once equilibrium is naturally achieved. These conditions could potentially alter visual predator-prey relations in the immediate project vicinity. In addition, sediment adheres to fish gills, resulting in respiratory stresses, and natural movement of eggs and larvae could be potentially altered as a result of the sediment adherence. These are minor, short-term impacts due to the short duration of construction activities. It is expected that distinct bars would develop nearshore by the nature of the waves and depths within the project vicinity and could potentially result in a seaward expansion.

Construction of the levee around Forest Heights, and environmental restoration sites could cause sediment movement and isolated increased turbidity around the construction sites. Changes in substrate are not expected nor will any deleterious materials be added to the sediment during construction activities.

(2) **Effects on Chemical and Physical Properties of the Water Column**.

(a) **Light Penetration**. Light penetration through the water column at the proposed sites may be temporarily affected but is anticipated to return to previous conditions upon completion of construction activities.

(b) **Dissolved Oxygen**. Future studies would be conducted prior to construction and implementation of certain measures to determine impacts within the bays and Mississippi Sound.

(c) **Toxic Metals and Organics**. Sites have been picked to avoid any potential toxic metals and organics.

(d) **Pathogens**. No effect.

(e) **Esthetics**. Esthetics would be reduced within construction areas, due to the physical presence of the heavy equipment used in the construction process; however, these impacts would be temporary and insignificant. Once the construction is complete, the esthetic values provided by barrier island restoration, a restored beach-dune system, and environmental restoration of wetlands would have many beneficial impacts. Construction of the projects would actually result in an improvement to aesthetic quality as coastal Mississippi was devastated as a result of Hurricane Katrina. No adverse impacts are anticipated from the ring levee around Forest Heights and the non-structural plan.

(3) **Effects on Biota**. The proposed beach and ecosystem restoration projects are designed to enhance the barrier island ecosystems. These actions would increase valuable habitat resulting in an overall improvement and continued health of the local wildlife. No adverse impacts are anticipated from the ring levee around Forest Heights and the non-structural plan due to its existing urbanization.

(a) **Primary Production Photosynthesis**. No impacts to primary production photosynthesis are anticipated.

(b) **Suspension/Filter Feeders**. It is anticipated a temporary impact to suspension/filter feeders would occur as a result of the construction activities; however, no long-term impacts are anticipated.

(c) **Sight Feeders**. Shorebirds tend to be attracted to established beach/dune systems. Construction activities (i.e. dredging and subsequent placement to restore the barrier islands) are sometimes attractive sites to many sight feeders due to the presence of food items in the material. Impact of these activities along uplands, beaches, and ecosystem restoration sites on sight feeders is expected to be a beneficial, short-term effect. No adverse impacts are anticipated to occur to sight feeders as they would avoid construction areas.

(4) **Actions Taken to Minimize Impacts (Subpart H)**. BMPs would be incorporated into project designs and specifications during project development.

E. **Contaminant Determinations**. Materials used in the construction of the proposed measures would consist of marine and/or river sand and sediments from sources removed from contamination. Previous construction activities and water quality certifications of these type projects in this region has found that the materials are free of contaminants.

F. **Aquatic Ecosystem and Organism Determinations**.

(1) **Effects on Plankton**. It is anticipated a temporary impact to plankton would occur as a result of the construction activities; however, no long-term impacts are anticipated.

(2) **Effects on Benthos**. Temporary disruption of the aquatic community is anticipated at the beach, dune, and marsh restoration sites. Non-motile benthos at areas where materials will directly covering water bottom would be destroyed. Non-motile benthic fauna within these areas will be lost as a result of the organisms not being able to penetrate through the thick layer of fill material that will be used to construct the tidal marsh and beaches. This loss would be minor due to the project areas encompassing only a small percentage of the entire Mississippi Sound (approximately 750,000 acres). Benthic fauna, such as crabs, are anticipated to rapidly re-colonize these areas upon construction completion. Non-motile benthic fauna within other construction areas may be destroyed by the proposed operations, but should repopulated within several months after completion. Motile benthic and pelagic fauna, such as crabs, shrimp, and fishes, are able to avoid the disturbed area

and should return shortly after the activity is completed. Larval and juvenile stages of these forms may not be able to avoid the activity due to limited mobility. Construction activities at the proposed sites are anticipated to have no significant effects to the benthos.

(3) **Effects on Nekton**. No Effect.

(4) **Effects on Aquatic Food Web**. No Effect.

(5) **Effects on Special Aquatic Sites**. No Effect.

(a) **Sanctuaries and Refuges**. The measures have been developed in such a way as to avoid direct impacts to sanctuaries and refuges. The Sandhill Crane Wildlife Refuge and the Grand Bay National Estuarine and Research Reserve are both located in Jackson County. Numerous measures, particularly ecosystem restoration sites, would provide additional wetland functions nearby existing refuges.

(b) **Wetlands**. The ecosystem restoration sites would result in numerous acres of wetland restoration which would provide numerous positive benefits. Under the current Forrest Heights 21-foot levee alignment alternative, there is an expected loss of 3.6 acres of wetland vegetation impacted by construction of the levee. Although native vegetation under the levee footprint would be lost, the levee itself would be vegetated with non-native species for stabilization of the structure. The compensatory mitigation would be incorporated in the project plan development phase.

(c) **Mud Flats**. No Effect.

(d) **Vegetated Shallows**. The measures have been developed in such a way as to avoid vegetated shallows directly; however, the indirect and cumulative effects are unknown and further studies would need to be conducted to determine the full level of impacts prior to project development and construction.

(e) **Coral Reefs**. Not applicable.

(f) **Riffle and Pool Complexes**. The measures have been developed in such a way as to avoid direct impacts.

(6) **Effects on Threatened and Endangered Species**. The Corps, Mobile District is currently coordinating with the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration Fisheries concerning the proposed MsCIP Comprehensive Report and Programmatic EIS impacts to any threatened and endangered species. Protective measures will be implemented in order to reduce impacts to listed species.

(7) **Effects on Other Wildlife**. Hurricane Katrina and the associated storm surge resulted in numerous adverse impacts to existing wildlife and wildlife habitat. The proposed projects should enhance overall wildlife and associated habitats. Construction activities may result in temporary impacts to existing vegetation in the immediate areas; however it is expected all impacts would be short-term and minor, and in some cases discountable. Urbanization of rural lands could occur and cumulative impacts of this relocation would need to be evaluated to determine the full level of impacts to wildlife habitat.

(8) **Actions to Minimize Impacts**. BMPs would be incorporated into project designs and specifications during project development. Further studies would be conducted prior to implementation of certain measures and prior to specific project development.

G. **Proposed Disposal Site Determinations**:

(1) **Mixing Zone Determination**. The State of Mississippi will specify a mixing zone not to exceed ambient turbidity by more than 50 nephelometric turbidity units at the outer limits of 750 feet for turbidity compliance. Turbidity from material placed in or near the water is anticipated to quickly settle out of the water column. Thus, not exceeding the proposed water quality criteria issued. No adverse impacts are anticipated from construction sites located at upland sites. Thus, no mixing violations are expected.

(a) **Depth of water at the disposal site**. Placement of material associated with beach and marsh restorations will be along the shoreline or nearshore waters.

(b) **Current velocity, direction, and variability at disposal sites**. Further studies would be conducted to determine the impacts in conjunction with implementation of certain measures, such as restoration of Ship Island and placement of sand into the littoral zone around other barrier islands.

(c) **Degree of turbulence**. No impacts are anticipated.

(d) **Stratification attributable to causes such as obstructions, salinity or density profiles at the disposal site**. No impacts are anticipated.

(e) **Discharge vessel speed and direction, if appropriate**. Further studies during project development would determine impacts.

(f) **Rate of discharge**. Rate of discharge will vary according to the particular type of equipment placing materials.

(g) **Ambient concentrations of constituents of interest**. Not applicable.

(h) **Dredged material characteristics, particularly concentrations of constituents, amount of material, type of material (sand, silt, clay, etc.) and settling velocities**. Materials used for the beach restoration actions will consist of fine to medium grained sand that is compatible with existing beach sediments. Sandy material with a small silty component will be used where sediment is required for marsh restoration. Sandy clay fill material would be used to construct the levee around Forest Heights.

(i) **Number of discharge actions per unit of time**. The number of discharge actions per unit of time will vary depending upon particular project activity.

(2) **Determination of Compliance with Applicable Water Quality Standards**. Coordination will be conducted with the appropriate regulating agencies to ensure compliance with all applicable water quality standards.

(3) **Potential Effects on Human Use Characteristics**.

(a) **Municipal and Private Water Supply**. It is anticipated implementation of any measures would have no effect.

(b) **Recreational and Commercial Fisheries**. Recreational and commercial fishing would be temporarily impacted primarily as a result of the physical presence of heavy equipment during operation activities. Limited navigation would occur at the offshore borrow sites.

(c) **Water Related Recreation**. Water related recreation would be temporarily reduced in the immediate vicinity of project sites during construction.

(d) **Esthetics**. Esthetics will be temporarily reduced in the immediate vicinity of the proposed project sites. Many recreational vessels utilize Mississippi Sound within the project vicinities and it is believed some residents and visitors may be disturbed by the presence of the heavy equipment during construction. However, construction activities are temporary in nature so the disturbance is anticipated to be minimal. Furthermore, upon project completion, the restoration projects should provide residents and visitors with a more esthetically pleasing view. The proposed marsh creation and beach restoration projects would provide additional habitat to numerous marine birds.

(e) **Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves**. Further studies and coordination with resource agencies would need to be conducted to determine the full level of impacts of certain measures. Gulf Island National Seashore, administered by the National Park Service, including Petit Bois, Horn, East Ship, West Ship, and a portion of Cat Island are included within the scope of the restoration plan. The National Park Service is currently providing input regarding the feasibility of restoration involving the barrier islands in compliance with existing agency programs, management policies, and enabling legislation. Petis Bois and Horn Islands are also congressionally designated wilderness areas.

(f) **Other Effects**. No effect.

H. **Determination of Cumulative Effects on the Aquatic Ecosystem**. Further studies would need to be conducted to determine the cumulative impacts of certain measures.

I. **Determination of Secondary Effects of the Aquatic Ecosystem**. Further studies would need to be conducted to determine the cumulative impacts of certain measures.

III. **Finding of Compliance With the Restrictions on Discharge**.

A. No significant adaptations of the Section 404(b)(1) guidelines were made relative to this evaluation.

B. Further studies would need to be conducted to determine that any proposed project in conjunction with implementation of certain measures would represent the least environmentally damaging practicable alternative.

C. The planned construction activities and placement of dredged materials would not violate any applicable State water quality standards; nor will it violate the Toxic Effluent Standard of Section 307 of the Clean Water Act (CWA). Appropriate evaluation of analytical and ecotoxicological testing of sediments, site water, and elutriates results would reveal if any adverse impacts would result from the proposed disposal actions.

D. It is believed that use of the proposed disposal sites will not jeopardize the continued existence of any Federally-listed endangered or threatened species or their critical habitat.

E. It is anticipated construction of the proposed projects and placement of dredged material would not contribute to significant degradation of waters of the United States or result in significant adverse effects on human health and welfare, including municipal and private water supplies; recreation and commercial fishing; life stages of organisms dependent upon the aquatic ecosystem; ecosystem diversity, productivity and stability; or recreational, aesthetic or economic values.

F. Appropriate and practicable steps would be taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem.

DATE: _____

_____
Byron Jorns
Colonel, Corps of Engineers
District Engineer

3.2 Coastal Zone Management Program Federal Consistency Determination

The National Coastal Zone Management (CZM) Program is a voluntary partnership between the Federal government and United States (U.S.) coastal states and territories authorized by the Coastal Zone Management Act (CZMA) of 1972. The Coastal Programs Division, within the National Oceanic and Atmospheric Administration's (NOAA), Office of Ocean and Coastal Resource Management, administers the program at the Federal level and works with state coastal zone management partners to:

- Preserve, protect, develop, and, where possible, restore and enhance the resources of the nation's coastal zone for this and succeeding generations;
- Encourage and assist the states to exercise effectively their responsibilities in the coastal zone to achieve wise use of land and water resources, giving full consideration to ecological, cultural, historic, and aesthetic values, as well as the need for compatible economic development;
- Encourage the preparation of special area management plans to provide increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas and improved predictability in governmental decision-making; and
- Encourage the participation, cooperation, and coordination of the public, Federal, state, local, interstate and regional agencies, and governments affecting the coastal zone.

To comprehensively manage our coastal resources and balance often competing land and water uses while protecting sensitive resources, state CZM programs are expected to:

- Protect natural resources;
- Manage development in high hazard areas;
- Manage development to achieve quality coastal waters;
- Give development priority to coastal-dependent uses;
- Have orderly processes for the siting of major facilities;
- Locate new commercial and industrial development in, or adjacent to, existing developed areas;
- Provide public access for recreation;
- Redevelop urban waterfronts and ports, and preserve and restore historic, cultural, and aesthetic coastal features;
- Simplify and expedite governmental decision-making actions;
- Coordinate state and Federal actions;
- Give adequate consideration to the views of Federal agencies;
- Assure that the public and local governments have a say in coastal decision-making; and
- Comprehensively plan for and manage living marine resources.

A unique aspect of CZM is “Federal Consistency,” which ensures that Federal actions that are reasonably likely to affect any land or water use or natural resource of the coastal zone will be consistent with the enforceable policies of a coastal state's or territory’s federally approved CZM Program. Federal consistency is the CZMA requirement where Federal agency activities that have reasonably foreseeable effects on any land or water use or natural resource of the coastal zone (also referred to as coastal uses or resources and coastal effects) must be consistent to the maximum extent practicable with the enforceable policies of a coastal state's federally approved coastal management program. (Federal agency activities, including federally permitted activities, are activities and development projects performed by a Federal agency, or a contractor for the benefit of a Federal agency.)

The Mississippi Coastal Program, approved by NOAA in 1980, is comprised of a network of agencies with authority in the coastal zone. The Mississippi Department of Marine Resources (MDMR), through the Office of Ecology, serves as the lead agency. MDMR is governed by a Commission on Marine Resources appointed by the Governor. The primary authority guiding the Coastal Program is the Coastal Marshlands Protection Act, which includes a wetlands plan designating the allowable use of the state's tidal wetlands. The Mississippi coastal zone includes the three coastal counties as well as all adjacent coastal waters and the barrier islands of the coast.

The Coastal Program is responsible for permitting, Federal consistency review, and the Coastal Nonpoint Pollution Control Program. Through the Coastal Preserves Program, MDMR protects and restores coastal habitats. The Comprehensive Resource Management Plan is the primary program through which MDMR provides technical assistance for managing coastal development, with a focus on stormwater management, smart growth, and GIS training.

The MsCIP environmental team has been working closely with the MDMR technical staff throughout the entire planning process. The Corps, Mobile District has determined that the MsCIP effort described in the MsCIP Comprehensive Report and Integrated Programmatic EIS to be consistent with the requirements of the CZM Act to the maximum extent practicable. The Corps, Mobile District will request formal concurrence with our determination following the completion of the comment period the EIS. Upon documentation receipt, this information will be included in this appendix.

3.3 AIR QUALITY

The Mississippi Department of Environmental Quality (MDEQ) is responsible for protecting the state's air, land, and water. The MDEQ, Air Division is responsible for ensuring that air quality within Mississippi is protective of public health and welfare. This division is charged with controlling, preventing, and abating air pollution to achieve compliance with air emission regulations pursuant to the Mississippi Air and Water Pollution Control Act, applicable regulations promulgated by the U.S. Environmental Protection Agency (USEPA), and the Federal Clean Air Act.

The Ambient Air Quality Standards for Mississippi are in Regulation APC-S-4 as described in the following:

MISSISSIPPI COMMISSION ON ENVIRONMENTAL QUALITY
REGULATION APC-S-4: AMBIENT AIR QUALITY STANDARDS

Adopted February 9, 1983
Last Amended June 27, 2002

Except for odor, as covered below, the ambient air quality standards for Mississippi shall be the Primary and Secondary National Ambient Air Quality Standards as duly promulgated by USEPA in (or to be printed in) 40 Code of Federal Regulation (CFR) Part 50, pursuant to the Federal Clean Air Act, as amended. All such standards promulgated by USEPA as of June 22, 1988, are hereby adopted and incorporated herein by the Commission by reference as the official ambient air quality standards of the State of Mississippi and shall hereafter be enforceable as such (except that the word "Administrator" in said standards shall be replaced by the words "Executive Director" and the word "Agency" in said standards shall be replaced by the word "Department").

There shall be no odorous substances in the ambient air in concentrations sufficient to adversely and unreasonably:

(1) affect human health and well-being;
(2) interfere with the use or enjoyment of property; or
(3) affect plant or animal life.

In determining that concentrations of such substances in the ambient air are adversely and unreasonably affecting human well-being or the use or enjoyment of property of plant or animal life, the factors to be considered by the Commission will include, without limiting the generality of the foregoing, the number of complaints or petitioners alleging that such a condition exists, the frequency of the occurrence of such substances in the ambient air as confirmed by the MDEQ staff, and the land use of the affected area.

Mississippi has adopted Federal Standards (New Source Performance Standards, National Emissions Standards for Hazardous Air Pollutants, etc.) by reference. State specific emissions standards for Mississippi are in:

- Regulation APC-S-1 - Air Emission Regulations for the Prevention, Abatement, and Control of Air Contaminants; and
- Regulation APC-S-8 - Air Toxic Regulations.

Jackson, Harrison, and Hancock Counties have been designated in attainment with the National Ambient Air Quality Standards. The proposed Mississippi Coastal Improvement Program effort will be in attainment with the State of Mississippi's Air Quality Standards.

3.4
COMPLIANCE WITH ENVIRONMENTAL LAWS AND REGULATIONS

1
2

Environmental Laws and Regulations

Law/Regulation/ Executive Order (EO)	Description	Principal Federal Responsible Agency(s)
Endangered Species Act (ESA) of 1973	Establishes a national policy designed to protect and conserve threatened and endangered (T&E) species and the ecosystems upon which they depend	U.S. Fish and Wildlife Service (USFWS) National Oceanic and Atmospheric Administration (NOAA) Fisheries
Marine Mammal Protection Act of 1972 (MMPA)	Prohibits the take (i.e., hunting, killing, capture, and/or harassment) of marine mammals, and enacts a moratorium on the import, export, and sale of marine mammal parts and products	NOAA Fisheries USFWS
National Historic Preservation Act of 1966 (NHPA) and EO 11593	Seeks to preserve the historical and cultural foundation of the U.S. EO 11593 of 1991 states the Federal Government will provide leadership in preserving, restoring, and maintaining the historic and cultural environment	Mississippi State Historic Preservation Officer (SHPO)
Clean Water Act (CWA)	Regulates activities resulting in a discharge to navigable waters Section 401 (33 U.S.C. 1341) of the CWA specifies that any applicant for a Federal license or permit to conduct any activity that may discharge into the navigable waters shall obtain a certification that the discharge complies with applicable sections of the CWA Section 402 established the National Pollutant Discharge Elimination System (NPDES), which regulates discharges into waters of the U.S. Section 404 established a program to regulate the discharge of dredged or fill material into waters of the U.S. to include tributaries to navigable waters, interstate wetlands which could affect interstate or foreign commerce, and wetlands adjacent to waters of the U.S.	U.S. Environmental Protection Agency (USEPA)
Clean Air Act (CAA)	Establishes limits on how much of an air pollutant can be present in an area anywhere in the U.S. to promote uniformity in basic health and environmental protections	USEPA
Coastal Zone Management Act (CZMA)	Establishes a national coastal management program that comprehensively manages and balances competing uses of and impacts to any coastal area or resource	NOAA, National Ocean Service
Farmland Protection Policy Act (FPPA)	Minimizes the extent to which Federal programs contribute to the unnecessary conversion of farmland to nonagricultural uses	U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS)
Wild and Scenic Rivers Act of 1968	Establishes a National Wild and Scenic Rivers System to protect and preserve the free-flowing waters of the nation's most spectacular rivers. The act safeguards the special character of these rivers while striving to balance river development with permanent protection. The act prescribes the methods and standards through which additional rivers may be identified and added to the system to study areas and submit proposals to the President and Congress for addition to the system.	Secretary of the Interior and the Secretary of Agriculture
Estuary Protection Act	Authorizes study and inventory of U.S. estuaries, including	Secretary of the Interior

of 1968	land and water of the Great Lakes, to determine whether such areas should be acquired by the Federal Government for protection	
Federal Water Project Recreation Act of 1965	Declares recreation and fish and wildlife enhancement be given full consideration as purposes of Federal water development projects if non-Federal public bodies agree to: (1) bear not less than one-half the separable costs allocated for recreational purposes or twenty-five percent of the cost for fish and wildlife enhancement; (2) administer project land and water areas devoted to these purposes; and (3) bear all costs of operation, maintenance and replacement	Secretary of the Interior
Resource Conservation and Recovery Act (RCRA) of 1976	Provides for comprehensive 'cradle-to-grave' regulation of hazardous waste and authorizes environmental agencies to order the cleanup of contaminated sites	USEPA
Toxic Substances Control Act (TSCA) of 1976	Enacted by Congress to give USEPA the ability to track the 75,000 industrial chemicals currently produced or imported into the U.S.	USEPA
Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA)	Regulates ocean dumping in the territorial seas or the contiguous zone of the U.S. and provides for general research on ocean resources (includes designation of marine sanctuaries) and ocean disposal activities	USEPA/NOAA
Section 9 of the Rivers and Harbors Act of 1899	Prohibits the construction of any bridge, dam, dike, or causeway over or in any port, roadstead, haven, harbor, canal, navigable river, or other navigable water of the U.S. until receiving consent of Congress	Corps
Coastal Barrier Resources Act (CBRA)	Designated various undeveloped coastal barrier islands, depicted by specific maps, for inclusion in the Coastal Barrier Resources System (System). Areas so designated were made ineligible for direct or indirect Federal financial assistance that might support development, including flood insurance, except for emergency life-saving activities. Exceptions for certain activities, such as fish and wildlife research, are provided, and National Wildlife Refuges and other, otherwise protected areas are excluded from the System.	Department of Interior, USFWS
EO 11988, Floodplain Management	Requires Federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative	Federal Emergency and Management Agency (FEMA)
EO 11990, Protection of Wetlands	Minimizes the destruction, loss or degradation of wetlands and preserves and enhances the natural and beneficial values of wetlands	USFWS
EO 12114, Environmental Effects Abroad of Major Federal Actions	Enables Federal agencies responsible for authorizing and approving actions to be informed of pertinent environmental considerations and to take such considerations into account, with other pertinent considerations of national policy, in making decisions regarding such actions	All Federal agencies
EO 12898: Environmental Justice	Requires Federal agencies to incorporate into NEPA documents an analysis of the environmental effects of their proposed programs on minorities and low-income	USEPA

	populations and communities.	
EO 13045: Protection of Children from Environmental Health Risks and Safety Risks	Each Federal agency is to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children. The President also directed each Federal agency to ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.	USEPA
Wilderness Act of 1964	Assures that an increasing population, accompanied by expanding settlement and growing mechanization, does not occupy and modify all areas within the U.S. and its possessions, leaving no lands designated for preservation and protection in their natural condition, it is hereby declared to be the policy of the Congress to secure for the American people of present and future generations the benefits of an enduring resource of wilderness.	All Federal agencies
Magnuson Fishery Conservation and Management Act and Essential Fish Habitat (EFH)	Establishes and delineates an area from the states' seaward boundary out 200 nautical miles as a fisheries conservation zone for the U.S. and its possessions Established national standards for fishery conservation and management, and created eight regional Fishery Management Councils (FMCs) to apply those national standards in FMCs EFH is defined as the water and substrate necessary for fish spawning, breeding, feeding, and growth to maturity.	NOAA Fisheries

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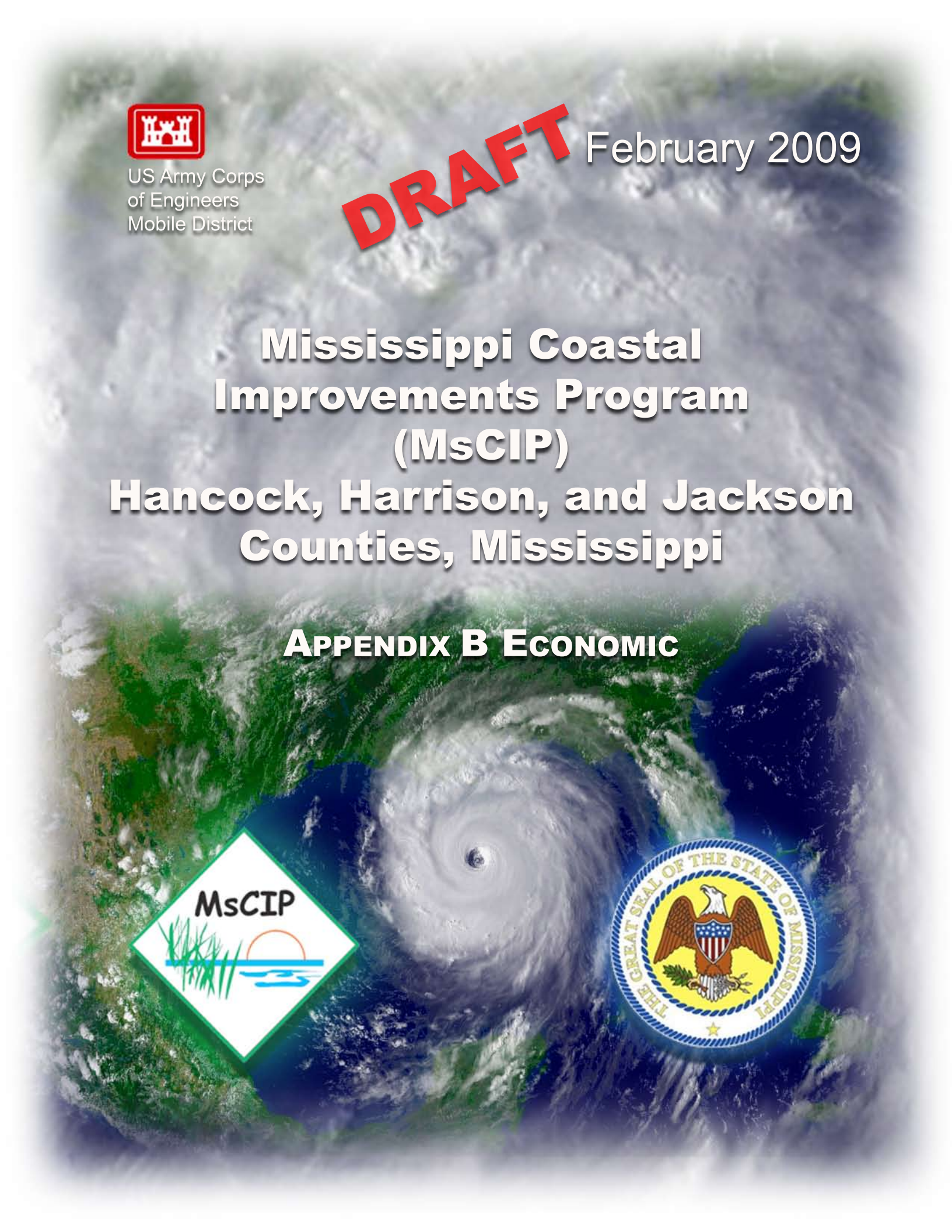
US Army Corps
of Engineers
Mobile District

DRAFT

February 2009

Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

Appendix B Economic



FOREWORD

This document is one of a number of technical appendices to the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Feasibility Report and Environmental Impact Statement.

The Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Integrated Feasibility Report and Environmental Impact Statement provides systems-based solutions and tentatively-selected recommendations that address: hurricane and storm damage reduction, ecosystem restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion. The tentatively-selected recommendations contained in the Main Report/EIS also provide measures that aid in: greater coastal environmental and societal resiliency, regional economic re-development, and measures to reduce long-term risk to the public and property, as a consequence of hurricanes and coastal storms. The tentatively-selected recommendations cover a comprehensive package of projects and activities that treat the environment, wildlife, and people, as an integrated system that requires a multi-tiered and phased approach to recovery and risk reduction, irrespective of implementation authority or agency.



The MsCIP Study Area

The purpose of the Comprehensive Plan Report is to present, to the Congress of the United States, the second of two packages of tentatively-selected recommendations (i.e., the first being the "interim" recommendations funded in May 2007, and this "final" response, as directed by the Congress), directed at recovery of vital water and related land resources damaged by the hurricanes of 2005, and development of tentatively-selected recommendations for long-term risk reduction and community and environmental resiliency, within the three-county, approximately 70 mile-long coastal zone, including Mississippi Sound and its barrier islands, of the State of Mississippi.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and an External Peer Review (EPR). Both review processes will have been conducted in accordance with the Corps "Peer Review of Decision Documents" process, has been reviewed by Corps staff outside the originating office, conducted by a Regional and national team of experts in the field, and coordinated by the National Center of Expertise in Hurricane and Storm Damage Protection, North Atlantic Division, U.S. Army Corps of Engineers.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing tentatively-selected recommendations directed at assisting the people of the State of Mississippi in recovery, recommended actions and projects that would assist in the recovery of the physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

This appendix contains detailed technical information used in the analysis of existing and future without-project conditions, in the development of problem-solving measures, and in the analysis, evaluation, comparison, screening, and selection of alternative plans, currently presented as tentatively-selected recommendations contained in the Main Report/EIS.

Each appendix functions as a complete technical document, but is meant to support one particular aspect of the feasibility study process. However, because of the complexity of the plan formulation process used in this planning study, the information contained herein should not be used without parallel consideration and integration of all other appendices, and the Main Report/EIS that summarizes all findings and tentatively-selected recommendations.

The intent of the economic appendix is to outline the economic evaluation conducted for the Mississippi Coastal Improvements Programs (MsCIP) Comprehensive Plan. This appendix will display the National Economic Development (NED) benefits, Regional Economic Development (RED) benefits, Environmental Quality (EQ) benefits, Other Social Effects (OSE), and costs that were evaluated for the various Comprehensive Plan measures. The intent of this appendix is to demonstrate the cost effectiveness of measures. Tentatively-selected recommendations of cost effective plans are outlined in the MsCIP Main Report, and are based on the data from this appendix, other technical appendices, and the results of the Risk Informed Decision Framework (RIDF) evaluations.

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LIST OF ACRONYMS

AAFU – Average Annual Functional Units

ABFE – Advisory Base Flood Elevation

BFE – Base Flood Elevation

CEFIT – Corps of Engineers Flood Inventory Tool

EAD – Equivalent Annual Damages

EIFS – Economic Impact Forecast System

EGM – Economic Guidance Memorandum

EM – Engineering Manual

EQ – Environmental Quality

ER – Engineering Regulation

ERDC – Engineer Research and Development Center

FEMA – Federal Emergency Management Agency

FHI – Functional Habitat Unit

HEC-FDA – Hydrologic Engineering Centers - Flood Damage Analysis

IWR – Institute for Water Resources

LaCPR – Louisiana Coastal Protection and Restoration

MEMA – Mississippi Emergency Management Agency

MPI – Maximum Probable Intensity

MsCIP – Mississippi Coastal Improvements Program

NAVD88 – North American Vertical Datum 1988

NED – National Economic Development Benefits

NFIP –National Flood Insurance Program

OSE – Other Social Effects

P&G – Planning and Guidance

RED – Regional Economic Development

ROM Costs – Rough Order Magnitude Costs

USACE – US Army Corps of Engineers

EXECUTIVE SUMMARY

General

The intent of the economic appendix is to outline the economic evaluation conducted for the Mississippi Coastal Improvements Programs (MsCIP) Comprehensive Plan. This appendix will display the National Economic Development (NED) benefits, Regional Economic Development (RED) benefits, Environmental Quality (EQ) benefits, Other Social Effects (OSE), and costs that were evaluated for the various Comprehensive Plan measures. The intent of this appendix is to demonstrate the cost effectiveness of measures. Plan features of cost effective plans are outlined in the MsCIP Main Report, and are based on the data from this appendix, other technical appendices, and the results of the Risk Informed Decision Framework (RIDF) evaluations.

Authorizing Language

The Coastal Mississippi Comprehensive Plan Report was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states: ***"For an additional amount for "investigations" to expedite studies of flood and storm damage reduction related to the consequences of hurricanes in the Gulf of Mexico and Atlantic Ocean in 2005, $37,300,000 to remain available until expended: Provided, that using $10,000,000 of the funds provided, the Secretary shall conduct an analysis and design for comprehensive improvements or modifications to existing improvements in the coastal area of Mississippi in the interest of hurricane and storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resource purposes at full Federal expense; Provided further, that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project plan features based upon maximizing net national economic development benefits; Provided further, that interim plan features for near term improvements shall be provided within 6 months of enactment of this act with final plan features within 24 months of this enactment."***

The requirements laid out in this authorizing language are unique in their direction that the study team use neither incremental cost-benefit analysis nor maximization of net national economic development (NED) benefits in the selection of plan features. This provided a unique opportunity, but also the requirement that the team very carefully describe the plan formulation and selection process developed for this study effort.

Study Purpose and Scope

The purpose of the comprehensive study is to present the second of two packages of tentatively-selected plan features, the "final" response requested by Congress, directed at recovery of vital water and related land resources damaged by the hurricanes of 2005 within the three-county coastal region of the State of Mississippi. The report presents background on the three coastal counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing plan features directed at assisting the people of the State of Mississippi in recovery, recommended actions and projects that would assist in the recovery of the

physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for coastal Mississippi.

Study Area

Delineation of the study area is critical for the evaluation of benefits and for their aggregation to determine the economic value of proposed measures. The over all study area for this analysis is the three coastal Mississippi counties; Hancock, Harrison, and Jackson from west to east respectively. The area was further delineated into planning zones, planning units, and planning sub-units.

The first delineation in the hierarchy of segregating the study area was the creation of four planning zones, as shown below in figure 1. The planning zones span the width of Mississippi from state line to state line, and run from south to north. The four zones have been titled the Off-shore Zone, the Coastal Zone, the Inland Zone, and the Upland Zone from south to north respectively. The Off-shore zone includes all areas south of the Mississippi Sound shoreline. The Coastal Zone includes all areas generally from the shoreline North to the CSX railroad and terminating at the Port Bienville railroad spur in Hancock County and Hwy 52 in Jackson County. The Inland Zone accounts for all areas north of the Coastal Zone to the MPI storm surge limit, and the Upland Zone extends from north of the MPI storm surge limit to the County lines.

For the comprehensive plan, the three coastal counties were divided into three planning units based on watershed boundaries which, coincidentally, align with the county jurisdictions. Planning unit one begins at the western state boundary, or the east bank of the Pearl River, and continue to the midpoint of St. Louis Bay. Planning unit two begins at the midpoint of St. Louis Bay and continues east to the midpoint of Biloxi Bay. Planning unit three extends from the midpoint of Biloxi Bay east to the border of Mississippi and Alabama.

Further delineation of the area required breaking the planning units into fifty-four planning sub-units based on hydrologic characteristics, population centers, and economic considerations of potential measure. For hydraulic considerations, Hurricane Surge Atlas maps were evaluated. These maps were prepared by FEMA and the Corps of Engineers, Mobile District from **SLOSH** (Sea, Lake, and Overland Surges from Hurricanes) programming done by the National Oceanic &Atmospheric Administration (NOAA). Sub-units were delineated so that the maximum storm surge difference between sub-units was approximately two-feet. Planning unit one includes ten sub-units, planning unit two eighteen sub-units, and planning unit three twenty-six sub-units. Figure 2 depicts the 54 planning sub-units.

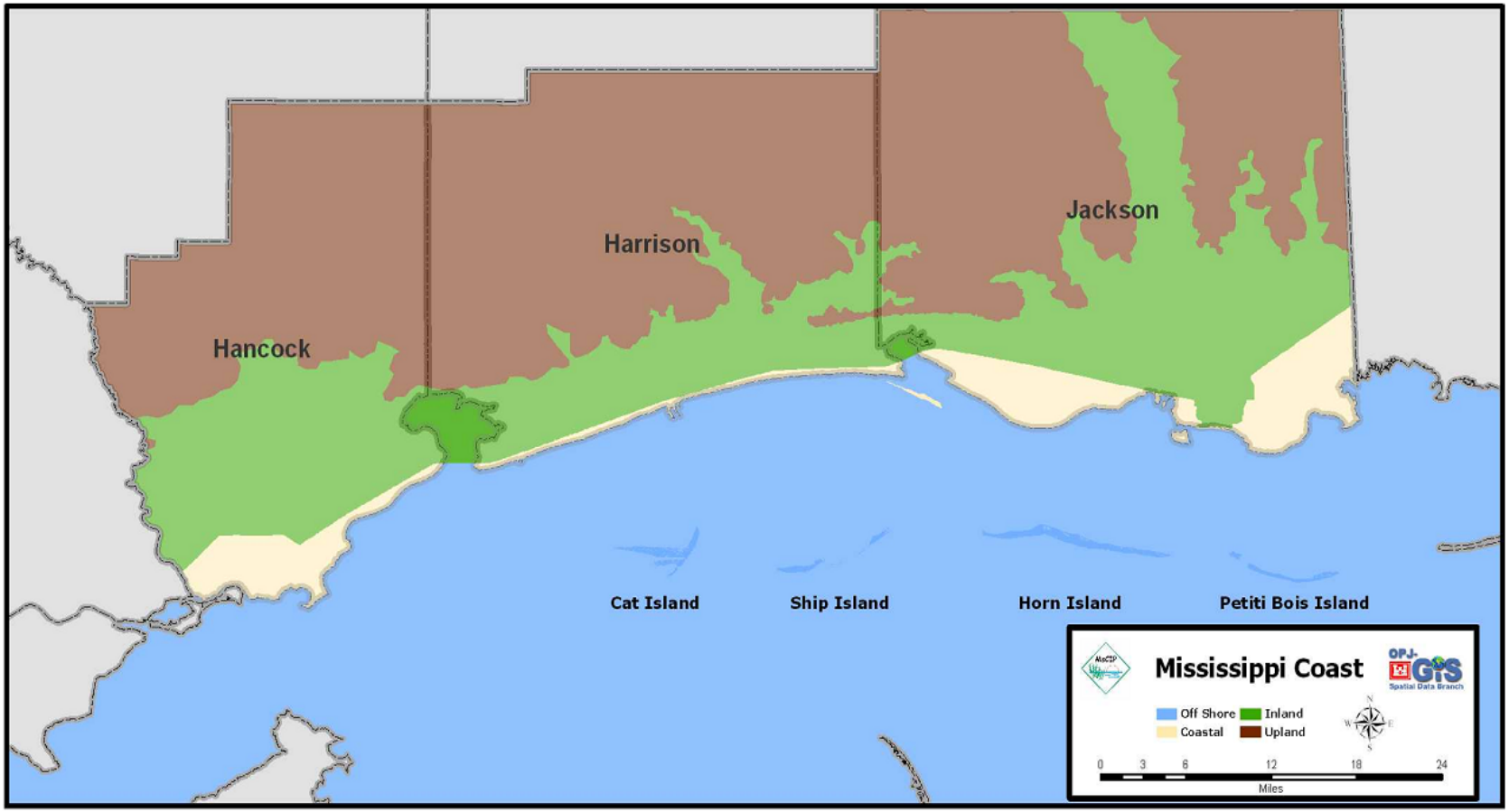


Figure 1. MsCIP Planning Zones

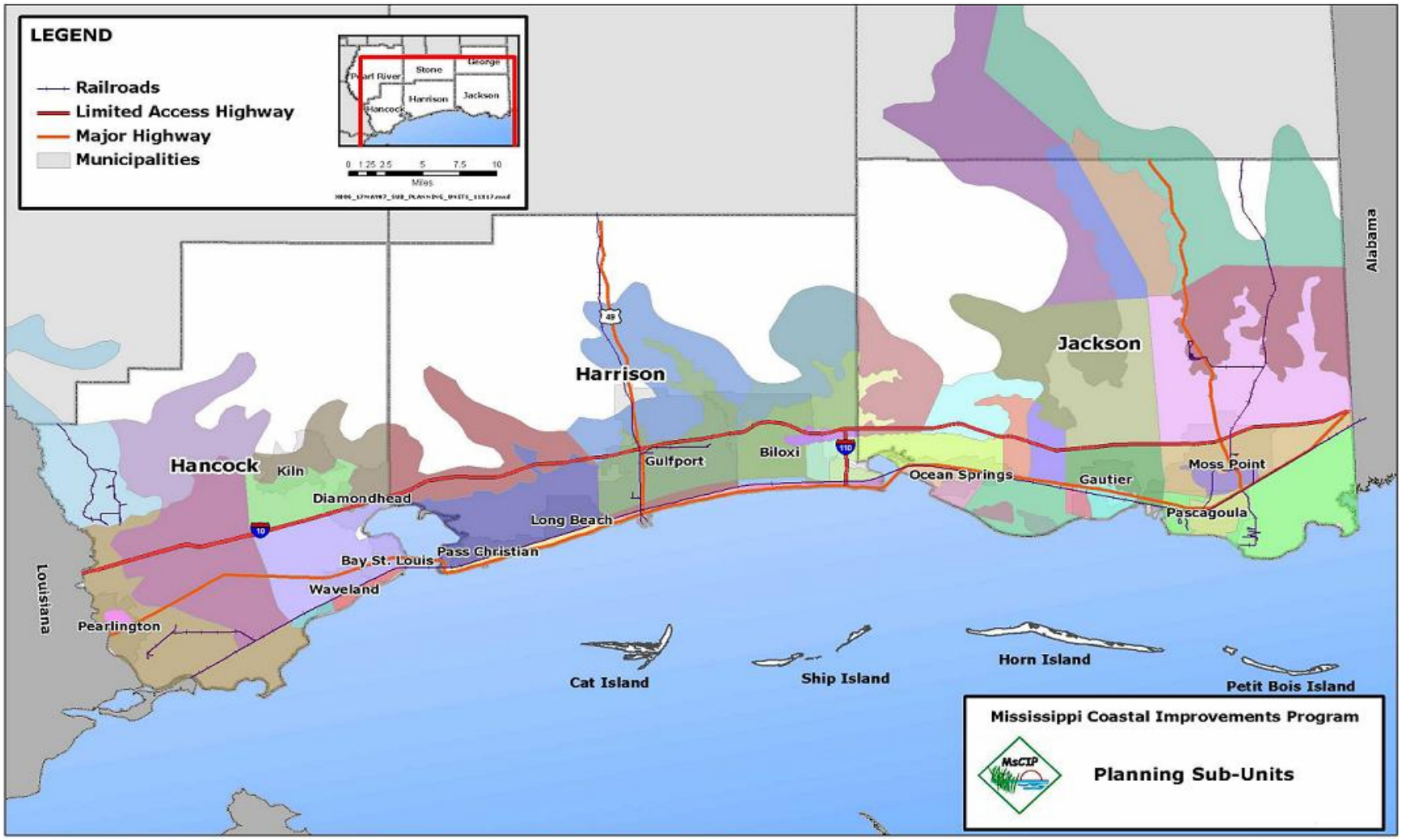


Figure 2. Overview of 3 planning units 54 planning sub-units

Economic Methodology

The economic methodology was developed to seamlessly fit into the six step planning process and current Corps guidance. The six step planning process, as defined by the Engineering Regulation (ER) 1105-2-100; Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council 1983), referred to as the P&G, is:

1/ Identify Problems and Opportunities
2/ Inventory and Forecast Conditions
3/ Develop Alternatives
4/ Evaluate Alternatives
5/ Compare Alternatives
6/ Select the Recommended Plan

The Mississippi Gulf Coast is a complex system that is made up of a diverse blend of ecological and human habitats. Given those complexities, a fluid and flexible process was needed to evaluate and aggregate the benefits of potential measures and measures. The process incorporates data collection, forecasting techniques, scenario planning, cost effective evaluation using state of the art modeling techniques, and the communication of both benefits and risks associated with potential measures and measures. Figure 3 outlines the process used for this analysis.

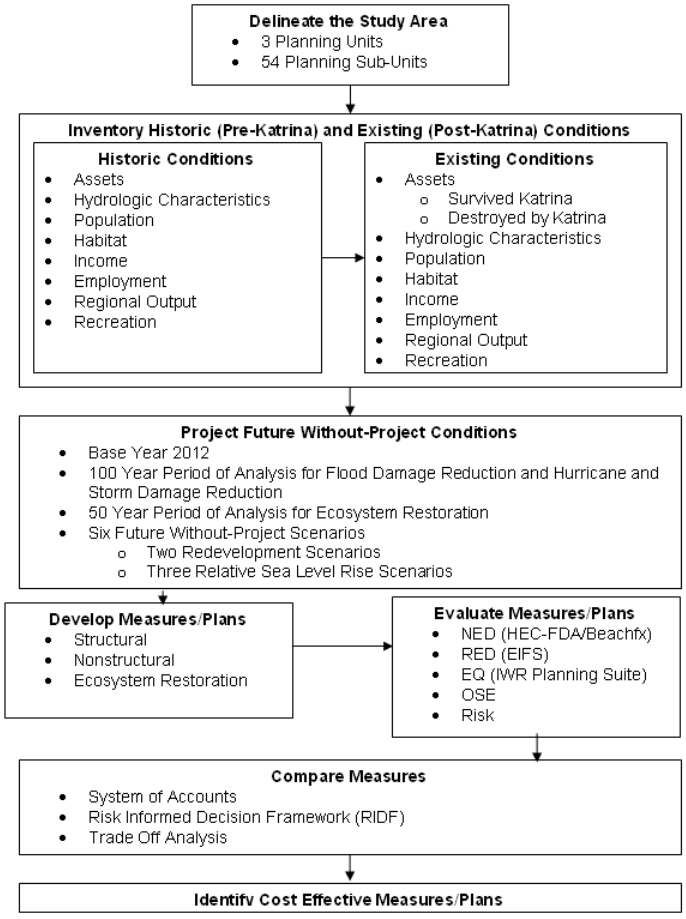


Figure 3. Overview of Economic Methodology

Historic Conditions

The Mississippi Gulf Coast is no stranger to large storm surge events. On August 17, 1969, Hurricane Camille impacted the area in a similar fashion to Hurricane Katrina. Hurricane Camille made landfall at Bay St. Louis, Mississippi only miles way from Hurricane Katrina's landfall path. The total surge area ranged from lower Plaquemines Parish in Louisiana to Perdido Pass, Alabama. Maximum surge from Hurricane Camille on the Mississippi coast ranged from 21.7-feet above m.s.l. in planning unit one, to 24.2-feet above m.s.l. in planning unit two, and 15.8-feet above m.s.l. in planning unit 3.

Damage to the Mississippi Coast from Hurricane Camille was extensive. Federal relief expenditures topped 100 million dollars at 1970 prices, over 600 million dollars when accounted for inflation. The magnitude of this number is astounding considering that many of the relief programs that exist today did not exist for Hurricane Camille. Table 1 shows selected Hurricane Camille damage statistics. Tables 2 and 3 show damage to residential and commercial structures caused by Hurricane Camille surge.

Table 1.
Select Hurricane Camille Statistics.

Camille Statistics	Mississippi	Louisiana	Alabama
Persons Dead	135	9	Unknown
Persons Missing	27	0	Unknown
Families Suffering Loss	63,665	9,442	750
Dwellings Destroyed	3,881	1,771	10
Dwellings with major damage	12,112	1,753	50
Dwellings with minor damage	29,736	3,697	500
Trailers destroyed	406	664	12
Trailers with major damage	325	290	6
Farm buildings destroyed	645	114	5
Farm buildings with major damage	2,002	97	5
Small businesses destroyed or with major damage	569	110	14
Damage to public property	$200,000,000	$10,000,000	$500,000
Damage to private property	$750,000,000	$312,000,000	$7,500,000

1 Source: Report on Hurricane Camille U.S. Army Corps of Engineers – MOBILE DISTRICT

2 These dollars reflect a 1970 price level.

Table 2.
Damage to Structures Caused by Hurricane Camille Surge.

County	Destroyed	Damaged	Total Homes Impacted
Hancock	988	4,217	**5,205**
Harrison	2,608	8,983	**11,591**
Jackson	280	1,289	**1,569**
Total	3,876	14,489	**18,365**

1 Source: Report on Hurricane Camille U.S. Army Corps of Engineers – MOBILE DISTRICT

The 1950-2000 population levels and growth for the U.S., Mississippi, the three-county study area, and each county are presented in Table 3. During this fifty year period, the population of the three-county study area grew by 186.6 percent. This is 5.6 times the Mississippi percentage population

growth of 33.2 percent and 2.2 times the U.S. percentage population growth of 86.0 percent for the same timeframe. The three-county area accounted for 32.7 percent of the nominal population growth for Mississippi from 1950 to 2000.

Table 3.
1950-2000 Population Levels and Growth (in thousands)

	United States	Mississippi	Three-County Study Area	Hancock County	Harrison County	Jackson County
1950	151,326	2,179	127	12	84	31
1960	179,323	2,178	189	14	119	56
1970	203,212	2,217	239	17	134	88
1980	226,546	2,521	301	25	158	118
1990	248,710	2,573	312	32	165	115
2000	281,421	2,903	364	43	190	131
50 Year Nominal Change	130,095	724	237	31	106	100
50 Year Percentage Change	86.0%	33.2%	186.6%	258.3%	126.2%	322.5%

Source: U.S. Census Bureau, 2000 Census

Existing Conditions

On August 29, 2005, Hurricane Katrina made land fall in Hancock County, Mississippi just east of the Pearl River. By virtually all accounts, it was the single largest disaster in U.S. history. Storm surge from Hurricane Katrina was the largest that has ever hit the continental United States. The surge inundated approximately 484 square miles of southern Mississippi. The relief expenditures in Mississippi alone have totaled in the billions of dollars.

The three planning units suffered tremendous devastation from Hurricane Katrina's surge. It is estimated that 32,446 structures were significantly destroyed (at least fifty-percent or more), with another 15,000 to 25,000 suffering moderate to minimal inundation damage. Of the structures sustaining significant destruction, 9,555 were in planning unit one, 16,528, in planning unit two, and 6,363 in planning unit three. Of those significant loss structures, approximately 19,000 claims were paid out by the Federal Emergency Management Agency's (FEMA's) National Flood Insurance Program (NFIP) totally over $2.3 Billion dollars, with the average claim around $137,000. Currently, no accurate data exists for uninsured losses, but estimates also range in the billions of dollars. Table 4 displays the significantly damaged structures by planning unit and by structure category. Figure 4 shows an example of the destruction caused by Hurricane Katrina in the planning unit one.

Table 4.
Structures Damaged 50% or More by Planning Unit and by Category

	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Commercial	1,267	1,794	378	**3,439**
Residential	8,099	14,500	5,780	**28,379**
Municipal	127	89	136	**352**
Mobile Home	62	145	69	**276**
Total	**9,555**	**16,528**	**6,363**	**32,446**

Source: U.S. Census Bureau, Population Division



Figure 4. Example of the extent of Hurricane Katrina Surge Damage – Planning Unit One

The 2000-2005 population level and growth estimates for the U.S., Mississippi, the three-county study area, and each county are displayed in Table 5.

Table 5.
2000-2005 Estimates of Population Levels and Growth

	United States	Mississippi	Three-County Study Area	Hancock County	Harrison County	Jackson County
July 1, 2000	282,216,952	2,848,634	364,863	43,283	189,699	131,881
July 1, 2001	285,226,284	2,856,108	366,362	43,944	189,512	132,906
July 1, 2002	288,125,973	2,863,091	367,498	44,607	189,996	132,895
July 1, 2003	290,796,023	2,874,171	367,790	45,166	189,189	133,435
July 1, 2004	293,638,158	2,892,668	372,885	45,821	192,129	134,935
July 1, 2005	296,507,061	2,908,496	375,304	46,546	193,187	135,571
5 Year Nominal Change	14,290,109	59,862	10,441	3,263	3,488	3,690
5 Year Percentage Change	5.06%	2.10%	2.86%	7.54%	1.84%	2.80%

Source: U.S. Census Bureau, Population Division

Future Without-Project Conditions

Forecasting future "without-project" conditions is an important part of the Corps planning process. In order to evaluate the true economic value of potential measures over the project life, a forecast is created based on the historic and existing information, as well as quantitative and qualitative assumptions about what may happen within the study area in the future. In addition to forecasting of future "without-project" conditions, this study also evaluated alternative re-development and relative sea-level rise scenarios. This "Scenario Forecasting" technique was used for the MsCIP Comprehensive Plan in an attempt to capture uncertainty pertaining to these two key variables. For this purpose, six future "without-project" scenarios were developed and are summarized in Table 6.

Table 6.
Overview of Future Scenarios

Future Scenario	Redevelopment Type	Relative Sea Level Rise	Description
Future Scenario 1	Residential	Historical Only	Rebuild structures as existed pre-Hurricane Katrina with no relative sea level rise over the period of analysis. This future scenario applies to all three planning units.
Future Scenario 2	Mixed Residential & Commercial	Historical Only	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, no relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.
Future Scenario 3	Residential	Expected	Rebuild structures as existed pre-Hurricane Katrina with up to 2.4-feet relative sea level rise over the 100-year period of analysis. This future scenario applies to all three planning units.
Future Scenario 4	Mixed Residential & Commercial	Expected	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, an up to 2.4-feet relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.
Future Scenario 5	Residential	High	Rebuild structures as existed pre-Hurricane Katrina with up to 3.4-feet of relative sea level rise over the period of analysis. This future scenario applies to all three planning units.
Future Scenario 6	Mixed Residential & Commercial	High	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, up to3.4-feet of relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.

Future Scenarios One and Two are included only to evaluate the effects of relative sea level rise. These Future scenarios will not be used in the evaluation of potential measures. Futures Three, Four, Five, and Six will be the future scenarios by which potential measures will be evaluated depending on the planning unit.

Structure inventory data was developed for the six future without-project scenarios including structure categories, structure value, content value, and other characteristics, which were input into the HEC-FDA program. Tables 7, 8, and 9 show a summary of select structure characteristics by future without-project scenario and table 10 summarizes the average annual without-project damages by future without-project scenario.

Table 7.
Future Without-Project Scenarios One, Three, and Five Inventory Parcels by Planning Unit and by Structure Category

Structure Categories	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Residential	17,907	49,121	49,688	**116,716**
Mobile Homes	498	2,497	3,553	**6,548**
Commercial	3,255	5,618	4,266	**13,139**
Municipal	653	351	763	**1,767**
Vacant Land	22,843	29,984	29,779	**82,606**
Total	**45,156**	**87,571**	**88,049**	**220,776**

Table 8.
Future Without-Project Scenarios Two, Four, and Six Inventory Parcels by Planning Unit and by Structure Category

Structure Categories	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Residential	17,757	48,636	49,688	**69,942**
Mobile Homes	498	2,497	3,553	**52,687**
Commercial	3,408	6,101	4,266	**13,775**
Municipal	651	381	763	**1,795**
Vacant Land	22,842	29,956	29,779	**82,577**
Total	**45,156**	**87,571**	**88,049**	**220,776**

Table 9.
Structure and Content Values by Category and Planning Unit

	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Future Without-Project Scenarios One, Three, and Five Inventory				
Structure Value Subtotal	**$3,370,979,973**	**$9,284,611,429**	**$5,605,921,896**	**$18,261,513,298**
Content Value Subtotal	**$2,565,304,099**	**$7,011,916,003**	**$3,808,364,637**	**$13,385,584,739**
Total	**$5,936,284,072**	**$16,296,527,432**	**$9,414,286,533**	**$31,647,098,037**
Future Without-Project Scenarios Two, Four, and Six Inventory				
Structure Value Subtotal	**$4,234,629,816**	**$8,944,955,778**	**$5,605,921,896**	**$18,785,507,490**
Content Value Subtotal	$4,012,724,707	$7,074,305,948	$3,808,364,637	**$14,895,395,292**
Total	**$8,247,354,523**	**$16,019,261,726**	**$9,414,286,533**	**$33,680,902,782**

Table 10.
Equivalent Annual Without-Project Damages by Planning Unit and Future Scenario

Without-Project Damages	Future 1[2] Damages	Future 2[2] Damages	Future 3 Damages	Future 4 Damages	Future 5 Damages	Future 6 Damages
Planning Unit One	$198,960,000	$202,060,000	$218,050,000	$222,220,000	$237,310,000	$241,520,000
Planning Unit Two	$91,260,000	$94,680,000	$103,280,000	$107,120,000	$115,470,000	$119,760,000
Planning Unit Three	$88,670,000	$88,670,000	$104,700,000	$104,700,000	$122,420,000	$122,420,000
Total	**$378,890,000**	**$385,410,000**	**$426,030,000**	**$434,040,000**	**$475,200,000**	**$483,700,000**

Damages are rounded to the nearest ten thousand.

Evaluation of Measures and Alternatives

Initial analysis yielded an extensive list of potential measures that were appropriate to a given site or problem area. The sites/problem areas are illustrated in the Main Report. The development of preliminary measures for structural and non-structural damage reduction is discussed in detail in the Engineering Appendix. The development of preliminary measures for ecosystem restoration and saltwater intrusion remediation is discussed in detail in the Environmental Appendix.

Many measures were initially evaluated and screened, based on technical or environmental criteria, and are not discussed here. Those measures that were found to be technically sound for a particular application, and environmentally sound, in regards to potential impacts to environmental resources, were forwarded for evaluation. The development of more detail included preliminary design and cost estimation, coastal, hydrologic and/or hydraulic analysis and design, environmental analysis, and determination of potential damages prevented, residual damages, and other factors. Models used to evaluate the benefits of the measures included the Corps of Engineers Flood Inventory Tool (CEFIT), the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) program, the Beach-FX program, the Institute for Water Resources (IWR) Plan program, and the Economic Impact Forecasting System (EIFS).

Tentatively-Selected Plan features

The system wide plan features for the MsCIP Comprehensive plan, explained in more detail in the Main Report, have multiple levels. Some of the features will be recommended as work for entities other than the Corps of Engineers, some will be recommended for further construction, and some will be recommended for implementation. The list of measures in this appendix which are recommended for further study include the ring levee and nonstructural measures at the Pearlington, Ocean Springs, Gautier, Gulf Park Estates, Belle Fontaine, and Pascagoula/Moss Point areas, as well as further inquiry into the coast wide 20-foot, 30-foot, and 40-foot elevation nonstructural measures. Among the list of tentatively-selected plan features for construction that were analyzed in this appendix include barrier island restoration, beach and dune placement, ecosystem restoration at the Admiral Island, Turkey Creek, Bayou Cumbest, Dantzler, and Franklin Creek areas, the 21-foot elevation levee at the Forrest Heights area, and the acquisition of parcels within high risk areas.

For planning and screening purposes, the analysis in this appendix used a 100-year period of analysis for measures that were determined to be complex in nature such as the barrier island restoration or measures that had a high risk of residual damages due to relative sea level rise such as flood risk management measures. Other measures that were not as complex in nature, such as the beach and dune placement and the ecosystem restoration measures were evaluated at the traditional 50-year period of analysis used in Corps of Engineers studies. In order to show consistency among the plans recommended for construction, those measures that were initially screened at a 100-year period of analysis have been converted to a 50-year period of analysis for costs and benefits and are summarized in table 11. The costs in table 11 represent Rough Order Magnitude (ROM) utilized for screening. Detailed Micro-Computer Aided Cost Estimating System (MCACES) costs can be found in the cost estimating appendix.

Table 11.
Summaries of Benefits and Costs for Measures Recommended for Implementation[1]

	Equivalent annual damages Reduced Future 3 (Annual $)	Recreation (Annual $)	Environmental Impacts	Changes in Sales Volume ($)	Changes in Income ($)	Changes in Employment	Total First Cost with IDC[2] ($)	Average Annual Cost (Annual $)
Barrier Island Restoration	$18,028,000	$466,000	$43,618,000 Fishery Losses Avoided	$798,984,000	$167,850,000	4,920	$370,439,000	$20,372,000
Beach and Dune Placement	Moderate Reduction	N/A	736 Functional Habitat Index (FHI) Score	$33,413,200	$7,307,000	208	$15,890,800	$854,000
Acquisition in High Risk Areas	$22,000,000 to $33,000,000	Potential Recreational Opportunities	Potential Restoration Opportunities	$3,238,602,000	$706,330,000	19,452	$447,274,000	$18,532,000
Forrest Heights 21-FT Ring Levee	$89,000	N/A	3.6 Acres Impacted	$30,425,000	$6,440,000	193	$11,652,000	$740,000
Admiral Island Ecosystem Rest.	Increased Surge Storage	N/A	60 Average Annual Functional Units (AAFU)	$49,750,000	$ 11,996,000	301	$24,320,000	$1,364,000
Turkey Creek Ecosystem Rest.	Increased Surge Storage	N/A	1,565 Average Annual Functional Units (AAFU)	$15,237,000	$3,226,000	97	$6,017,000	$370,000
Bayou Cumbest Ecosystem Rest.	Increased Surge Storage	N/A	188 Average Annual Functional Units (AAFU)	$54,073,000	$ 10,546,000	306	$23,870,000	$1,396,000
Dantzler Ecosystem Rest.	Increased Surge Storage	N/A	1,244 Average Annual Functional Units (AAFU)	$ 5,054,000	$ 986,000	29	$1,922,000	$129,000
Franklin Creek Ecosystem	Increased Surge Storage	N/A	516 Average Annual Functional Units (AAFU)	$3,890,000	$ 759,000	22	$1,670,000	$101,000

1/ These measures were analyzed for economic benefits and do not represent the entire tentatively-selected plan features for implementation. See the main report for more detail.
2/ Implementation costs are based on ROM cost estimates and an FY 08 price level and do not include escalation. See the engineering appendix for more details on the costs.
3/ Average annual damages reduced and costs are based on a 50-year period of analysis and an FY 08 discount rate of 4.875-percent. Dollar values are rounded to the nearest thousand.

CHAPTER I. DEFINING THE STUDY AREA

This section describes the location and delineation of the study area used in this analysis. Delineation of the study area is critical for the evaluation of benefits and for their aggregation to determine the economic value of proposed measures. The over all study area for this analysis is the three coastal Mississippi counties; Hancock, Harrison, and Jackson from west to east respectively. The area was further delineated into planning zones, planning units, and planning sub-units which are detailed in the following subsections. Figure 1-1 shows the congressionally mandated study area for the Mississippi Coastal Improvements Program.



Figure 1-1. Congressionally authorized study area

1.3.1 Planning Zones

The first delineation in the hierarchy of segregating the study area was the creation of four planning zones. The planning zones span the width of Mississippi from state line to state line, and run from south to north. The four zones have been titled the Off-shore Zone, the Coastal Zone, the Inland Zone, and the Upland Zone from south to north respectively. The Off-shore zone includes all areas south of the Mississippi Sound shoreline. The Coastal Zone includes all areas generally from the shoreline North to the CSX railroad and terminating at the Port Bienville railroad spur in Hancock County and Hwy 52 in Jackson County. The Inland Zone accounts for all areas north of the Coastal Zone to the MPI storm surge limit, and the Upland Zone extends from north of the MPI storm surge limit to the County lines. Figure 1-2 depicts the four planning zones.

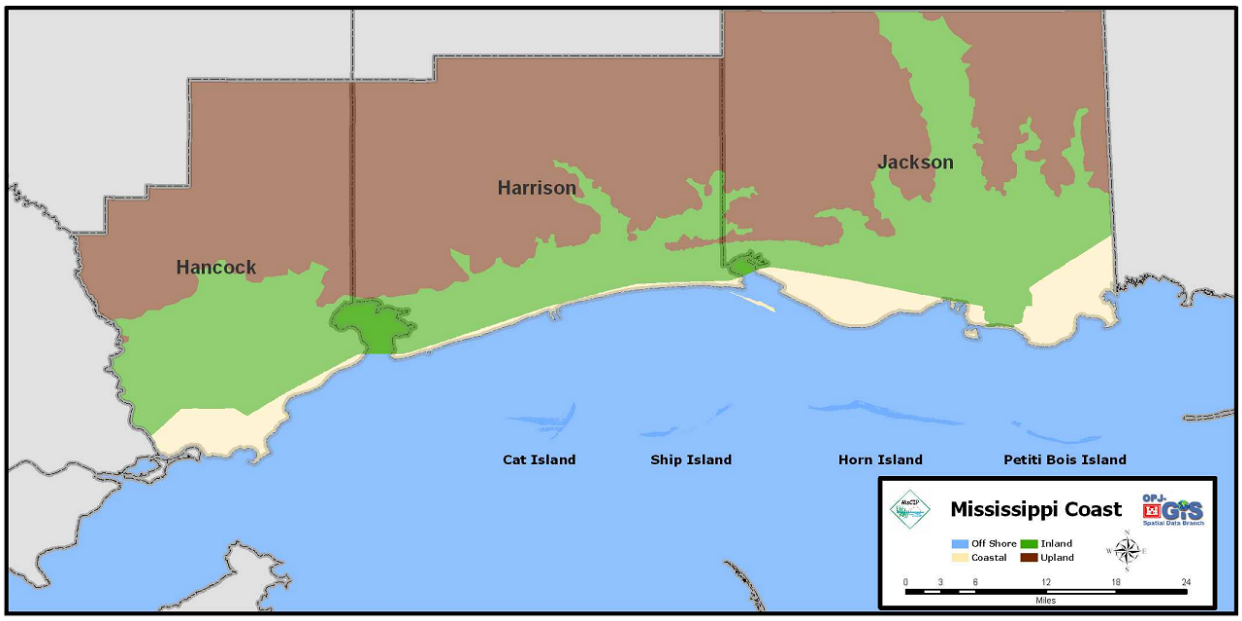


Figure 1-2. Planning Zones

1.3.2 Planning Units

For the comprehensive plan, the three coastal counties were divided into three planning units based on watershed boundaries which, coincidentally, align with the county jurisdictions. Planning unit one begins at the western state boundary, or the east bank of the Pearl River, and continue to the midpoint of St. Louis Bay. Planning unit two begins at the midpoint of St. Louis Bay and continues east to the midpoint of Biloxi Bay. Planning unit three extends from the midpoint of Biloxi Bay east to the border of Mississippi and Alabama. Figure 1-3 shows the planning unit boundaries.

1.3.3 Planning Sub-Units

Further delineation of the area required breaking the planning units into fifty-four planning sub-units based on hydrologic characteristics, population centers, and economic considerations of potential measure. For hydraulic considerations, Hurricane Surge Atlas maps were evaluated. These maps were prepared by FEMA and the Corps of Engineers, Mobile District from **SLOSH** (Sea, Lake, and Overland Surges from Hurricanes) programming done by the National Oceanic &Atmospheric Administration (NOAA). Sub-units were delineated so that the maximum storm surge difference between sub-units was approximately two-feet. Planning unit one includes ten sub-units, planning unit two eighteen sub-units, and planning unit three twenty-six sub-units. Figures 1-4 shows all the sub-units and figures 1-5, 1-6, and 1-7 illustrate the planning units one, two, and three and their sub-units, respectively.

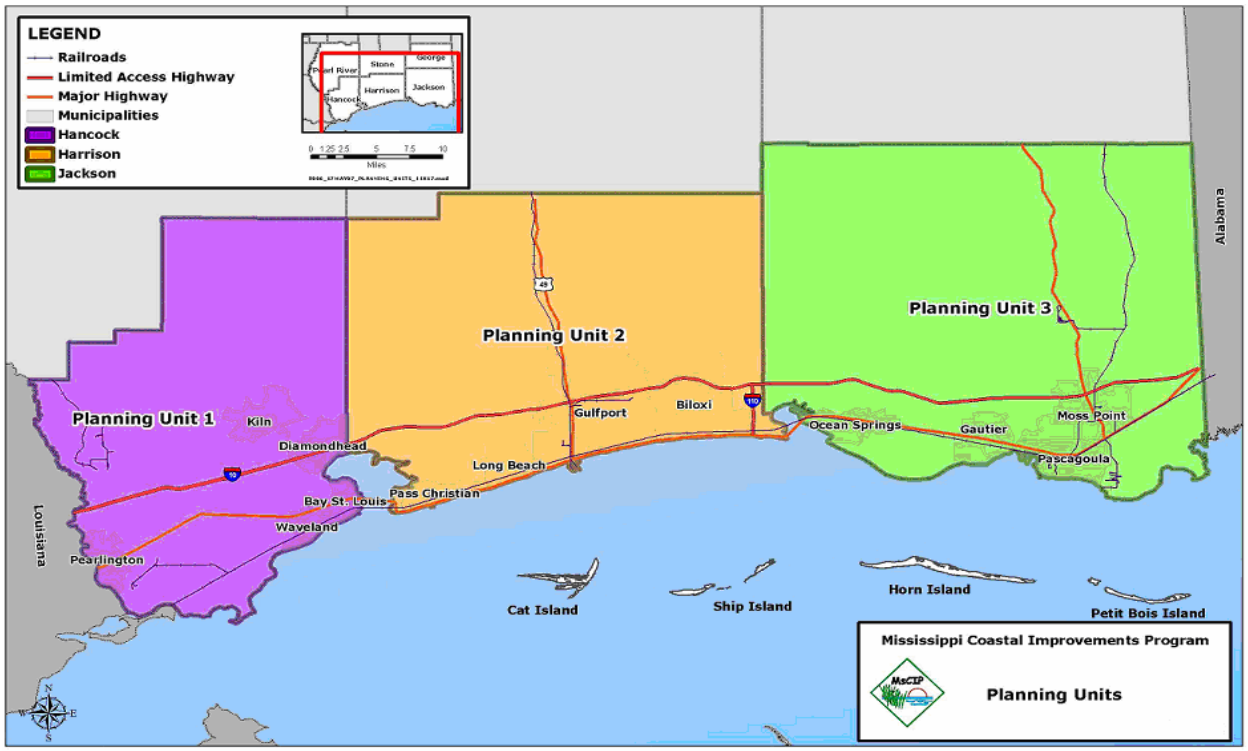


Figure 1-3. Planning Units

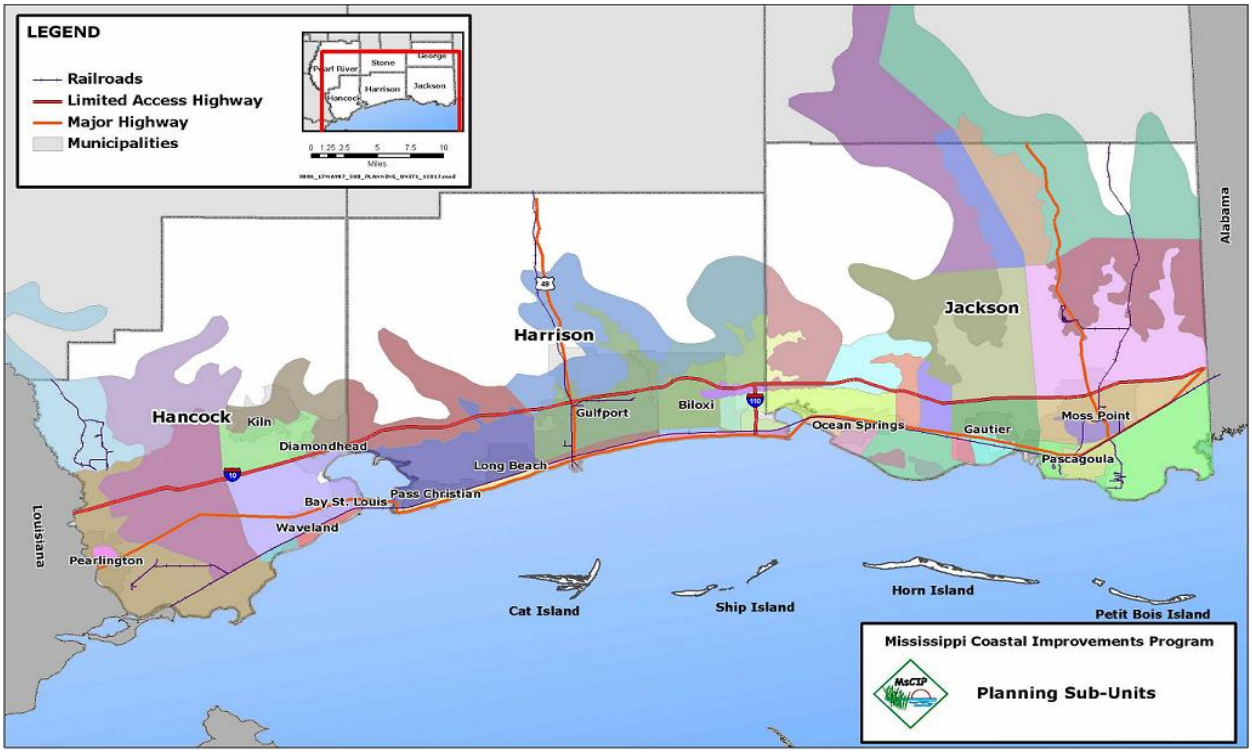


Figure 1-4. Overview of 54 planning sub-units

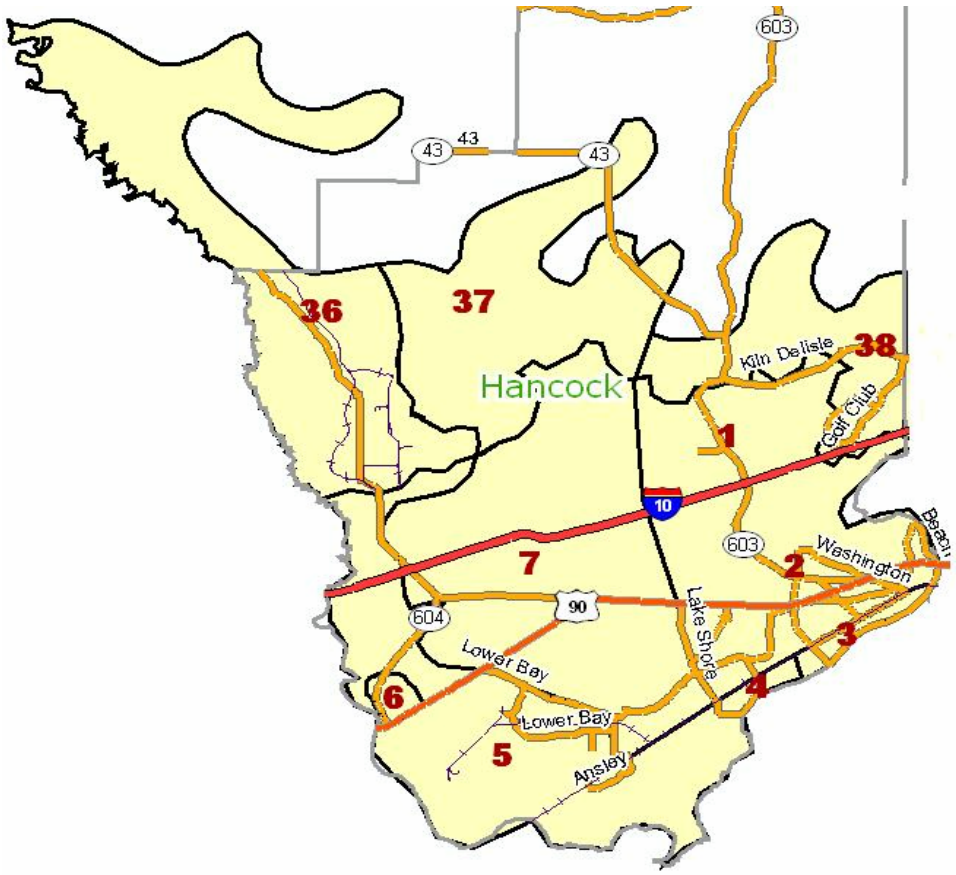


Figure 1-5. Sub-units for Planning Unit One

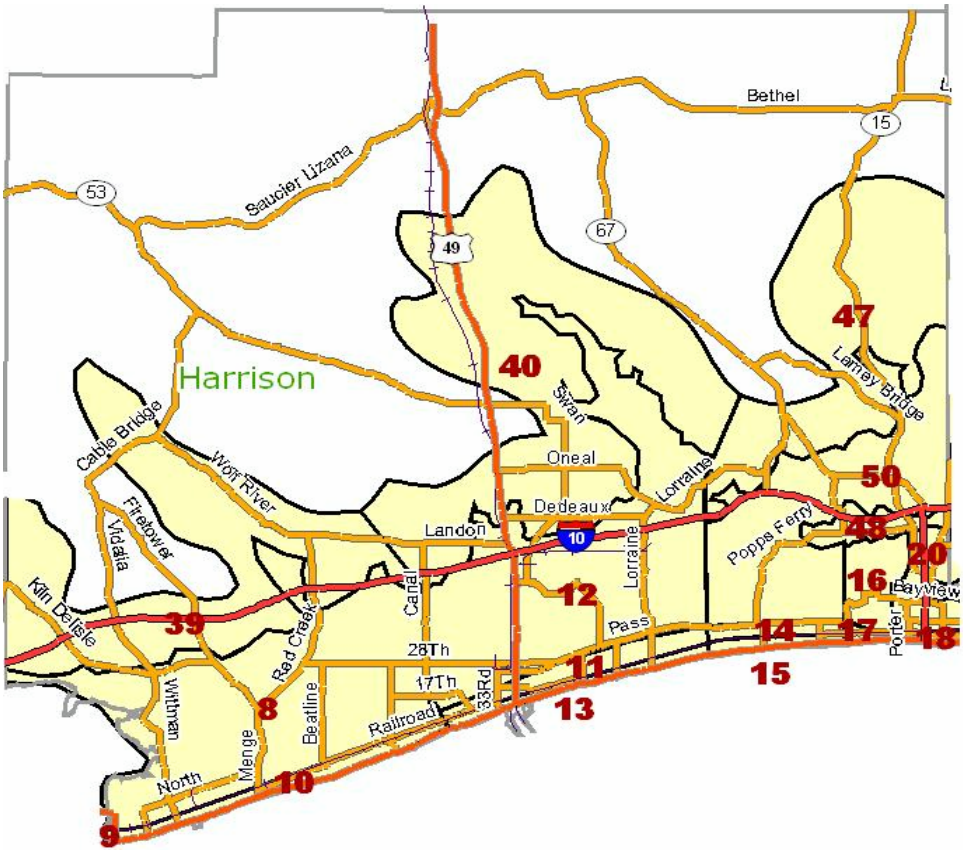


Figure 1-6. Sub-units for Planning Unit Two

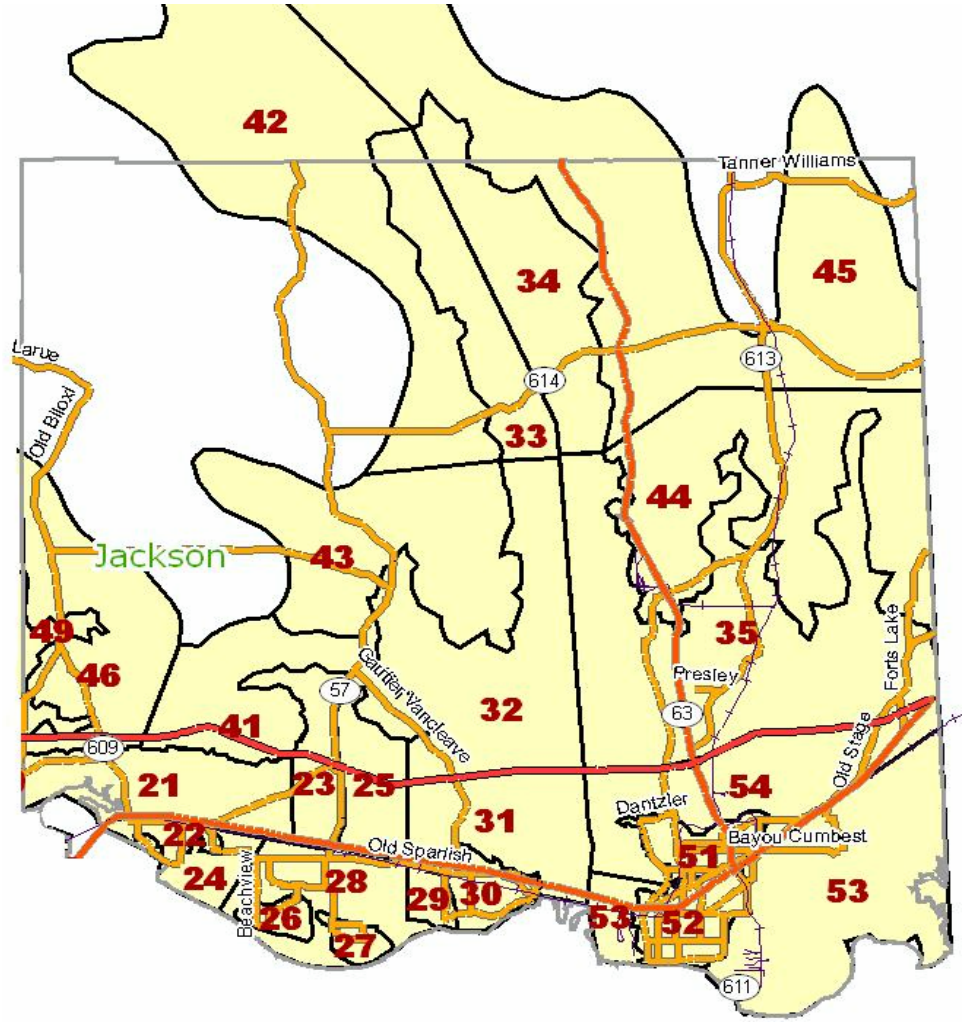


Figure 1-7. Sub units for Planning Unit Three

CHAPTER II. OVERVIEW OF ECONOMIC METHODOLOGY

This section describes the methodology for the evaluation of economic impacts of potential solutions for the Mississippi Gulf Coast under the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Report. It is intended to be an outline of the process used to determine the economic impacts that are fully detailed throughout this appendix and in the main report. The methodology was developed to seamlessly fit into the six step planning process and current Corps guidance. The six step planning process, as defined by the Engineering Regulation (ER) 1105-2-100; Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council 1983), referred to as the P&G, is:

1/ Identify Problems and Opportunities
2/ Inventory and Forecast Conditions
3/ Develop Alternatives
4/ Evaluate Alternatives
5/ Compare Alternatives
6/ Select the Recommended Plan

The Mississippi Gulf Coast is a complex system that is made up of a diverse blend of ecological and human habitats. Given those complexities, a fluid and flexible process was needed to evaluate and aggregate the benefits of potential measures and measures. The process incorporates data collection, forecasting techniques, scenario planning, cost effective evaluation using state of the art modeling techniques, and the communication of both benefits and risks associated with potential measures and measures. Figure 2-1 outlines the process used for this analysis.

The first step in the process was to delineate the study area. The overarching study area, as defined by Congress, is the three coastal counties in Mississippi; Hancock, Harrison and Jackson from west to east respectively. For purposes of system wide evaluation and aggregating benefits, the study area was divided into four planning zones, three planning units, and fifty-four sub-planning units. These are described in more detail in the following section.

Once the planning zones, planning units, and planning sub-units were identified, the next step was inventorying the economic, social, and environmental characteristics of the area. Data from Local, State, and Federal government agencies was utilized to determine the Historic (Pre-Hurricane Katrina) Condition, including data from the U.S. Census Bureau, the Federal Emergency Management Agency (FEMA), U.S. Fish and Wildlife, the Mississippi Emergency Management Agency (MEMA), the Mississippi Governor's Recovery Office, County Tax Assessors, previously conducted Corps of Engineers studies conducted in the area, and other valuable data sources. Historic data included economic structures (structures, content, and critical infrastructure), social and regional indicators (population, income, and employment), topographic and hydrologic characteristics, acreage of habitat, and etc.

With the historic data serving as a foundation, the next step was to determine the impacts of surge inundation from Hurricane Katrina. The team developed an inventorying methodology that was a combination of sampling and field verification. Every street within the fifty-four planning sub-units was driven over the course of four months from June to October, 2006, for purposes of determining the existing (Post-Hurricane Katrina) conditions and characteristics of structures. The findings of this work were put into a structure database that included over 200,000 tax parcels, 138,000 of which contained structures. Hydrologic programming was used to evaluate the surge inundation of each

planning sub-unit and a combination of Geographical Information System (GIS) data and ground truthing was used for habitat evaluation.

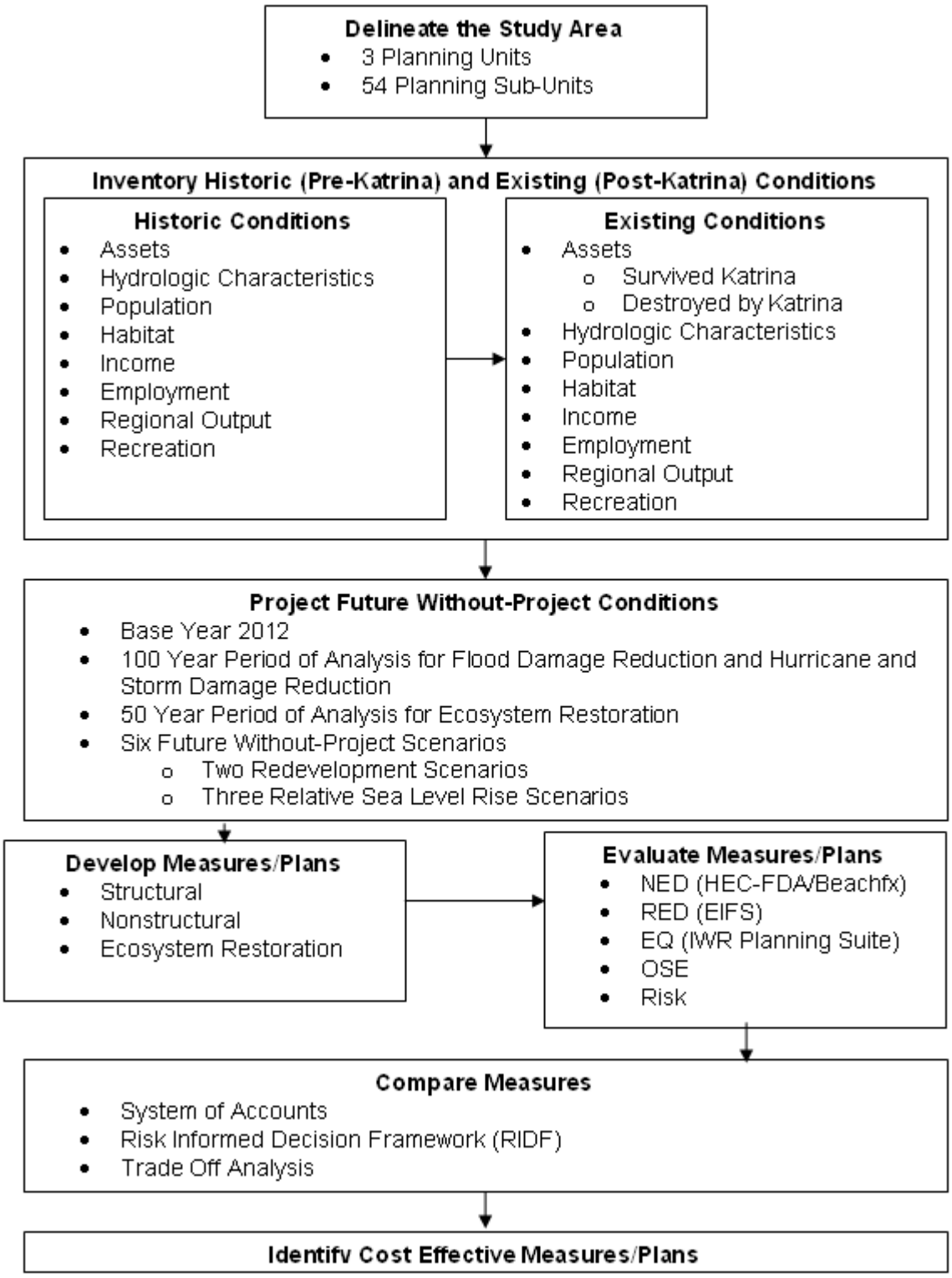


Figure 2-1. Overview of Economic Methodology

Six future without-project scenarios were developed, based on the existing condition characteristics, for the evaluation of future without-project conditions. In order to address sensitivity issues, the six scenarios were initially evaluated over a 100-year period of analysis from the base year 2012 (2012–2111) and using the FY08 federal discount rate of four-and-seven-eighths (4.875) percent. The six future scenarios include two redevelopment scenarios (residential and mixed-residential and commercial) and three relative sea level rise scenarios (existing, moderate, and high relative sea level rise) for a total of six different future scenarios. Scenario one is a residential redevelopment with no relative sea level rise over the 100-year period of analysis, scenario two is a mixed residential and commercial redevelopment with no relative sea level rise, scenario three is a residential redevelopment with a maximum relative sea level rise depending on location of 2.0-feet over the period of analysis, scenario four is a mixed residential and commercial redevelopment and a maximum relative sea level rise of a 2.0-foot, scenario five is a residential redevelopment with a relative sea level rise depending on location of 3.4-feet, and scenario six is a mixed residential and commercial redevelopment with a maximum relative sea level rise depending on location of 3.4-feet. All plans recommended for construction in the Comprehensive Plan were adjusted to a 50-year period of analysis per Corps Policy. The detailed evaluation of these scenarios is outlined below in the Future Without-Project section, and a technical description of the calculation of relative sea level can be found in the engineering appendix.

The next step, identified as step three in the planning process, was to develop measures that relate to the planning objectives for this study, which are detailed in section 2.3 of this document. An measure is something that can be implemented to directly address a problem within the study area. Some examples of measures include levees and acquisitions for flood damage reduction, beach and dune construction for flood damage reduction and ecosystem restoration, excavation and planting of native species for ecosystem restoration. These measures can be stand alone or may be able to be combined like a system.

For the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Report, multiple measures were developed under structural, nonstructural, and ecosystem restoration categories. The project delivery team applied a screening process based on engineering, environmental, and economic feasibility to narrow the list of viable measures. The full list of measures and how they were screened can be found in the MsCIP Comprehensive Plan Main Report.

The result of the screening was a list of measures that were fully evaluated as compared to the future without-project conditions. These measures were evaluated using the four systems of accounts, outlined in ER 1105-2-100, which include National Economic Development (NED) benefits, Regional Economic Development (RED) benefits, Environmental Quality benefits, and Other Social Effects (OSE). Evaluations of the various metrics that make up these four accounts were conducted using multiple economic programs, expert opinion, and other sources where available. The main economic programs used for the evaluation of measures include the Corps of Engineers Flood Inventory Tool (CEFIT), the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) program, the Beach-FX program, the Institute for Water Resources (IWR) Planning Suite, and the Economic Impact Forecasting System (EIFS). Outputs from these programs were carried forward for the comparison of the measures.

The final two steps of the process include a comparison of measures/plans and the identification of cost effective plans. A comparison of the evaluated measures was conducted using the System of Accounts (SOA) table and the Risk Informed Decision Framework (RIDF) process developed specifically for the MsCIP and LaCPR studies. Detailed descriptions of these two comparison methods and a list of tentatively-selected plan features can be found in Chapter Eight of this appendix and in the main report.

CHAPTER III. MODELING EFFORTS

3.1 Corps of Engineers Flood Inventory Tool (CEFIT)

3.1.1 Program Overview

The Corps of Engineers Flood Inventory Tool (CEFIT) program allows users to calculate replacement estimates for a variety of structures and replacement cost of commercial inventory. The CEFIT program is a proprietary program produced by Marshall and Swift in coordination with the Institute for Water Resources (IWR). The program consists of two components: a Residential Estimator component and a Commercial Contents Inventory component. The program allows for user inputs to define the type of structure that is being evaluated and provides outputs based on observed data collected by Marshall & Swift.

- Residential Estimator

The Residential Estimator component is a program that allows the user to calculate replacement cost for a variety of structures. It will calculate the depreciated replacement cost for single family residential, schools, and churches.

It has a variety of inputs that allow for a realistic estimate of depreciated replacement cost. It incorporates the location of the structure (by zip code), age, square footage, quality of construction, exterior wall material, roof type etc. All of these inputs increase the accuracy in gauging a correct estimate. The required inputs are location, age, square footage, quality of construction, and exterior wall material. Residential Estimator allows you to input your own depreciation factor or it allows the user to use program defined depreciated replacement factors based on data collection efforts for the defined area and other inputs.

The outputs for the Residential Estimator include a list of the inputs, total replacement cost of a new structure, depreciation on the structure due to age and quality, and the total depreciated replacement cost for the structure. Age and quality are the most influential factors in determining the amount of depreciation.

- Commercial Contents Inventory (CCI)

The Commercial Contents Inventory component is a program that allows the user to calculate depreciated replacement cost for inventory and equipment for various businesses. This program will calculate the depreciated replacement cost for a variety of business types. There are over 975 industry categories and 12 sales-size groupings.

There are 4 required inputs for CCI. They include: the sic code for primary and secondary operation, projected annual revenue for upcoming year, square footage of occupied building or portion of occupied building, and the number of full and part-time employees. CCI also has an input for the number of production shifts. However, the users manual recommend that the user should leave the production shifts at 1.

CCI has built in checkpoint procedures when it appears that certain inputs are outside the bounds of typical industry experience. When this happens inputs will be highlighted in red. The program also notes that it does not capture the value of leased or rented equipment. The program only captures the value on solely owned property and equipment.

The program recommends, for accurate results, to use current information, search for the closet sic code for the specific business type, use company specific data for optional items, and modify the quality and density level of equipment as appropriate.

The program returns three output values. It returns an inventory replacement value, an industry-norm equipment replacement value, and a company specific equipment replacement value. All of these values are depreciated replacement costs. The accuracy of the company specific depreciated replacement cost depends on the confidence level of input values.

3.1.2 Extent of Use

Where available, data from field interviews was utilized in estimating depreciated replacement cost for structure and content values. This was done by comparing tax data to data that was collected in the field and applying comparison percentages to different structure types. A detailed explanation of this process can be found below in chapter IV.

For those structure types, such as municipal and commercial and industrial structures, the CEFT program was employed for the estimation of depreciated replacement cost of structures and their contents. Specifically, the CEFIT program was used to estimate depreciated replacement cost of public structures and their contents, such as schools and churches, as well as to estimate the value of inventory within commercial and industrial structures. Data used as input for the program came from a variety of sources including field interviews of businesses, available financial statements of publicly traded companies, and existing data from previous Corps of Engineers studies. Outputs from the program were incorporated into the structure database described in detail in a later section of this appendix, and ultimately incorporated as inputs into the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) and Beach-FX programs for evaluation of damages and damages reduced.

3.1.3 Uncertainty

The CEFIT program does not contain a direct mechanism for addressing any uncertainty that exists in the estimation of the program's outputs. Since the output values, which include the depreciated replacement cost of schools and churches and of commercial and industrial structures, of the CEFIT program are an input for the HEC-FDA and Beach-FX programs, uncertainty is addressed within those program frameworks. Both programs allow you to input the uncertainty around the depreciated replacement cost of the structure and inventory values derived by the CEFIT program. The programs account for two standard deviations of uncertainty, or approximately the ninety-five percent confidence level. A detailed description of how the HEC-FDA and Beach-FX programs address uncertainty regarding these and other variables is described below in greater detail.

3.2 Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA)

3.2.1 Program Overview

The Hydrologic Engineering Center's-Flood Damage Analysis (HEC-FDA) program is the standard analytical tool for calculating equivalent annual damages (EAD) from flood inundation. As per the user's manual, the HEC-FDA program "Provides the capability to perform an integrated hydrologic engineering and economic analysis during the formulation and evaluation of flood damage reduction plans. The program follows functional elements of a study involving coordinated study layout and configuration, hydrologic engineering analyses, economic analyses, and plan formulation and

evaluation…the procedures are consistent with federal and Corps of Engineers policy regulations (ER-1105-2-100 and ER 1105-2-101)."

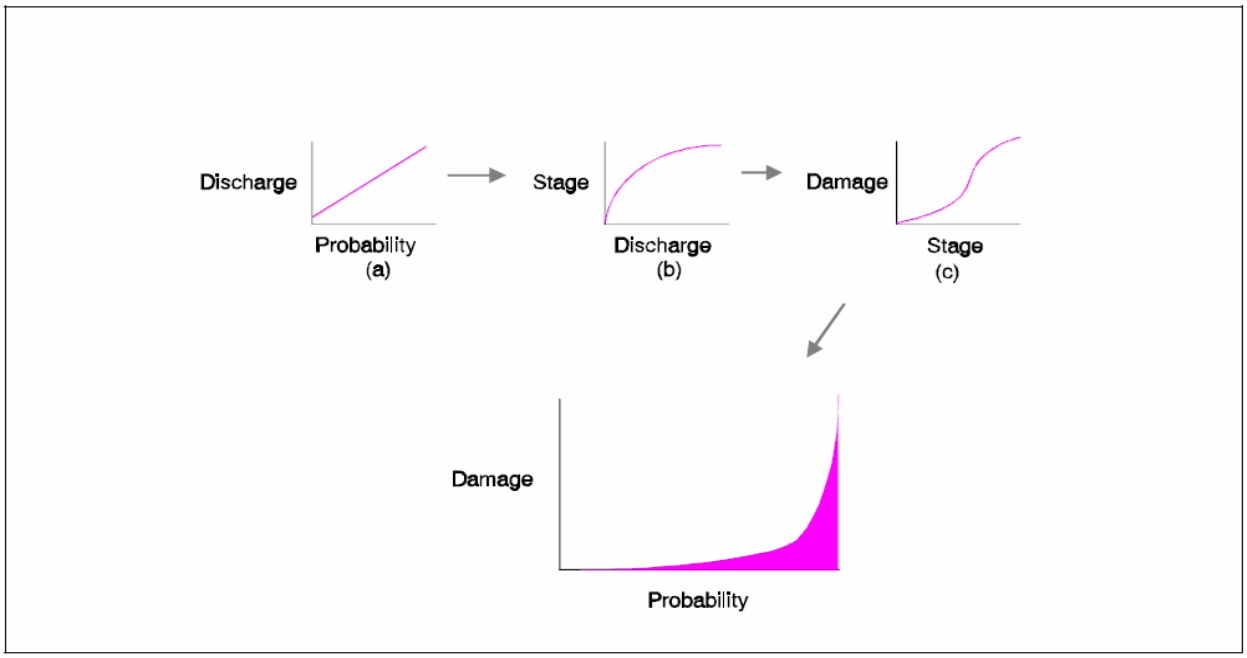
"Both economic flood damage and hydrologic engineering analyses are performed using a consistent study configuration (streams, damage reaches, plans, and analysis years). Two types of evaluations are available: analysis of damage and project performance by analysis year: and equivalent annual damage. Many Output tables and plots are used for reporting results. Computations and display of results are consistent with technical procedures described in EM 1110-2-1619."

The steps for evaluation using HEC-FDA are:

- Define Study Parameters
    - Study Stream(s) – defines the source of the water
    - Analysis Years - defines the base year and most likely future year
    - Survey Year – the year the data was initially collected
    - Update Year - allows for an update of data in the future
- Define Damage Reaches (Planning sub-units)
    - Reach Name – the limits of an area that share hydrologic and economic similarities
    - Beginning and Ending stations – the start and finish points of a reach
    - Index Location – a point between the beginning and ending stations of a reach where the greatest confidence in data is located for that reach (e.g. At a stream gage location)
- Define Plans
    - Existing Condition – typically the defined study area at the point in time the data was collected
    - Without-Project Condition – defines the study area with the assumptions made regarding the hydrologic and economic characteristics expected in the future if nothing were to be done
    - With-Project Conditions – defines each of the potential measures that could be implemented and how it acts (reduces damages) as compared to the without-project condition
- Enter Hydrologic Data
    - Water Surface Profile
    - Stage-Discharge Functions
    - Exceedance-Probability Functions
- Enter Economic Data
    - Structure Inventory Data – compiled database that includes structure characteristics such as location, structure and content value, first floor elevation, etc.
    - Depth Damage Relationships – defined relationships between the depth of water and the damage to each of the structures and their respective contents

- Assign Structure Inventories to Plans – each plan has its own specific structure inventory that is defined specifically for that plan and attributed to that plan
- Compute Aggregated Stage Damage with Uncertainty and Equivalent Annual Damages – this is the first computational step in the HEC-FDA model. It evaluates the damage at the various stages of the stage frequency curves and determines the damages attributed to each of the stage intervals. This step can be computed with or without uncertainty.
- Evaluation of Plans by Analysis Years – evaluates a plan and its performance reaches based on target standards defined for the without project conditions for the study. These standards are based on the residual damages associated with a specific exceedance probability event.
- Equivalent Annual Damage Analysis – computes the equivalent annual damages for each plan based on the pre-defined period of analysis years (e.g. 100-years) and the desired discount rate (e.g. 4.875-percent). Figure 3.2-1 shows the traditional EAD computation process.

EM 1110-2-1619
1 Aug 96



Source: Engineering Manual (EM) 1110-2-1619

Figure 3.2-1. Illustration of transformation for traditional equivalent annual damage computation

3.2.2 Depth Damage Relationships

The depth damage relationships used for the HEC-FDA analysis are based on expert elicitation and observation of damages from flood events. Generic curves for residential one-story and two-story structures and their contents are from *Corps of Engineers Economic Guidance Memorandum (EGM) 01-03, Generic Depth Damage Relationships*. Commercial, municipal, and mobile home structure and content curves are from the July 1997 final Report entitled *Depth-Damaged Relationships for Structures, Contents, and Vehicles and Content-To-Structure Value Ratios (CSVR) in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies* prepared for New Orleans District Corps of Engineers. Addendum A to this appendix describes the HEC-FDA damage curves in detail.

3.2.3 Extent of Use

For the MsCIP Comprehensive Plan Report, the HEC-FDA model was used to evaluate the without-project flood damages of the study area and the respective damages reduced of various measures in the coastal and inland planning zones. The use of this model for the MsCIP Comprehensive Plan Report is slightly different than the typical riverine application of the model, but it is still an appropriate tool for the evaluation of measures under MsCIP. The Hydrologic Engineering Center (HEC) made several modifications to the model specifically for this study. Both modifications were with respect to the uncertainty bounds around the stage frequency curves and the first floor elevations of structures.

3.2.4 Uncertainty

The HEC-FDA model allows for the quantification of uncertainty pertaining to hydrologic characteristics, such as the exceedance probability functions, and economic characteristics such as first floor elevation, structure value, content value, and depth-damage relationships. Uncertainty regarding these parameters, and their effect on EAD, are captured by using Monte Carlo simulation. Monte Carlo simulation samples the parameters from a range, typically two standard deviations, and incorporates the potential variance in the values that may occur in the real world.

3.3 Beach-FX

3.3.1 Program Overview

Beach-FX is an engineering-economic program that simulates beach response over time, as storms, natural recovery, and management methods alter the beach profile. The model estimates expected structural damages expressed as losses due to flooding, erosion and waves. It is an event-based, data-driven Monte Carlo simulation program. This structure has been used successfully in the past in a large number of U.S. Corps of Engineers (USACE) studies.

The program is an event-driven life-cycle Monte Carlo simulation program. A shore protection project life cycle (e.g. 100-years) is simulated by determining the beach and structure response to a set of storms (the events driving the process). The associated damages are determined for each structure that is programmed. This simulation is repeated for many different sets of storms, and the results averaged. Input data to the program is stored in databases, and, wherever possible, information needed to localize, parameterize, and modify program behavior is also stored as data (data-driven programming).

The program simulates beach response over time as storms, natural recovery, and management methods alter the beach profile. Events of interest (storms, beach nourishment) take place at calculated times. As each event takes place, the program simulates the physical and economic responses associated with that event. Structural damages include losses due to flooding, erosion, and wave impact. Simplified beach profiles, as defined by key data points, are tracked as the beach profile evolves over time.

The program makes use of a Shoreline Response Database (SRD). The SRD is a pre-generated set of beach profile responses to storms, for a range of storms and profiles. The program uses “plausible storms”, based on historic storms, as initiating events. The procedure for developing plausible storms is described in Appendix A. The shoreline modification due to a storm is determined through use of a shoreline response program, in this case SBeach, a cross-shore storm response program developed by the Waterways Experiment Station (WES) of the Corps. The SRD contains information on the input (pre-storm) profile, the storm, and the response (post-storm) profile, for

many combinations of storms and pre-storm profiles. The Monte Carlo simulation program then reads information from the SRD as needed to determine shoreline change following a storm event.

As each storm is processed, the shoreline response is determined, and a post-storm beach configuration is calculated, as well as profiles of maximum water level, wave height, and erosion during the storm. This information is used to determine economic damages, based on empirical curves (damage functions) relating the percentage loss of value of structure and contents to "damage-driving parameters" calculated from the aforementioned profiles and characteristics of the structure. The nature of the data used by the program is shown in Figure 3.3.1.

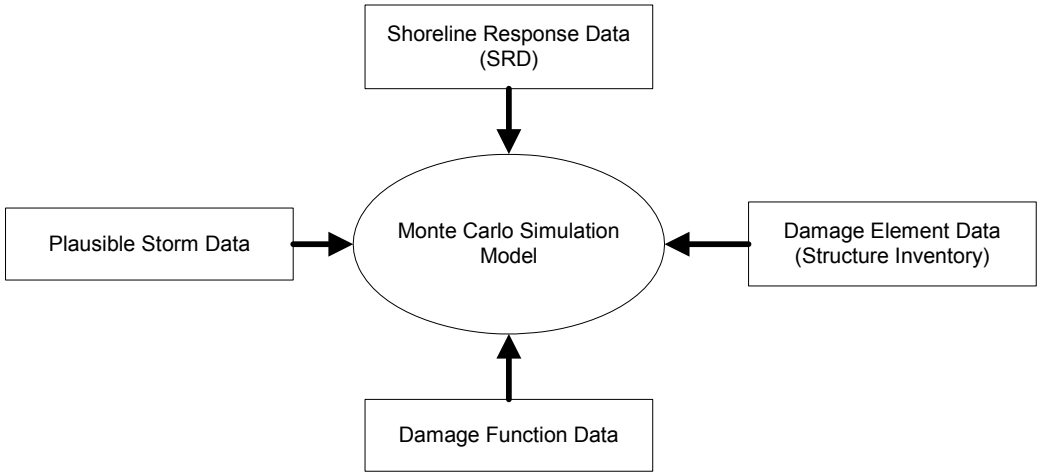


Figure 3.3-1. Data used for Beach-FX Program

3.3.2 Depth Damage Functions

Depth damage functions used within the Beach-FX simulations are based on expert elicitation and are broken into several damage categories. These damage categories include inundation damages, wave's damage, wave run-up (wave set-up) damages, and erosion damages. Addendum B to this appendix is an abstract of how the damage functions were developed and Addendum C describes in detail the damage functions used for Beach-FX.

3.3.3 Extent of Use

For the MsCIP Comprehensive Plan Report, the Beach-FX program was set up to be used to evaluate without-project damages and damages reduced for commercial structures that are physical located south (Gulf Side) of the major roadways in the three planning units. Those structures north of the major roadways in each of the planning units are evaluated using HEC-FDA (see previous section). Each of the beach and dune placement measures, described in detail later in this appendix, were evaluated against two future without-project scenarios: 1/ a future scenario with n expected relative sea level rise of 2.0-feet and 2/ a future scenario with a with an expected relative sea level rise of 3.4-feet. Section 6.2 of this appendix describes the Beach-FX evaluation in greater detail.

3.3.4 Uncertainty

The complexities of the combined engineering-economic problem of risk-based analysis, in which there are uncertainties associated with the physical performance of systems and the economic consequences of that performance, are typically addressed through the use of Monte Carlo

simulation techniques. Monte Carlo simulation is particularly useful for physically based real-world problems, where the results of the simulation can be tested against historical and reasonable behaviors.

Beach-FX uses Monte Carlo simulation to sample variable values within a range in order to capture uncertainty. Variables such as structure value, content and inventory, first floor elevation, and days to rebuild the structure when it is destroyed are given an upper and lower limit, which the simulation selects from each time a lifecycle is run.

3.4 Institute for Water Resources (IWR) Planning Suite

3.4.1 Program Overview

The US Army Corps of Engineers Institute for Water Resources (IWR) has developed IWR-PLAN Decision Support Software to assist with the formulation and comparison of alternative plans. While IWR-PLAN was initially developed to assist with environmental restoration and watershed planning studies, the program can be useful in planning studies addressing a wide variety of problems. IWR-PLAN can assist with plan formulation by combining solutions to planning problems and calculating the additive effects of each combination, or "plan." IWR-PLAN can assist with plan comparison by conducting cost effectiveness and incremental cost analyses, identifying the plans which are the best financial investments and displaying the effects of each on a range of decision variables.

IWR-PLAN builds upon the basic plan formulation and comparison framework of the DOS program ECO-EASY: Cost Effectiveness and Incremental Cost Analyses for Environmental Planning developed within the Corps Evaluation of Environmental Investments Research Program. The IWR-PLAN system transforms ECO-EASY to a Windows95 or Windows NT operating environment while adding new functions. Development of IWR-PLAN has been carried out within the Corps Decision Support Technologies Research Program, conducted at IWR. The Corps of Engineers and the Social Sciences Institute of the Natural Resources Conservation Service cosponsor IWR-PLAN development. To aid new users along the IWR-PLAN learning curve, a checklist of steps for applying the software is included under the section Getting Started.

IWR-PLAN takes user-defined solutions to planning problems and externally-generated estimates of each solution's effects and can formulate all possible combinations of those solutions, considering user-defined relationships between solutions. IWR-PLAN will then identify which combinations are the best financial investments through cost effectiveness and incremental cost analyses. Each combination of solutions is an alternative plan. If alternative plans have already been formulated outside IWR-PLAN, the user can bypass the routine for building combinations and still use IWR-PLAN to assist in identifying which plans are the best investments.

IWR-PLAN includes many new functions. An important one is that IWR-PLAN will keep track of the effects on up to ten user-defined variables. This makes IWR-PLAN a useful tool in watershed scale studies where there are likely to be a wide range of effects under consideration.

Other new functions include the ability to set constraints for all variables, to define derived variables (weighted combinations of other variables), to conduct sensitivity analysis, to examine different scenarios with different assumptions from one set of input data, to make comparisons across different scenarios, to track user defined "plans of interest", to export all IWR-PLAN data with direct links to other software, to view results through a variety of reporting and graphing measures, and to access on-screen help.

IWR-PLAN’s context-sensitive on-screen help system is available on each screen to define terms and explain how to use the screen's functions. This Online help, together with the Getting Started

checklist and accompanying operating instructions, should provide enough information to operate IWR-PLAN successfully. Additional background information is provided by the procedures manual Cost Effectiveness and Incremental Cost Analyses published by IWR in 1995 (IWR Report 95-R-1). This manual is recommended reading - especially for new users without previous ECO-EASY experience. The manual is available by download from the section "Current Reports Online" on IWR's home page.

3.4.2 Extent of Use

IWR Plan was used to conduct a cost effectiveness analysis for each of the measures and alternatives that were formulated for ecosystem restoration (see Chapter VI). The analyses followed the methodologies established in the US Army Corps of Engineers Institute for Water Resources publications, Evaluation of Environmental Investment Procedures Manual, Interim: Cost Effectiveness and Incremental Analyses, May 1995, IWR Report #95-R-1 and Cost Effectiveness Analysis for Environmental Measuring: Nine Easy Steps, October 1994, IWR Report 94-PS-2. The nine steps outline in the cited IWR report have become the standard practice for identifying what are known as “Best Buy” ecosystem restoration measures, or those measures that yield the greatest ‘bang for the buck’ at various levels of output.

The IWR Measure model was developed based on these nine steps and is the preferred Corps of Engineers model for the evaluation for ecosystem restoration measures. For the MsCIP Comprehensive Plan Report, Congressional Authority stated, "…but shall not perform an incremental benefit-cost analysis to identify the recommended project…." Following this authorization, only the first five steps of the nine easy steps, which are bolded below, were used in the IWR Plan evaluation, resulting in the identification of cost effective plans for restoration purposes. The nine steps are:

- Formulation of combinations:
  Step 1 - Display Outputs and Costs
  Step 2 – Identify Combinable Management Measures
  Step 3 – Calculate Outputs and Costs
- Cost Effective Analysis:
  Step 4 – Eliminate Economically Inefficient Solutions
  Step 5 – Eliminate Economically Ineffective Solutions
- Development of Incremental Cost Curve
  Step 6 – Calculate average costs
  Step 7 – Recalculate average costs for additional output
- Incremental Cost Analysis:
  Step 8 – Calculate incremental costs
  Step 9 – Compare successive outputs and incremental costs

3.4.3 Uncertainty

Uncertainty is a factor in any number manipulation program. Cost variability and output variability can be incorporated into the IWR Plan program using sensitivity calculations. Sensitivity can be calculated by using either variable sensitivity or solution sensitivity. A uniform coefficient can be applied to all variables or selected variables.

Variable sensitivity calculates high and low variable values using a uniform coefficient. This creates results for a range for the variable value. Custom sensitivity can be applied.

The high and low values entered for solution sensitivity are uniform coefficients used for computing the high and low values for the selected solution combination. This creates a value range result for that solution.

3.5 Economic Impact Forecasting Systems (EIFS)

3.5.1 Program Overview

The Economic Impact Forecast Systems (EIFS) was originally developed by the U.S. Army Corps of Engineers Construction Engineering Research Laboratory (USACERL) in 1975 to efficiently identify and address the regional economic effects of proposed military actions. EIFS is a web-based program and information system that provides regional economic analyses to planners and analysts. The program was developed to provide socioeconomic impact assessment, necessitated by the passage of the National Environmental Policy Act (NEPA) in 1969, which requires federal agencies to consider the impacts of an action on the "human environment" before decisions are made or an action is taken. This process is intended to help public officials make better decisions that are based on an understanding of environmental consequences and take actions that protect, restore, and enhance the human environment.

The EIFS program draws information from a tailored socioeconomic database for any county (or multi-county area) in the United States, estimating the changes associated with any project proposal, as defined by the user. EIFS database consists of data gathered from economic analyses, including Census of Agriculture, the Bureau of Economic Analysis, and County Business Patterns. The EIFS program requires basic input data regarding the action being studied: the dollar amounts of associated construction, number of military and civilian employees and their average salaries. Once these inputs are ascertained, the local multi-county region of influence (ROI) can be defined. Given the inputs for a particular project proposal, EIFS through a series of algorithm that are based on regional economic theory will assess potential impacts on four elements of a local economy: business volume, employment, personal income, and population. In short the program provides flexibility for the evaluation of measure scenarios and "what if" games at minimal expense.

3.5.2 Extent of Use

The EIFS program was used to evaluate the Regional Economic Development (RED) of proposed measures and plans. The conclusion that EIFS makes is that it predicts resultant changes in total personal income, total employment, and total sales by local businesses, and total population. Once these aggregate changes are predicted, EIFS provides analyses of historical trends in the defined ROI, and uses the Rational Threshold Level (RTV) and Forecast Significance of Impacts (FSI) profiles to develop significance criteria. Comparisons of projected change are then easily compared to the significance thresholds to produce conclusions. If insignificant impacts result, the analysis is complete. If significant impacts are indicated, a more detailed analysis will likely be required. In other words, because a projected change indicates that it would not be within the historic RTV range, it does not necessarily mean that it has a significant impact. It only means that a more detailed analysis is likely required to resolve this issue. The EIFS program, in combination with the RTV, has proven successful in determining socioeconomic impacts. The system meets the criteria for a good assessment program; theoretically sound and defensible, available for public review and scrutiny, and pragmatic in its application.

3.5.3 Uncertainty

The EIFS model incorporates uncertainty by using a Rational Threshold Value (RTV). Once model projections are obtained, the Rational Threshold Value profile allows the user to evaluate the significance of the impacts. This analytical tool reviews the historical trends for the defined region and develops measures of local historical fluctuations in sales volume, income, employment, and population. These evaluations identify the positive and negative changes within which a project can affect the local economy without creating a significant impact. The greatest historical changes define the boundaries that provide a basis for comparing an action's impact on the historical fluctuation in a particular area. Specifically, EIFS sets the boundaries by multiplying the maximum historical deviation of the following variables:

	Increase	**Decrease**
Sales Volume	x%	x%
Income	x%	x%
Employment	x%	x%
Population	x%	x%

The major strengths of the RTV are its specificity to the region under analysis and its basis on actual historical data for the region. The EIFS impact model, in combination with the RTV, has proven successful in addressing perceived socioeconomic impacts. The EIFS model and the RTV technique for measuring the intensity of impacts have been reviewed by economic experts and have been deemed theoretically sound.

CHAPTER IV. DATA COLLECTION METHODOLOGY

This section describes in detail the methodology implemented for the collection of data for the evaluation of National Economic Development (NED) benefits, Regional Economic Development (RED) benefits, Environmental Quality (EQ) benefits, and Other Social Effects (OSE). Data collection is a central element in the overall inventory and evaluation process. Hurricane Katrina hit the Mississippi Gulf Coast on August 29th, 2005 and caused significant damage to the environmental, human, and economic landscape of the area. The effects of this devastating event form the existing conditions for the MsCIP Comprehensive Plan and the basis to which the analysis of potential solutions were conducted and outlined in this appendix.

Due to limited time and the magnitude of the number of structures in the 40-foot NAVD88 surge inundation footprint, a hybrid field verification/sampling technique was developed for purposes of collecting structure data. Structure characteristics are crucial in the evaluation of risk and potential damage from surge events. The main structure data collected for this analysis was 1/ damage category, 2/ structure occupancy type, 3/ first floor elevation, 4/ structure value, 5/ content value, and 6/ whether or not the structure was significantly damaged by Hurricane Katrina. The ability to confidently obtain values for these data variables were the driving force in the development of the field verification methodology.

The first step in the field verification process was to obtain existing data from Local, State, and Federal government agencies as well as credible academic sources. For economic structure data, pre-Hurricane Katrina (2005) tax data for each of the planning units was obtained from Hancock, Harrison, and Jackson Counties, Mississippi. Next, utilizing GIS software, all of the tax parcels that fell within the 40-foot (NAVD-88) surge inundation footprint were identified, creating the maximum extent of parcels that would be identified that would be impacted by a surge analysis. This area is approximately 1,361 square miles or 100 square miles larger than the state of Rhode Island.

Next, a cluster sampling methodology was created and inventoried by driving every street within the inundation area. The sampling methodology was based upon the fact that construction along the Gulf Coast is very similar and that blocks, streets, and or subdivisions could be grouped together. While driving the area, the PDT members determined the grouping sizes based on observations in the field, and then defined typical structure characteristics for the grouping. For example, “A subdivision may be four streets and include approximately fifty structures. The subdivision may have two basic construction types, 1/ residential one-story and 2/ residential two-story, split approximately seventy-percent and thirty-percent respectively. Within the subdivision, the first floor elevation above ground of structures may range from four to six feet. The homes were built in the 1990’s so the construction is generally good in quality. Water was a factor in this area and approximately sixty percent of the homes in this area sustained significant inundation damage (50% or more damaged).” These observations were noted and input into the structure database for this area as the economic characteristics. The process was repeated over the course of six months from June through November, 2006. The end result was a database with economic data for over 200,000 tax parcels within the 40-foot NAVD88 inundation area.

Other sources of existing data were also identified for purposes of evaluating Environmental Quality, Regional Economic Development, and Other Social Effects. Data from Local, State, and Federal government agencies as well as reputable academic sources were utilized for data collection in these areas. The methodology used for the collection of data in this analysis is outline in Figure 4-1.

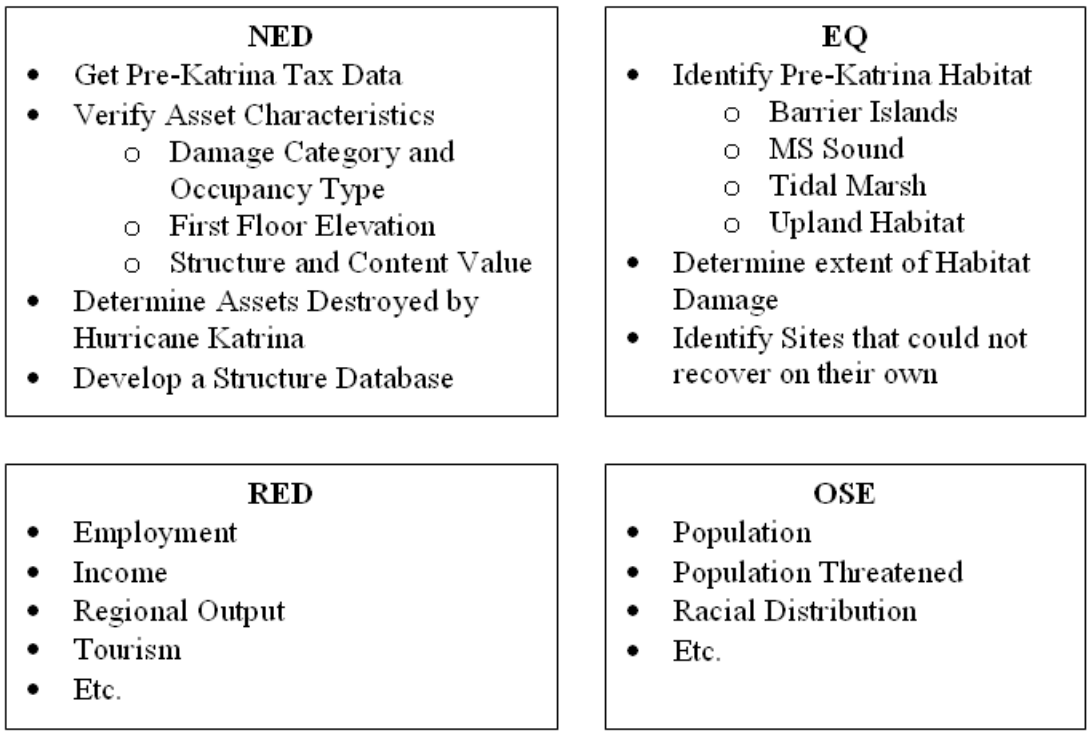


Figure 4-1. Overview of Economic Data Collection Methodology

4.1 Damage Categories

Damage categories are a means of initially categorizing the structures within the study area. This basic category is dictated primarily by general use of the structure. For this report, all structures fall within the categories of residential, commercial, municipal, and mobile home. A combination of tax data and field verification were used to determine the damage category for each structure.

4.2 Occupancy Types

Structures in each damage category were further subcategorized into structure occupancy types. The structure occupancy type allows for the combining of structures that have very similar characteristics such as construction material and depth-damage relationships. The residential damage category includes one-story and two-story single family residences. The commercial category includes: 1/ eating and recreation, 2/ groceries and gas stations, 3/ multi-family residences, 4/ repair and home use, 5/ retail and personal services, 6/ professional business, and 7/ warehouse and contractor services. The municipal category includes those structures which are generally non-taxable structures including federal, state, and local structures as well as churches. The Mobile Home category includes pre-manufactured single family residential housing that is not on a permanently fixed foundation (can be moved with relative ease). Table 4-1 provides a list of structures that fall into the various categories and occupancy types. Figures 4.2-1 through 4.2-14.

Table 4-1.
Structure Damage Categories and Occupancy Types

Damage Category	Occupancy Type	Structure Examples
COMMERCIAL	EAT	Restaurants, bars, and lounges
COMMERCIAL	MULT	Apartments, condos, multi-family
COMMERCIAL	REPA	Auto repair shops
COMMERCIAL	RETA	Retail, Laundromat, barber shop
COMMERCIAL	GROC	Grocery stores and gas stations
COMMERCIAL	WARE	Warehouses, light industry
COMMERCIAL	PROF	Hospitals, medical clinics, lawyer and professional offices
RESIDENTIAL	1-STORY	Single family dwellings with one story construction
RESIDENTIAL	2-STORY	Single family dwellings with two story construction
Mobile Homes	MOBHOME	Mobile Homes and other small metal structures
Municipal	PUBL	Municipal buildings, schools, police and fire stations



Figure 4.2-1. Example of a residential brick - slab on grade structure



Figure 4.2-2. Example of a residential masonry - slab on grade structure



Figure 4.2-3. Example of a residential wood – slab on grade structure



Figure 4.2-4. Example of a Wood Frame on Slab Residential Structure



Figure 4.2-5. Example of a mobile home residence



Figure 4.2-6. Example of a Mobile Home Residence



Figure 4.2-7. Example of Mobile Home Residence



Figure 4.2-8. Example of a residential wood on piles structure



Figure 4.2-9. Example of residential wood on piles structure



Figure 4.2-10. Example of Masonry on Piles Residential Structure

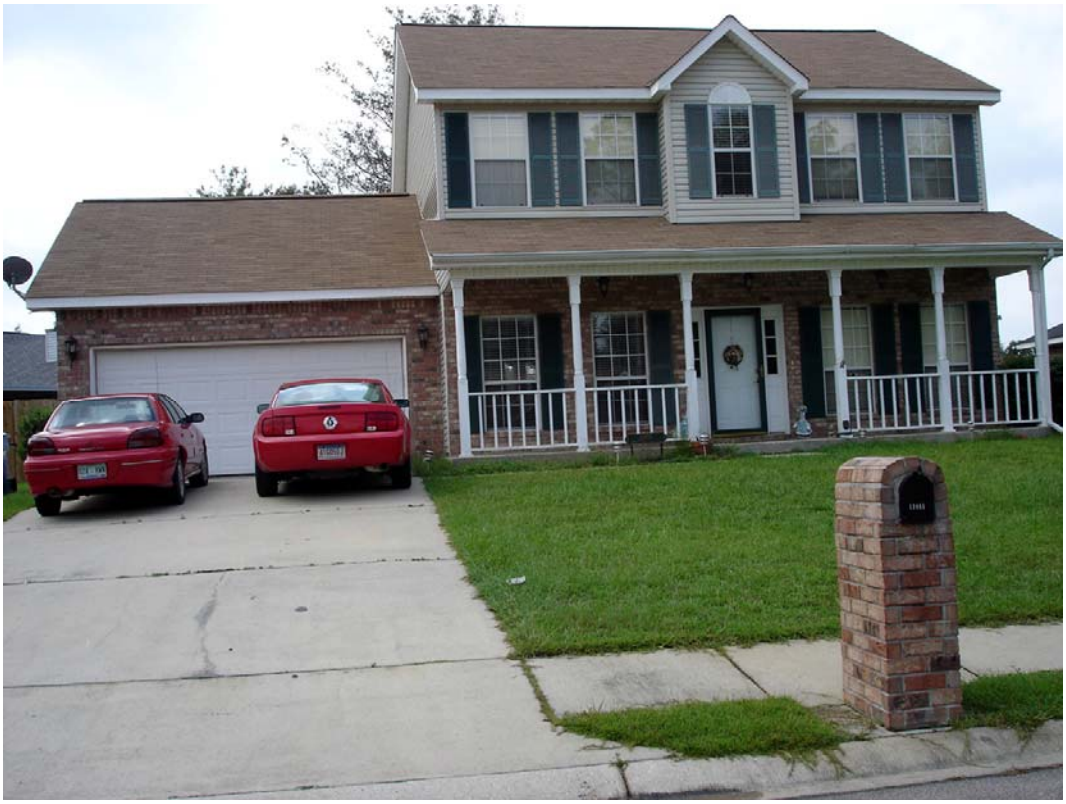


Figure 4.2-11. Example of two-story masonry on slab



Figure 4.2-12. Example of a Church (Municipal Category)



Figure 4.2-13. Example of a Commercial Services Building



Figure 4.2-14. Example of a Municipal Fire Station

4.3 First Floor Elevations

First floor elevations were estimated using a two part approach. The first step was to estimate the ground elevation NAVD88 at the center point of each parcel using LIDAR data and a GIS program. The second part of the process was to estimate the finished floor elevation above the ground for each structure. The entire study area driven and estimates were made of the height above ground for each structure within a group or cluster. For example, “In neighborhood A, all on the structures were slab on grade and therefore the finished floor above ground for all the structures in that neighborhood were assigned a zero value. Thus, all structures in neighborhood A had a first floor elevation equal to the ground elevation.” The sum of the ground elevation plus the finished floor height above ground (ground + finished floor above ground = first floor elevation) was the first floor elevation NAVD88 for a given structure. Those first floor elevations were then attributed to the appropriate structure in the structure database.

Uncertainty pertaining to first floor elevation estimates exist for reasons ranging from human error to software rounding and uncertainty with regards to the precision of LIDAR data collection. Both the HEC-FDA and Beach-FX programs allow for the inclusion of uncertainty with regards to first floor elevation estimates. For this analysis, the field observed uncertainty pertaining to first floor elevations is 3.52-feet at one standard deviation.

Uncertainty was calculated by comparing surveyed first floor elevations to LIDAR plus field estimating technique. This was accomplished by the comparison of 3,000 structures (1,000 in each planning unit), or approximately a two-percent sample. Contractors working for the MOBILE DISTRICT shot accurate first floor elevations for those 3,000 structures and the PDT members compared the contractor values with the LIDAR plus field estimated values to calculate the one-

standard deviation uncertainty. This uncertainty was then used as an input into HEC-FDA and Beach-FX for the calculation of equivalent annual damages.

The 3.52-feet of uncertainty at one standard deviation are a significant uncertainty, and are commensurate of the time and scoping limitations placed on the MsCIP Comprehensive Effort. At approximately $25 per structure to acquire field shot first floor elevations, a cost of approximately $3,250,000 and an estimated time of two-and-a-half years would be needed to acquire the first floor elevation with the traditional confidence level of a feasibility level effort. A complete traditional survey of all of the first floor elevations within the MPI footprint is neither cost effective nor feasible with respect to timing constraints.

Even though the data shows a 3.52-foot uncertainty, it is believed that the first floor elevation data is more accurate than the distribution based on the two-percent sample suggests. Therefore a sensitivity analysis was conducted based on uncertainty used in previously conducted feasibility studies where costs and timing allowed for a complete traditional survey. This sensitivity analysis can be found below in Chapter VII of this appendix.

4.4 Structure Values

This section describes the estimation of structure values used as inputs for the calculation of equivalent annual damages. Typical Corps economic policy is to use an estimate of depreciated replacement cost for the value of a structure. Depreciated replacement cost was used for structures that were not destroyed by Hurricane Katrina, and full depreciated replacement cost was used for those structures that were expected to be rebuilt. The process for estimating depreciated replacement cost of structures was unique for the residential, commercial and industrial, and municipal categories. Where applicable, field observed and tax data was incorporated into the processes described in the following subsections. Where field and tax data gaps existed, Marshall and Swift proprietary software were used to estimate the value of structures.

4.4.1 Residential Structure Values

1) Tax data for all residential structures in the maximum probable intensity (MPI) inundation footprint area was collected from each county tax assessor. A sample for each residential category was provided to Savannah District (SAS) Real Estate Division.

2) Residential categories include:

a. Single family residences (SFR) - were categorized based on construction type (wood/slab, brick/pile, etc.) and floors (1, 2, or 3).

b. Multi-family residences (MFR)[1] - were categorized as town homes, duplexes, or triplexes and apartments were either 1 or 2 stories.

3) SAS Real Estate used Marshall and Swift software to determine the depreciated replacement cost of each residential structure within the sample and provided the estimates to the SAM Economic team.

[1] Multi-family residences (Duplexes, Triplexes, and Town homes) are given the commercial category name for depth damage purposes only, since they damage in a different way from single family residences even though they are still residential for discussion purposes.

Depreciated replacement cost estimates produced by the Marshall and Swift program were calculated using a number of inputs including:

- Square footage
- Number of stories
- Exterior wall materials e.g. masonry or wood
- Foundation
- Quality
- Age of structure

The most important input in determining the depreciated replacement cost of a structure is its age.

4) The Mobile District (SAM) Economic team compared the Marshall and Swift estimates to the pre-Hurricane Katrina tax assessed value of the sample and determined a depreciated replacement cost 'factor' by each category. Table 4-2 describes the depreciated replacement cost factors for the different types of residential structures.

Table 4-2.
Depreciated Replacement Factors by Occupancy Type Used for Residential Structures that Suffered Moderate to No Damage (Less than 50%) from Hurricane Katrina

Category Name	Type	Construction Type	Depreciated Replacement Factor (%)
Residential	Single Family Residence	Wood on Slab	81%
Residential	Single Family Residence	Masonry on Slab	88%
Residential	Single Family Residence	Wood on Piles	84%
Residential	Single Family Residence	Masonry on Piles	98%
Commercial[1]	Duplex	N/A	70%
Commercial[1]	Triplex	N/A	87%
Commercial[1]	Town Homes	N/A	70%
Commercial[1]	Apartments	N/A	100%

1 Multi-family residences (Duplexes, Triplexes, and Town homes) are given the commercial category name for depth damage purposes only, since they damage in a different way from single family residences even though they are still residential for discussion purposes.

5) The depreciated replacement cost factors described in table 4-2 were then applied to all the residential structures in the corresponding category by multiplying that percentage times the tax assessed value for the structure. For example, if the tax value for a single family wood on slab residence was $100,000, then the depreciated replacement value for the structure was $81,000 ($100,0000 x 81% = $81,000).

6) If the structure was sustained significant damage from Hurricane Katrina (50% or more destroyed), full depreciated replacement costs were given to that structure. The CEFIT program was used to determine the depreciated replacement cost of residential structures. The CEFIT model estimates depreciated replacement cost value based on the parameters mentioned above, such as square footage and age of structure. The estimation of depreciated replacement cost values was conducted by taking an average of values produced from a range of values in each parameter. For example, a range of 1,000, 1,250, 1,500, 1,750, 2,000, and 2,500 square feet was used when defining the size; a range of fair-to-good, good, good-to-very good, very good, very-good to excellent

and excellent were used for quality and condition; etc. Table 4-3 shows the averages from the sample range by residential category.

Table 4-3.
Depreciated Replacement Cost Values for Residential Structures Used for Residential Structures that Suffered Significant Damage (50% or more) from Hurricane Katrina

Category Name	Construction Type	Number of Floors	Depreciated Replacement Cost ($)
Residential	Wood	1	$119,400
Residential	Wood	2	$148,702
Residential	Masonry	1	$193,475
Residential	Masonry	2	$176,079

1/ Based on estimates obtained from the CEFIT program.

B. Commercial/Industrial:

1) Commercial structures were categorized by business type (fast food, grocery, restaurant, gas station, motel/hotel, etc).

2) SAS Real Estate used Marshall and Swift Estimator to determine the depreciated replacement cost of a typical structure in each category and provided the estimates to the SAM Economic team which was then applied to all structures in that category. This was compared with the Pre-Katrina tax records and a depreciated replacement cost factor was then found for each business category. The factor percentages for commercial structures were high in comparison with the norm of depreciated replacement costs. This is a result of deflated structure values before Hurricane Katrina and less recent tax data. Table 4-4 shows the depreciated replacement cost factors for various types of commercial structures. They were applied in the same way as the residential factors previously described.

Table 4-4.
Depreciated Replacement Factors by Occupancy Type Used for Residential Structures that Suffered Moderate to No Damage (Less than 50%) from Hurricane Katrina

Category Name	Type	Depreciated Replacement Factor (%)
Commercial	Airline Hanger	79%
Commercial	Bank	79%
Commercial	Casino (Small)	60%
Commercial	Casino (Medium)	88%
Commercial	Casino (Large)	100%
Commercial	Factory (Small)	80%
Commercial	Factory (Medium to Large)	100%
Commercial	Fast Food	92%
Commercial	Gas Station (Small)	83%
Commercial	Gas Station (Medium to Large)	95%
Commercial	Grocery (Small)	54%
Commercial	Grocery (Medium)	78%
Commercial	Grocery (Large)	100%

Table 4-4.
Depreciated Replacement Factors by Occupancy Type
Used for Residential Structures that Suffered Moderate to No Damage
(Less than 50%) from Hurricane Katrina (continued)

Category Name	Type	Depreciated Replacement Factor (%)
Commercial	Small Retail (Sore)	80%
Commercial	Large Retail	95%
Commercial	Hospital (Small)	71%
Commercial	Hospital (Medium to Large)	75%
Commercial	Laundromat	72%
Commercial	Lodge	70%
Commercial	Medical Clinic	80%
Commercial	Meeting Hall	55%
Commercial	Mini-Storage	88%
Commercial	Motel	100%
Commercial	Nursing Home	82%
Commercial	Office (Medical)	90%
Commercial	Quick Lube	94%
Commercial	Restaurant (Local)	80%
Commercial	Restaurant (National Chain)	96%
Commercial	Seafood Factory	100%
Commercial	Strip Mall (Small)	69%
Commercial	Strip Mall (Medium-Large)	100%
Commercial	Theater	100%
Commercial	Warehouse	69%
Commercial	Warehouse	100%

3) If the structure sustained significant damage from Hurricane Katrina (50% or more destroyed), full depreciated replacement costs were given to that structure. SAS Real Estate division estimated full depreciated replacement cost for the same business categories previously mentioned. Those depreciated replacement cost values were applied to the structures that were destroyed by Hurricane Katrina. Table 4-5 shows the depreciated replacement cost for the various commercial structure types.

Table 4-5.
Depreciated Replacement Cost Values for Residential Structures
Used for Residential Structures that Suffered Significant Damage
(50% or more) from Hurricane Katrina

Category Name	Type	Depreciated Replacement ($)
Commercial	Airline Hanger	$23,488
Commercial	Bank	$146,855
Commercial	Casino (Small)	$15,100,912
Commercial	Casino (Medium)	$63,289,595
Commercial	Casino (Large)	$176,994,638
Commercial	Factory (Small)	$454,045

Table 4-5.
Depreciated Replacement Cost Values for Residential Structures Used for Residential Structures that Suffered Significant Damage (50% or more) from Hurricane Katrina (continued)

Category Name	Type	Depreciated Replacement ($)
Commercial	Factory (Medium to Large)	$874,997
Commercial	Fast Food	$225,626
Commercial	Gas Station (Small)	$112,040
Commercial	Gas Station (Medium to Large)	$261,828
Commercial	Grocery (Small)	$580,453
Commercial	Grocery (Medium)	$1,609,533
Commercial	Grocery (Large)	$2,103,448
Commercial	Small Retail (Sore)	$319,779
Commercial	Large Retail	$3,535,050
Commercial	Hospital (Small)	$5,977,498
Commercial	Hospital (Medium to Large)	$8,445,952
Commercial	Laundromat	$72,224
Commercial	Lodge	$129,923
Commercial	Medical Clinic	$1,046,930
Commercial	Meeting Hall	$211,446
Commercial	Mini-Storage	$110,651
Commercial	Motel	$7,482,273
Commercial	Nursing Home	$123,606
Commercial	Office (Medical)	$350,235
Commercial	Quick Lube	$114,692
Commercial	Restaurant (Local)	$80,947
Commercial	Restaurant (National Chain)	$400,306
Commercial	Seafood Factory	$300,608
Commercial	Strip Mall (Small)	$319,779
Commercial	Strip Mall (Medium-Large)	$8,985,291
Commercial	Theater	$2,050,454
Commercial	Warehouse (Small)	$39,474
Commercial	Warehouse (Medium-Large)	$92,224

C. Municipal and Churches (Tax exempt):

1) No tax data existed for Municipal structures/Churches since they are tax exempt, therefore a depreciated cost factor could not be estimated for structures that fell into this category. Marshall and Swift software was used to estimate depreciated replacement cost for these structures.

2) Municipal structures/Churches were categorized as low, medium, and high based on size, number of floors, and other structure characteristics.

3) SAS Real Estate used Marshall and Swift software to determine the depreciated replacement cost of a typical structure in each category and provided the estimates to the SAM Economic team which were then applied to all structures in that category.

Estimates were calculated using a number of inputs including:

- Square footage
- Number of stories
- Exterior wall materials e.g. masonry or wood
- Foundation
- Quality
- Age of structure

The most important input in determining the depreciated replacement cost of a structure was its age. Table 4-6 shows the depreciated replacement costs for the various types of municipal structures.

Table 4-6.
Depreciated Replacement Factors by Occupancy Type

Category Name	Type	Depreciated Replacement Cost ($)
Municipal	Church (Small)	$126,125
Municipal	Church (Medium)	$990,116
Municipal	Church (Large)	$5,612,686
Municipal	Government and School (Small)	$462,712
Municipal	Government and School (Medium)	$523,404
Municipal	Government and School (Large)	$1,537,263

Uncertainty pertaining to structure value was estimated and put into the HEC-FDA and Beach-FX models as part of the process to calculate equivalent annual damages. Previous MOBILE DISTRICT feasibility studies estimated uncertainty of structure values between 10 and 15-percent. Since the nature of the sampling used for the MsCIP study was less rigorous than normal feasibility level efforts, a 25-percent uncertainty was used for structure values.

4.5 Content Values

This section describes the process used to estimate content values for residential, commercial and industrial, and municipal and church structures. Were available, data collected from field interviews was collected and utilized. It was difficult to obtain information about content and inventory during the field inventory process, thus significant data gaps of 'real world' data existed. In order to fill those data gaps, existing data from previous studies, Corps of Engineers Economic Guidance Memorandums (Gem's), and the CEFIT model was used.

A. Residential Content Values:

1) SAM Economic Team uses the Corps of Engineers Flood Inventory Tool (CEFIT) Residential Estimator by Marshall & Swift (in close cooperation with the Institute for Water Resources) to develop an appropriate structure-to-content ratio based on the various categories mentioned for depreciated replacement costs. Since limited data was available for the damage to contents from Katrina and other surge events, the methodology outline in the Corps of Engineer's Civil Works – Planning Guidance, Economic Guidance Memorandum 01-03 dated 12/2004 was adopted for the estimation of residential content values. Table 4-7 shows the content-to-structure ratio by occupancy type for residentially occupied dwellings.

Table 4-7.
Depreciated Replacement Factors by Occupancy Type

Category Name	Type	Construction Type	Content-to-Structure Ratio (%)
Residential[1]	Single Family Residence	Wood on Slab	100%
Residential[1]	Single Family Residence	Masonry on Slab	100%
Residential[1]	Single Family Residence	Wood on Piles	100%
Residential[1]	Single Family Residence	Masonry on Piles	100%
Commercial[2]	Duplex	N/A	23%
Commercial[2]	Triplex	N/A	23%
Commercial[2]	Town Homes	N/A	23%
Commercial[2]	Apartments	N/A	23%

1 Defined by Corps of Engineers EGM 01-03.
2 Multi-family residences (Duplexes, Triplexes, and Town homes) are given the commercial category name for depth damage purposes only, since they damage in a different way from single family residences even though they are still residential for discussion purposes.

B. Commercial/Industrial Inventory and Equipment Values:

1) SAM Economic Team interviewed businesses for inventory and equipment values based on categories of business types (fast food, grocery, restaurant, gas station, motel/hotel, etc.)

2) Where data gaps arose the team used previous studies, the FEMA Hazus MH program, and the Corps of Engineers Flood Inventory Tool (CEFIT) Residential Estimator by Marshall & Swift. The Commercial Contents Inventory Estimator was used to generate theses estimates. The team calculated estimates for a small, medium, and large business in each business category. Business such as large discount retailers e.g. Wal-Mart or home improvement stores like Home Depot had only one estimate each.

Each output generated consists of 4 inputs:

- The Standard Industrial Classification Code (sic code)
- Annual Revenue
- Square Footage
- Number of Employees

The inputs were altered to give realistic estimates for small, medium, and large businesses. The most important determinants in calculating an accurate output were the annual revenue and number of employees in a sample business.

3) The data was used to identify a typical inventory and equipment value by business type that will be applied to that category. Table 4-8 shows the commercial inventory and equipment values by category named and occupancy type.

Table 4-8.
Depreciated Replacement Factors by Occupancy Type

Category Name	Business Type	Annual Revenue ($)	Business Size	Total Estimated Employees	Depreciated Content Value ($)
Commercial	AIRLINE HANGER	$400,000	SMALL	7	**$44,404**
Commercial	AIRLINE HANGER	$1,500,000	MEDIUM	21	**$297,423**
Commercial	AIRLINE HANGER	$4,000,000	LARGE	35	**$722,361**
Commercial	AUTO AUDIO STORE	$600,000	SMALL	12	**$217,741**
Commercial	AUTO MART	$600,000	MEDIUM	7	**$129,626**
Commercial	AUTO REPAIR	$500,000	MEDIUM	9	**$52,223**
Commercial	BANK	$655,860	SMALL	10	**$380,262**
Commercial	BANK	$6,403,250	MEDIUM	50	**$4,021,226**
Commercial	BANK	$15,169,000	LARGE	100	**$15,083,976**
Commercial	BARBER SHOP	$100,000	SMALL	6	**$7,744**
Commercial	BEAUTY SHOP	$200,000	SMALL	10	**$27,744**
Commercial	BOAT REPAIR	$250,000	SMALL	5	**$26,200**
Commercial	BOAT STORAGE	$600,000	MEDIUM	9	**$124,370**
Commercial	BOOK STORE	$300,000	SMALL	6	**$60,080**
Commercial	CABINET MANUFACTURER	$700,000	MEDIUM	11	**$110,100**
Commercial	CARWASH	$750,000	LARGE	15	**$129,720**
Commercial	CHURCH	$209,010	SMALL	6	**$7,360**
Commercial	CHURCH	$639,072	MEDIUM	21	**$97,539**
Commercial	CHURCH	$7,500,000	LARGE	160	**$2,139,728**
Commercial	ELECTRICAL SUPPLY	$800,000	MEDIUM	10	**$169,600**
Commercial	FACTORY	$1,000,000	MEDIUM	13	**$188,100**
Commercial	FACTORY	$13,000,000	LARGE	50	**$6,054,700**
Commercial	FACTORY*	$257,000	SMALL	3	**$80,000**
Commercial	FAST FOOD	$1,600,000	MEDIUM	50	**$206,300**
Commercial	FAST FOOD	$765,840	SMALL	40	**$134,000**
Commercial	FIBERGLASS	$600,000	MEDIUM	7	**$80,000**
Commercial	FLORIST	$300,000	SMALL	7	**$57,861**
Commercial	FUNERAL HOME	$1,500,000	LARGE	24	**$293,113**
Commercial	GARDEN NURSERY	$600,000	MEDIUM	7	**$160,088**
Commercial	GAS STATION	$2,000,000	SMALL	16	**$234,357**
Commercial	GAS STATION	$5,000,000	LARGE	36	**$568,484**
Commercial	GENERAL CONTRACTING	$1,200,000	MEDIUM	6	**$340,548**
Commercial	GROCERY	$750,000	SMALL	15	**$86,600**
Commercial	GROCERY	$2,000,000	MEDIUM	50	**$292,150**
Commercial	GROCERY	$5,000,000	LARGE	90	**$1,397,268**
Commercial	HARDWARE STORE	$600,000	MEDIUM	8	**$168,566**
Commercial	HEALTH CLUB/ GYM	$500,000	MEDIUM	20	**$104,851**
Commercial	HOME DEPOT	$34,473,615	LARGE	220	**$30,925,597**
Commercial	HOSPITAL	$5,000,000	SMALL	125	**$419,680.00**
Commercial	HOSPITAL	$70,000,000	MEDIUM	1,000	**$7,266,392**
Commercial	HOSPITAL	$134,430,900	LARGE	1,700	**$11,820,155**
Commercial	INDUSTRIAL MACHINERY	$1,000,000	MEDIUM	8	**$193,450**
Commercial	INSURANCE/OFFICE	$800,000	MEDIUM	9	**$131,247**
Commercial	JUNIOR COLLEGE	$15,000,000	MEDIUM	321	**$1,817,232**
Commercial	LANDSCAPING	$300,000	SMALL	6	**$60,540**
Commercial	LAUNDROMAT	$200,000	SMALL	7	**$17,811**
Commercial	LAUNDROMAT	$400,000	MEDIUM	15	**$116,577**

Table 4-8.
Depreciated Replacement Factors by Occupancy Type (continued)

Category Name	Business Type	Annual Revenue ($)	Business Size	Total Estimated Employees	Depreciated Content Value ($)
Commercial	LAUNDROMAT	$700,000	LARGE	18	**$231,209**
Commercial	LIQUOR STORE	$600,000	MEDIUM	7	**$110,128**
Commercial	LODGE	$889,000	SMALL	25	**$178,925**
Commercial	LOUNGE	$254,110	SMALL	10	**$93,595**
Commercial	MACHINE FABRICATION	$1,000,000	MEDIUM	17	**$108,400**
Commercial	MARINE CARGO	$1,000,000	SMALL	15	**$268,151**
Commercial	MEDICAL CLINIC	$600,000	SMALL	8	**$47,415**
Commercial	MEDICAL CLINIC	$2,000,000	MEDIUM	27	**$218,292**
Commercial	MEDICAL CLINIC	$4,000,000	LARGE	40	**$329,675**
Commercial	MOTEL	$2,000,000	MEDIUM	45	**$567,267**
Commercial	MOVIE THEATER	$1,500,000	LARGE	50	**$400,000**
Commercial	NURSERY SCHOOL	$300,000	SMALL	17	**$12,795**
Commercial	NURSING HOME	$3,000,000	SMALL	120	**$466,992**
Commercial	NURSING HOME	$7,896,400	MEDIUM	270	**$1,403,893**
Commercial	PAPER MILL	$800,000	MEDIUM	10	**$152,100**
Commercial	PETFOOD MANUFACTURING	$700,000	MEDIUM	11	**$93,900**
Commercial	QUICK LUBE	$1,000,000	LARGE	15	**$325,469**
Commercial	RADIO STATION	$433,815	SMALL	15	**$77,300**
Commercial	RESTAURANT[1]		SMALL		**$250,000**
Commercial	RESTAURANT	$1,370,000	LARGE	70	**$219,141**
Commercial	SCHOOL	$300,000	SMALL	15	**$47,132**
Commercial	SCHOOL	$1,500,000	MEDIUM	35	**$216,118**
Commercial	SCHOOL	$5,000,000	LARGE	155	**$866,136**
Commercial	TIMBER COMPANY	$600,000	SMALL	12	**$256,809**
Commercial	WALMART	$100,000,000	LARGE	350	**$17,904,400**
Commercial	WAREHOUSE	$2,000,000	MEDIUM	20	**$287,708**
Commercial	WAREHOUSE	$4,000,000	LARGE	40	**$729,199**
Commercial	WAREHOUSE	$8,000,000	X-LARGE	80	**$2,546,637**
Commercial	WAREHOUSE/MINI STORAGE	$750,000	SMALL	8	**$69,631**
Commercial	AUTO DEALERSHIP[1]	N/A	N/A	N/A	**$27,375,190**
Commercial	MINI STORAGE[1]	N/A	N/A	N/A	**$8,000**
Commercial	HVAC INSTALL/REPAIR[1]	N/A	N/A	N/A	**$60,000**
Commercial	WOMEN'S APPAREL	$2,000,000	MEDIUM	18	**$580,458**
Commercial	FAST FOOD	$1,600,000	MEDIUM	50	**$206,300**
Commercial	FAST FOOD	$765,840	SMALL	40	**$134,000**
Commercial	DEPARTMENT STORE	$7,000,000	MEDIUM	100	**$969,471**
Commercial	RESTAURANT	$1,370,000	LARGE	70	**$219,141**
Commercial	VIDEO RENTAL	$700,000	MEDIUM	18	**$302,736**
Commercial	BEAUTY SHOP	$300,000	SMALL	18	**$193,247**
Commercial	DRY CLEANERS	$400,000	SMALL	13	**$65,566**
Commercial	DRUG STORE	$2,000,000	MEDIUM	20	**$441,860**
Commercial	STRIP MALL[2]	$16,135,840	MEDIUM	347	**$3,112,779**

1 Denotes real world identified values.
2 Strip Mall includes the rows from women's apparel through drug store.
3 All other values were derived from the Corps of Engineers Flood Inventory Tool (CEFIT) Residential Estimator Program.

C. Municipal/Churches:

1) Existing data from other Corps studies or the FEMA Hazus MH Program was used for municipal and church structures along with the Corps of Engineers Flood Inventory Tool (CEFIT) Residential Estimator by Marshall & Swift. The Commercial Contents Inventory Estimator was used to generate these estimates. Estimates were calculated for small, medium, and large churches and schools.

Each output generated consisted of 4 inputs:

- The Standard Industrial Classification Code (sic code)
- Annual Revenue
- Square Footage
- Number of Employees

The inputs were altered to give realistic estimates for small, medium, and large government buildings, schools, and churches. The most important determinants in calculating an accurate output were the annual revenue and number of employees in a sample school or church. The amount of annual funding was used as a substitute for annual revenue for schools. Both schools and churches have specific sic codes. Table 4-9 shows the content values for the different types of municipal structures.

Table 4-9.
Depreciated Replacement Factors by Occupancy Type

Category Name	Business Type	Annual Revenue ($)	Business Size	Total Estimated Employees	Depreciated Content Value ($)
Municipal	Church (Small)	$209,010	SMALL	6	**$7,360**
Municipal	Church (Medium)	$639,072	MEDIUM	21	**$97,539**
Municipal	Church (Large)	$7,500,000	LARGE	160	**$2,139,728**
Municipal	Government and School (Small)	$300,000	SMALL	15	**$47,132**
Municipal	Government and School (Medium)	$1,500,000	MEDIUM	35	**$216,118**
Municipal	Government and School (Large)	$5,000,000	LARGE	155	**$866,136**

Uncertainty pertaining to content value was estimated and put into the HEC-FDA and Beach-FX models as part of the process to calculate equivalent annual damages. Previous MOBILE DISTRICT feasibility studies estimated uncertainty of structure values between 5 and 15-percent. Since the nature of the sampling used for the MsCIP study was less rigorous than normal feasibility level efforts, a 25-percent uncertainty was used for content values.

CHAPTER V. INVENTORY AND FORECASTING CONDITIONS

This chapter describes the pre-Hurricane Katrina (historic) conditions, post-Hurricane Katrina (existing) conditions and the future without-project conditions for the fifty-four planning sub-units that define the surge inundation footprint up to the 40-foot NAVD88 contour (see figure 1.4.3. above).

5.1 Historic Conditions

5.1.1 Impacts of Hurricane Camille

The Mississippi Gulf Coast is no stranger to large storm surge events. On August 17, 1969, Hurricane Camille impacted the area in a similar fashion to Hurricane Katrina. Hurricane Camille made landfall at Bay St. Louis, Mississippi only miles way from Hurricane Katrina's landfall path. The total surge area ranged from lower Plaquemines Parish in Louisiana to Perdido Pass, Alabama. Maximum surge from Hurricane Camille on the Mississippi coast ranged from 21.7-feet above m.s.l. in planning unit one, to 24.2-feet above m.s.l. in planning unit two, and 15.8-feet above m.s.l. in planning unit 3.

Damage to the Mississippi Coast from Hurricane Camille was extensive. Federal relief expenditures topped 100 million dollars at 1970 prices, over 600 million dollars when accounted for inflation. The magnitude of this number is astounding considering that many of the relief programs that exist today did not exist for Hurricane Camille. Table 5-1 shows selected Hurricane Camille damage statistics. Tables 5-2 and 5-3 show damage to residential and commercial structures caused by Hurricane Camille surge.

Table 5-1.
Select Hurricane Camille Statistics.

Camille Statistics	Mississippi	Louisiana	Alabama
Persons Dead	135	9	Unknown
Persons Missing	27	0	Unknown
Families Suffering Loss	63,665	9,442	750
Dwellings Destroyed	3,881	1,771	10
Dwellings with major damage	12,112	1,753	50
Dwellings with minor damage	29,736	3,697	500
Trailers destroyed	406	664	12
Trailers with major damage	325	290	6
Farm buildings destroyed	645	114	5
Farm buildings with major damage	2,002	97	5
Small businesses destroyed or with major damage	569	110	14
Damage to public property	$200,000,000	$10,000,000	$500,000
Damage to private property	$750,000,000	$312,000,000	$7,500,000

1 Source: Report on Hurricane Camille U.S. Army Corps of Engineers – MOBILE DISTRICT
2 These dollars reflect a 1970 price level.

Table 5-2.
Damage to Residential Structures Caused by Hurricane Camille Surge.

County	Homes Destroyed	Homes Damaged	Total Homes Impacted
Hancock	936	4,067	**5,003**
Harrison	2,347	8,603	**10,950**
Jackson	276	1,232	**1,508**
Total	3,559	13,902	**17,461**

1 Source: Report on Hurricane Camille U.S. Army Corps of Engineers – MOBILE DISTRICT

Table 5-3.
Damage to Commercial Structures Caused by Hurricane Camille Surge.

County	Homes Destroyed	Homes Damaged	Total Homes Impacted
Hancock	52	150	**202**
Harrison	261	380	**641**
Jackson	4	57	**61**
Total	317	587	**904**

1 Source: Report on Hurricane Camille U.S. Army Corps of Engineers – MOBILE DISTRICT

Other damage statistics from Hurricane Camille include (1970 price levels):

- $23.5 million in industrial damages in Mississippi in flooded areas
- $7.8 million in damages to schools in Mississippi in flooded areas
- $3.5 million in damages to Mobile District navigation projects
- $10.1 million in damages to the two VA hospitals in Harrison County and $593,300 aggregate damage to other hospitals in Mississippi in flooded areas
- $5.2 million in damages to highways in Mississippi in flooded areas
- $2.1 million in damages to bridges in Mississippi
- $10.5 million in damages to vehicle in Mississippi in flooded areas
- $4.8 million in damages to Keesler Air Force Base
- Roughly $50 million in damages to Federal Government facilities
- $1.7 million in damages to Non-Federal Government facilities in Mississippi
- $14.7 million in marine damages in Mississippi
- $14.8 million cost of debris removal in flooded areas in Mississippi

5.1.2 Historic (Pre-Hurricane) Population Trends

The 1950-2000 population levels and growth for the U.S., Mississippi, the three-county study area, and each county are presented in Table 5-4. During this fifty year period, the population of the three-county study area grew by 186.6 percent. This is 5.6 times the Mississippi percentage population

growth of 33.2 percent and 2.2 times the U.S. percentage population growth of 86.0 percent for the same timeframe. The three-county area accounted for 32.7 percent of the nominal population growth for Mississippi from 1950 to 2000.

Table 5-4.
1950-2000 Population Levels and Growth (in thousands)

	United States	Mississippi	Three-County Study Area	Hancock County	Harrison County	Jackson County
1950	151,326	2,179	127	12	84	31
1960	179,323	2,178	189	14	119	56
1970	203,212	2,217	239	17	134	88
1980	226,546	2,521	301	25	158	118
1990	248,710	2,573	312	32	165	115
2000	281,421	2,903	364	43	190	131
50 Year Nominal Change	130,095	724	237	31	106	100
50 Year Percentage Change	86.0%	33.2%	186.6%	258.3%	126.2%	322.5%

Source: U.S. Census Bureau, 2000 Census

5.1.3 Historic (Pre-Hurricane Katrina) Environmental Setting

The study area consists of the three coastal counties within the State of Mississippi: Hancock, Harrison, and Jackson counties; and the coastal (offshore) ecosystem including its barrier islands. This area ranges in elevation from sea level to about 30-feet NAVD88. The essentially flat to gently undulating, locally swampy Coastal Lowlands are underlain by alluvial, deltaic, estuarine, and coastal deposits and merge with the fluvial-deltaic plains of the streams of the area. According to the Cowardin et. al., *Classification of Wetlands and Deepwater Habitat of the United States*, there are five major wetland and deepwater systems, four of which are found within Coastal Mississippi. They include marine, estuarine, riverine, and palustrine wetland systems.

Within Coastal Mississippi, the marine system is the area along the Gulf of Mexico front south of the barrier islands. It is comprised of the intertidal beachfront of the barrier islands along the Gulf of Mexico, and subtidal which consists of the unconsolidated sandy water bottoms. The string of barrier islands are comprised of dynamic and diverse habitats and are part of a complex integrated system of beaches, dunes, marshes, bays, tidal flats, and inlets. These barrier islands are located along a littoral drift zone that moves sand westward creating three elongated islands and then to the westward most island (i.e. Cat) where littoral currents are not as well defined. From east to west, the islands are Petit Bois, Horn, Ship, and Cat. Ship Island was breached by prior hurricanes and now is actually two small islands, West Ship Island and East Ship Island, with a shallow sand bar between the two. Since Hurricane Camille in 1969, this breach has existed with varying amounts of natural rebuilding between later storms.

Under current conditions, the islands provide a natural boundary between the water's salinity [~33 parts per thousand (ppt)] of the open Gulf of Mexico and the brackish water found in Mississippi Sound. Salinity in the Sound during low flow periods range from 10 to 30 ppt. Highest salinities occur just south of Pascagoula and Gulfport and the lowest salinities in the Lake Borgne-Pearl River area. Mississippi Sound is a shallow coastal lagoon along northern Gulf of Mexico from Mobile Bay, Alabama, in the east to Lake Borgne, Louisiana, in the west. Circulation is driven by tides modified slightly with the wind. Gulf waters enter the Sound through the deep passes between the barrier islands with the help of tidal forces. This mixing of freshwater runoff and saline waters has created a dynamic estuarine environment. Mississippi Sound receives its major freshwater flow from the

Pascagoula and Pearl Rivers and is critical to the survival of numerous birds, mammals, fish, and other marine organisms of national importance.

Many different habitat types are found in and around the estuarine environment, including shallow open-waters, salt marshes, sandy beaches, mud and sand flats, oyster reefs, river deltas, tidal pools, and submerged aquatic vegetation (SAVs). These diverse ecosystems serve a variety of critical functions necessary to sustain a vital thriving commercial fishing industry of national economic significance. Prior to the hurricane season of 2005, sea grasses were restricted to the northern shores of the barrier islands and small patches throughout the immediate shorelines. These areas are characterized by *Diplanthera Wright* (Shoal grass)*, Cymodocea manatorum* (Manatee grass), *Thalassia testudinum* (Turtle grass), and *Ruppia maritime* (Widgeon grass). Approximately 20,000 acres of SAVs were present in Mississippi Sound prior to 1969; however, in late 1969, Hurricane Camille caused the destruction of the majority of these areas. In 1969, an estimated 13,000 acres of SAVs were documented and as of 1998, only 2,000 acres were documented (Moncrieff 1998).

Prior to the 2005 hurricane season, the majority of the shoreline in Coastal Mississippi consisted of manmade beaches beyond concrete seawalls. A few remaining areas along the shoreline consist of more natural areas, such as expanses of marsh along the western and eastern borders of the state. A natural beach and dune system, located along Belle Fontaine in the central portion of Coastal Mississippi, is the only natural beach remaining and has experienced severe erosion to a point that it is virtually non-existent. The beach of Coastal Mississippi provides a unique habitat for a variety of plants and animals. For example, 75% of migratory waterfowl live in or depend on coastal beaches during their lifespan. Dune vegetation provides nesting areas for several kinds of birds, such as least terns, and animals, such as mole crabs and rodents.

Wet Pine Savannah wetlands found in Coastal Mississippi provide for diverse habitat for a number of plants and animals including many threatened and endangered species found only in these unique habitats. Pine Savannah wetlands are commonly referred to as sponges that provide floodwater retention, groundwater recharge, and water purification. Development stresses were impinging upon these wetland habitats.

Coastal Mississippi supports an array of reptiles, amphibians, birds, and mammals. Reptiles and amphibians found in the area include snakes, turtles, lizards, toads, frogs, salamanders, and crocodilians. Coastal Alabama and Mississippi have a great diversity of reptiles including 23 species of turtles, 10 species of lizards, 39 species of snakes, and the alligator. Eighteen species of salamanders and 22 species of frogs and toads are indigenous to the coastal region.

Overall, the environmental conditions of Coastal Mississippi were already stressed prior to the hurricane season of 2005 and with its onset, many habitats were adversely impacted. However, these stressed conditions in Coastal Mississippi are irreversible with adequate planning and management.

5.2 Existing (Post-Hurricane Katrina) Conditions

5.2.1 Impacts from Hurricane Katrina

On August 29, 2005, Hurricane Katrina made land fall in Hancock County, Mississippi just east of the Pearl River. By virtually all accounts, it was the single largest disaster in U.S. history. Storm surge from Hurricane Katrina was the largest that has ever hit the continental United States. The surge inundated approximately 484 square miles of southern Mississippi. The relief expenditures in

Mississippi alone have totaled in the billions of dollars. Figure 5.2-1 shows the inundation footprint of Hurricane Katrina.



Figure 5.2-1. Hurricane Katrina Path and Extent of Hurricane Katrina Surge in Planning Units One, Two, and Three

5.2.2 Existing Structure Conditions

Data collected as part of the field inventory process was used to create a structure database. The structure database is the compilation of the data collection effort previously described. It includes each of the structure characteristics mentioned above, damage categories, structure occupancy types, first floor elevations, structure value, content value collected. These characteristics were put into the database along with the data collected from the tax assessor to create a structure database. This structure database represents the existing condition of the structures residing within the study area and the basis for the calculation of equivalent annual damages for the existing, future without-project and future with-project conditions using the HEC-FDA and Beach-FX programs. The structure database is intended to be a snap-shot in time of the structures within the study area. The use of this database was essential for the analysis conducted throughout the course of the MsCIP Comprehensive Plan.

The three planning units suffered tremendous devastation from Hurricane Katrina's surge. It is estimated that 32,446 structures were significantly destroyed (at least fifty-percent or more), with another 15,000 to 25,000 suffering moderate to minimal inundation damage. Of the structures sustaining significant destruction, 9,555 were in planning unit one, 16,528, in planning unit two, and 6,363 in planning unit three. Of those significant loss structures, approximately 19,000 claims were paid out by the Federal Emergency Management Agency's (FEMA's) National Flood Insurance Program (NFIP) totally over $2.3 Billion dollars, with the average claim around $137,000. Currently, no accurate data exists for uninsured losses, but estimates range in the billions of dollars. Table 5-5 displays the significantly damaged structures by planning unit and by structure category. Figures 5.2-2 through 5.2-14 show examples of the destruction caused by Hurricane Katrina in the three planning units.

Table 5-5.
Structures Damaged 50% or More by Planning Unit and by Category

	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Commercial	1,267	1,794	378	**3,439**
Residential	8,099	14,500	5,780	**28,379**
Municipal	127	89	136	**352**
Mobile Home	62	145	69	**276**
Total	**9,555**	**16,528**	**6,363**	**32,446**

Source: Estimated from field inventory cluster sampling.



Figure 5.2-2. Example of Structure Damage in Planning Unit One



Figure 5.2-3. Structure Damage in Planning Unit One



Figure 5.2-4. Katrina Surge Damage in Planning Unit One



Figure 5.2-5. Surge Damage in Bay St. Louis – Planning Unit One



Figure 5.2-6. Surge Damage in Biloxi Area – Planning Unit Two



Figure 5.2-7. Surge Damage in Biloxi Area – Planning Unit Two



Figure 5.2-8. Surge Damage in Planning Unit Two



Figure 5.2-9. Pascagoula Beach Boulevard Pre-Hurricane Katrina – Planning Unit Three



Figure 5.2-10. Pascagoula Beach Boulevard Post-Hurricane Katrina – Planning Unit Three



Figure 5.2-11. Pascagoula Beach Boulevard Pre-Hurricane Katrina – Planning Unit Three



Figure 5.2-12. Pascagoula Beach Boulevard Post-Hurricane Katrina – Planning Unit Three



Figure 5.2-13. Pascagoula Yacht Club Pre-Hurricane Katrina – Planning Unit Three



Figure 5.2-14. Pascagoula Yacht Club Post-Hurricane Katrina – Planning Unit Three

5.2.3 Existing (Post-Hurricane Katrina) Socio-economic Conditions

This section contains a description of the existing conditions (post-Hurricane Katrina) demographic and economic characteristics of the study area. It also provides analysis of the interrelation of those characteristics. The people who live in the study area and the economic activities in which they are engaged are vital components of the study area. This information provides insight into the study area's socioeconomic characteristics and provides part of the basis for certain facets of the economic impact evaluation study.

5.2.3.1 Demographics (Population)

5.2.3.1.1 Recent Population Trends

The 2000-2005 population level and growth estimates for the U.S., Mississippi, the three-county study area, and each county are displayed in Table 5-6. The July 1, 2000 to July 1, 2005 timeframe is the most recent before Hurricane Katrina made landfall in late August of 2005. During this five year period, the population of the three-county study area grew by 2.86 percent. This is 1.4 times the Mississippi percentage population growth of 2.10 percent and 0.6 times the U.S. percentage population growth of 5.06 percent. The three-county study area accounted for 17.4 percent of the nominal population growth for Mississippi from 2000-2005.

Table 5-6.
2000-2005 Estimates of Population Levels and Growth

	United States	Mississippi	Three-County Study Area	Hancock County	Harrison County	Jackson County
July 1, 2000	282,216,952	2,848,634	364,863	43,283	189,699	131,881
July 1, 2001	285,226,284	2,856,108	366,362	43,944	189,512	132,906
July 1, 2002	288,125,973	2,863,091	367,498	44,607	189,996	132,895
July 1, 2003	290,796,023	2,874,171	367,790	45,166	189,189	133,435
July 1, 2004	293,638,158	2,892,668	372,885	45,821	192,129	134,935
July 1, 2005	296,507,061	2,908,496	375,304	46,546	193,187	135,571
5 Year Nominal Change	14,290,109	59,862	10,441	3,263	3,488	3,690
5 Year Percentage Change	5.06%	2.10%	2.86%	7.54%	1.84%	2.80%

Source: U.S. Census Bureau, Population Division

5.2.3.1.2 Existing Condition (Post-Katrina) Population

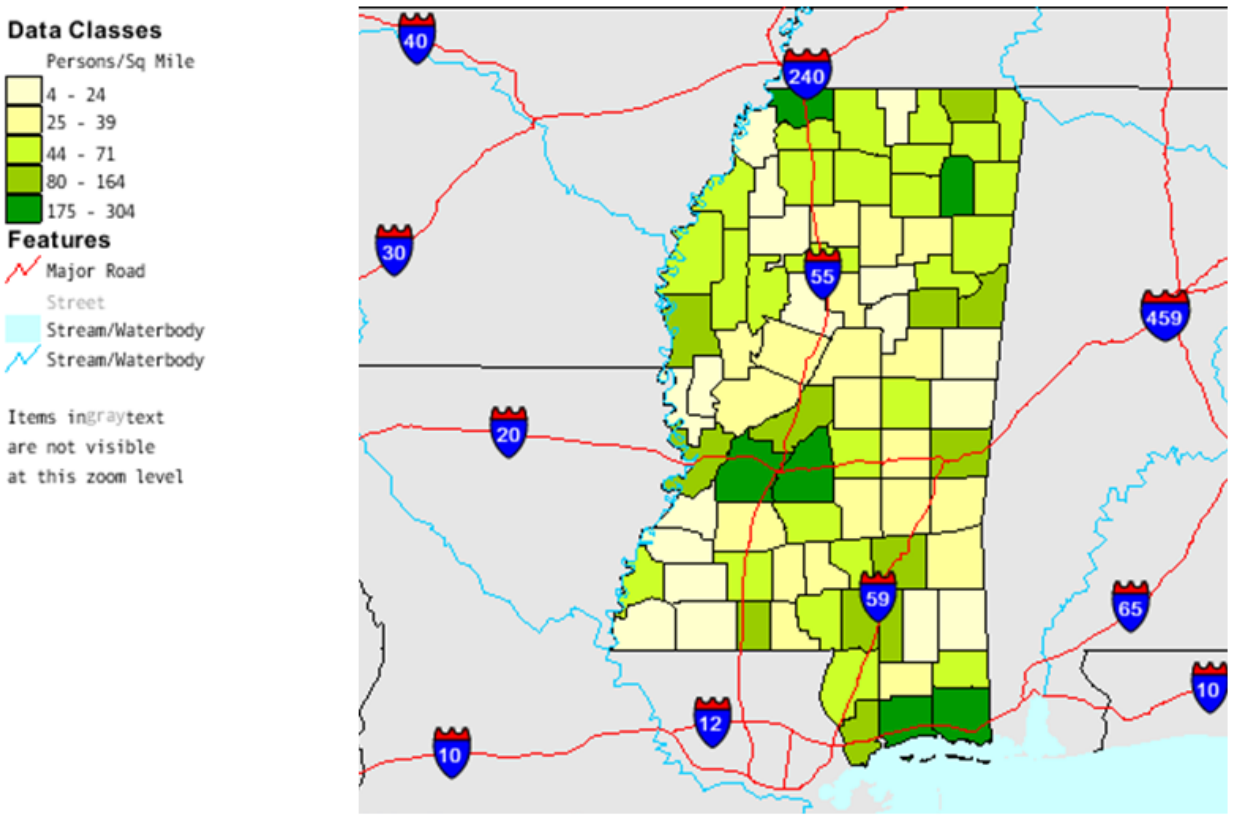
The 2006 population level estimates for the U.S., Mississippi, the three-county study area, and each county are shown in Table 5-7. The table also displays each county's population and the study area's population as a percentage of the populations of the U.S. and Mississippi.

Table 5-7.
2006 Estimated Population Levels

	United States	Mississippi	Three-County Study Area	Hancock County	Harrison County	Jackson County
July 1, 2006 Population Estimate	299,398,484	2,910,540	342,873	40,421	171,875	130,577
Percentage of U.S. Population	100.0%	0.972%	0.115%	0.014%	0.057%	0.040%
Percentage of Mississippi Population		100.0%	11.8%	1.4%	5.9%	4.5%

Source: U.S. Census Bureau, Population Division

Figure 5.2-15 is a map displaying the population densities of counties in Mississippi. As can be seen from the map, the three-county study area is one of the more densely populated areas in Mississippi. It can also be seen that Hancock County has a lower population density than Harrison County or Jackson County.



Source: U.S. Census Bureau

Figure 5.2-15. 2006 Mississippi Population Density

5.2.3.1.3 Urban Growth and Distribution

The 2000-2004 population changes for the U.S., Mississippi, the three-county study area, each county, and major cities within each county are displayed in Table 5-8. The city with the greatest nominal or percentage population growth in the study area from 2000 to 2004 is Gautier with population growth of 5,172 persons or 44.28 percent.

Table 5-8.
2000-2004 Urban Growth and Distribution

	2000	2004	2000-2004 Nominal Change	2000-2004 Percentage Change
United States	281,421,906	293,655,404	12,233,498	4.35%
Mississippi	2,844,658	2,902,966	58,308	2.05%
Three-County Area	363,988	373,762	9,774	2.69%
Hancock County	42,967	45,933	2,966	6.90%
Bay Saint Louis	8,209	8,293	84	1.02%
Waveland	6,674	7,120	446	6.68%
Harrison County	189,601	192,393	2,792	1.47%
Biloxi	50,644	50,115	-529	-1.04%
D'Iberville	7,608	7,757	149	1.96%
Gulfport	71,127	71,850	723	1.02%

Table 5-8.
2000-2004 Urban Growth and Distribution (continued)

	2000	2004	2000-2004 Nominal Change	2000-2004 Percentage Change
Long Beach	17,320	17,258	-62	-0.36%
Pass Christian	6,579	6,758	179	2.72%
Jackson County	131,420	135,436	4,016	3.06%
Gautier	11,681	16,853	5,172	44.28%
Ocean Springs	17,225	17,698	473	2.75%
Pascagoula	26,200	25,865	-335	-1.28%

Source: U.S. Census Bureau, Population Division

5.2.3.1.4 Racial Distribution

Table 5-9 shows the racial distribution for the U.S., Mississippi, each county in the study area, and also includes the racial distribution for the major cities in each county as of 2000.

Table 5-9.
2000 Population Racial Distribution

Table Header	White	Black	Hispanic	Asian	American Indian	Other	Multiple Races
United States	75.1%	12.3%	12.5%	3.6%	0.9%	5.5%	2.4%
Mississippi	61.4%	36.3%	1.4%	0.7%	0.4%	0.5%	0.7%
Hancock County	90.2%	6.8%	1.8%	0.9%	0.6%	0.3%	1.1%
Bay Saint Louis	80.2%	16.6%	1.7%	1.1%	0.4%	0.2%	1.4%
Diamondhead	95.3%	1.8%	2.9%	0.9%	0.4%	0.5%	1.1%
Pearlington	77.6%	20.4%	1.4%	0.1%	0.4%	0.1%	1.4%
Shoreline Park	94.6%	2.0%	1.9%	0.3%	1.0%	0.3%	1.7%
Waveland	85.4%	11.2%	2.0%	1.5%	0.5%	0.5%	0.9%
Harrison County	73.1%	21.1%	2.6%	2.6%	0.5%	0.9%	1.7%
Biloxi	71.4%	19.0%	3.6%	5.1%	0.5%	1.4%	2.4%
D'Iberville	78.2%	11.4%	2.6%	7.0%	0.4%	0.9%	2.1%
Gulfport	62.2%	33.5%	2.6%	1.3%	0.4%	0.5%	1.6%
Long Beach	87.5%	7.4%	2.3%	2.6%	0.4%	0.7%	1.4%
Pass Christian	65.9%	28.2%	1.7%%	3.5%	0.6%	0.6%	1.2%
Jackson County	75.4%	20.9%	2.1%	1.6%	0.3%	0.7%	1.1%
Escatawpa	80.5%	17.6%	0.6%	0.7%	0.3%	0.1%	0.7%
Gautier	68.2%	27.7%	3.2%	1.3%	0.5%	0.9%	1.4%
Moss Point	28.0%	70.6%	1.0%	0.2%	0.2%	0.4%	0.6%
Ocean Springs	87.7%	7.0%	2.5%	2.6%	0.4%	0.7%	1.5%
Pascagoula	67.2%	29.0%	3.9%	1.0%	0.2%	1.7%	1.0%

Source: U.S. Census Bureau, 2000 Census

5.2.3.2 Economy

5.2.3.2.1 Employment Distribution

The 2002 distribution of employment by major sectors for Mississippi, the three-county study area, and each county is shown in Table 5-10. Approximately 5.4% of Mississippi's Professional and Technical employment could be found in Hancock County in 2002. Hancock County is home to the John C. Stennis Space Center. The Stennis Space Center, with over 4,600 employees is NASA's primary center for rocket propulsion testing. Harrison County is a popular vacation destination for its beaches and casinos. Harrison County accounts for 26.9 percent of Mississippi's employment in the arts and 20.0 percent of Mississippi's employment in food and accommodation services. Jackson County features Pascagoula Harbor. In 2004, 66.7 percent of Mississippi's waterborne commerce volume and 1.3 percent of U.S. volume moved through Pascagoula Harbor. Pascagoula Harbor's annual volume increased 44% from 1986 to 2004. Northrop Grumman Ship Systems' Ingalls Operations, with over 10,000 employees, can also be found in Jackson County. Jackson County accounted for 8.8 percent of Mississippi's employment in manufacturing.

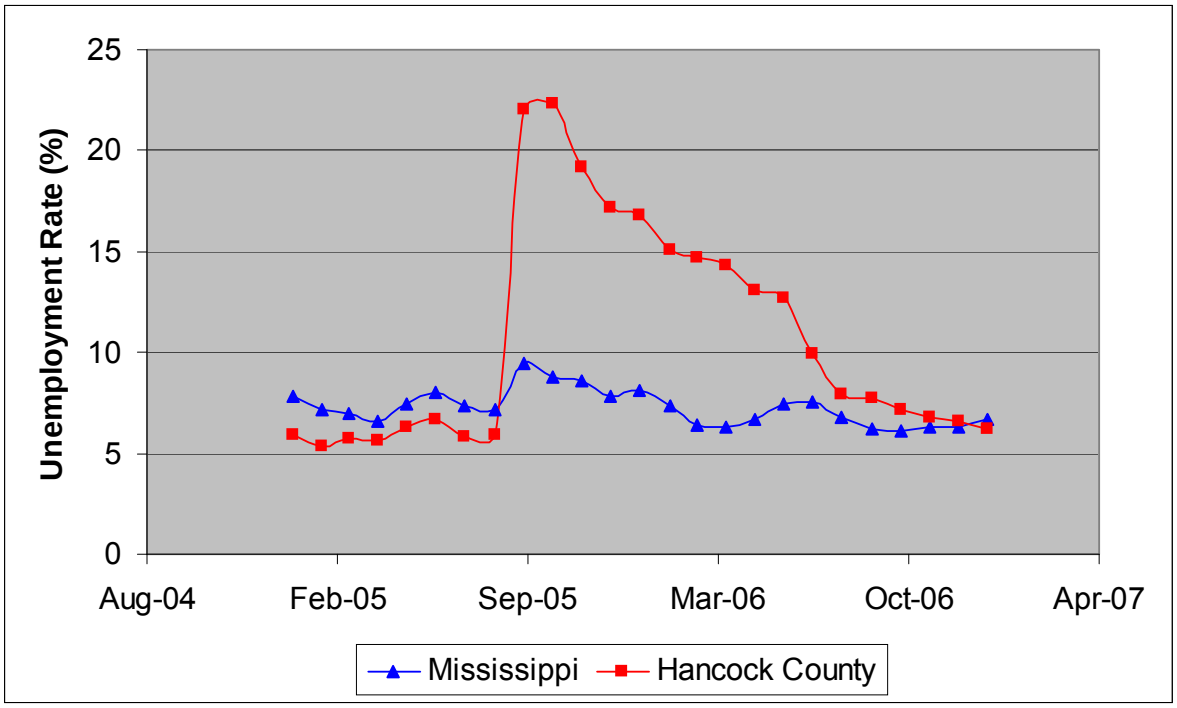
Table 5-10.
2002 Employment Distribution by Major Sector

	Mississippi	Three-County Study Area	Hancock County	Harrison County	Jackson County
Manufacturing	182,822	21,500	1,000	4,500	16,000
Wholesale	35,316	2,963	251	2,112	600
Retail	135,838	18,698	1,586	11,548	5,564
Real Estate	9,665	1,585	131	1,084	370
Professional & Technical	29,023	5,205	1,555	2,050	1,600
Administration	46,115	5,821	1,280	3,211	1,330
Education	1,678	204	20	100	84
Health & Social Care	131,976	17,549	500	12,429	4,620
Arts	9,292	2,700	100	2,500	100
Food & Accommodation	109,405	27,523	2,114	21,822	3,587
Other Services	22,180	3,558	176	2,067	1,315

Source: U.S. Census Bureau, 2002 Economic Census

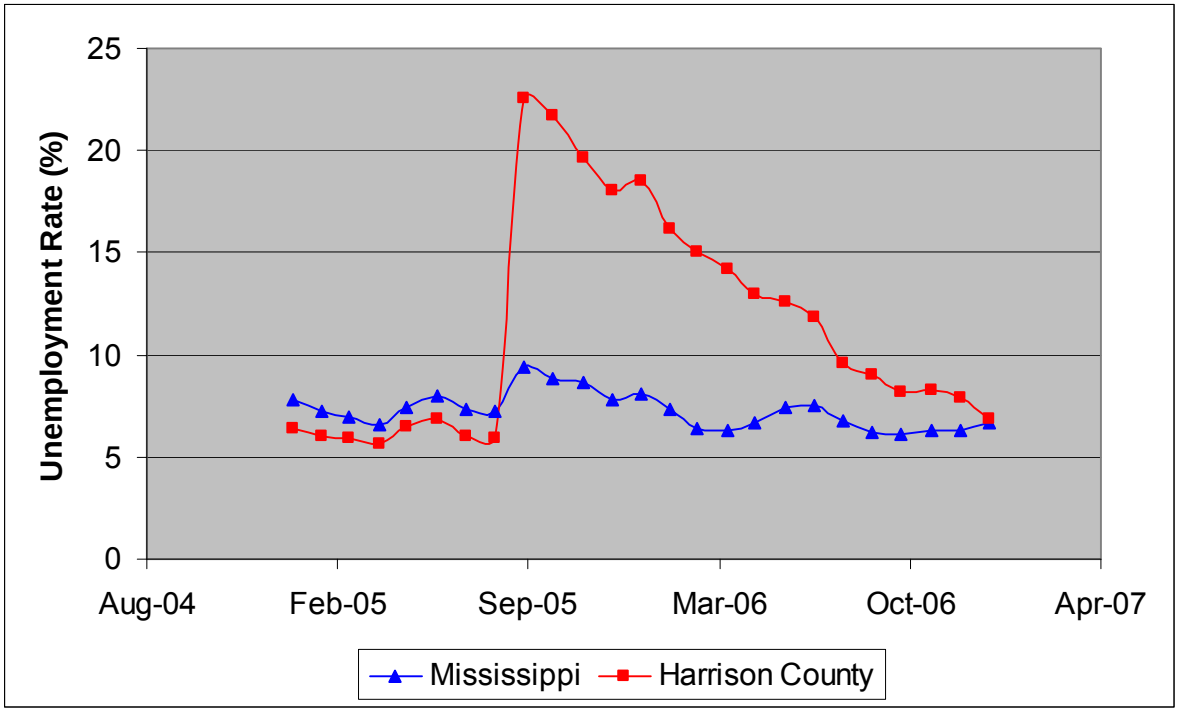
5.2.3.2.2 Unemployment

The non-seasonally adjusted unemployment rates for Mississippi and each county in the study area from January 2005 to January 2007 are displayed graphically in Figures 5.2-16, 5.2-17 and 5.2-18. These same numbers are also displayed in Table 5-11. Unemployment rates within the study area increased dramatically following Hurricane Katrina, but have since recovered to roughly pre-Katrina levels.



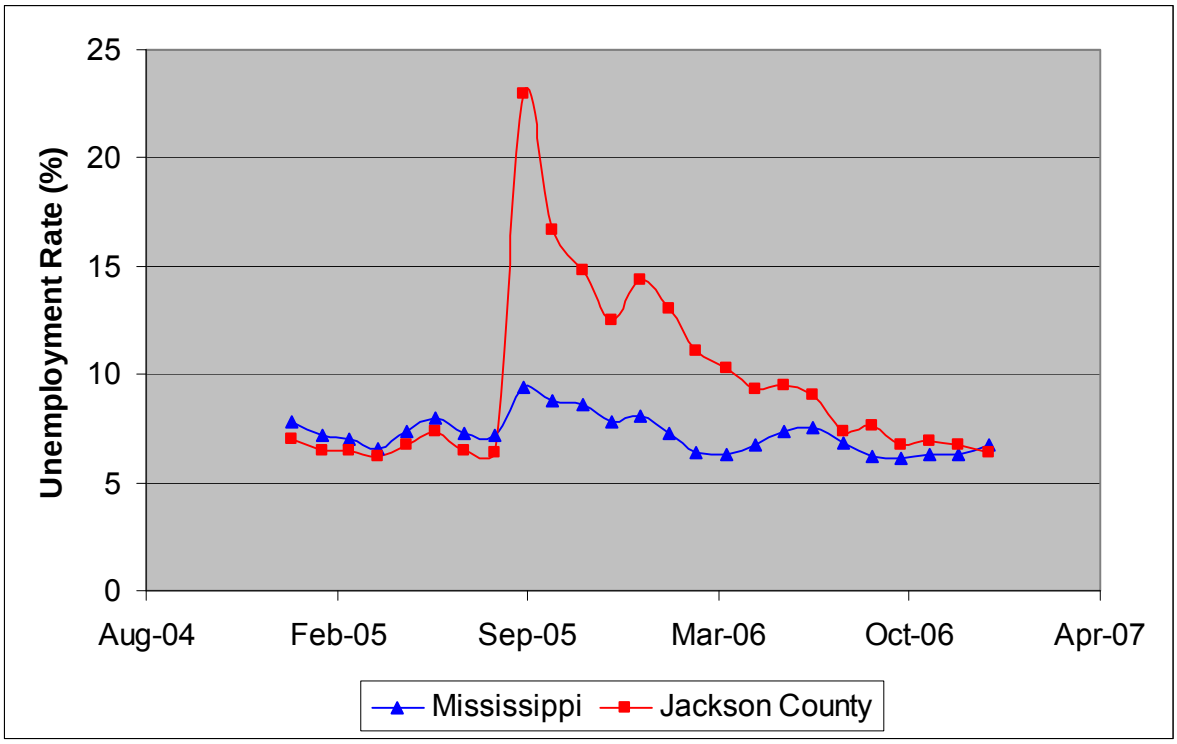
Source: Bureau of Labor Statistics

Figure 5.2-16. Non-Seasonally Adjusted Unemployment Rates for Mississippi and Hancock County



Source: Bureau of Labor Statistics

Figure 5.2-17. Non-Seasonally Adjusted Unemployment Rates for Mississippi and Harrison County



Source: Bureau of Labor Statistics

Figure 5.2-18. Non-Seasonally Adjusted Unemployment Rates for Mississippi and Jackson County

Table 5-11.
January 2005 – January 2007 Unemployment Rates (%)

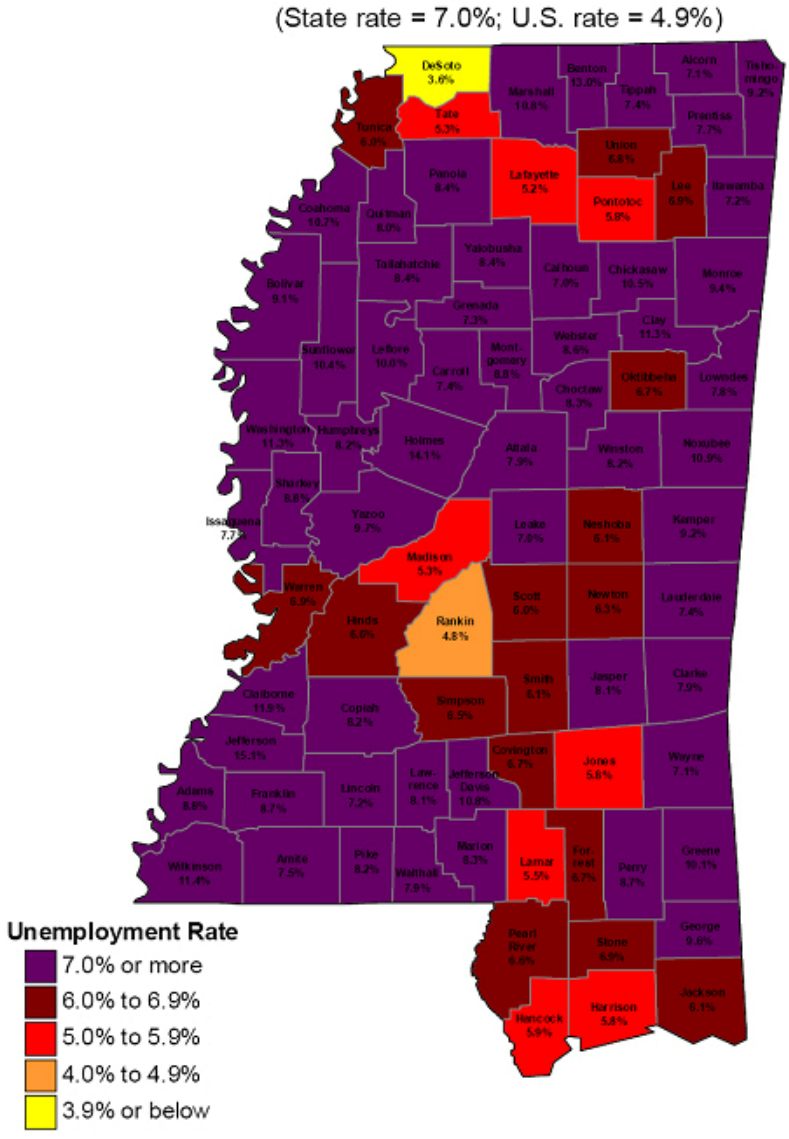
	Mississippi	Hancock County	Harrison County	Jackson County
Jan-05	7.8	5.9	6.4	7.0
Feb-05	7.2	5.3	6.0	6.5
Mar-05	7.0	5.7	5.9	6.5
Apr-05	6.6	5.6	5.6	6.2
May-05	7.4	6.3	6.5	6.7
Jun-05	8.0	6.7	6.9	7.4
Jul-05	7.3	5.8	6.0	6.5
Aug-05	7.2	5.9	5.9	6.4
Sep-05	9.4	22.0	22.6	23.0
Oct-05	8.8	22.3	21.7	16.7
Nov-05	8.6	19.2	19.6	14.8
Dec-05	7.8	17.2	18.0	12.5
Jan-06	8.1	16.8	18.5	14.4
Feb-06	7.3	15.1	16.2	13.0
Mar-06	6.4	14.7	15.0	11.1
Apr-06	6.3	14.3	14.2	10.3
May-06	6.7	13.1	13.0	9.3
Jun-06	7.4	12.7	12.6	9.5
Jul-06	7.5	9.9	11.8	9.0
Aug-06	6.8	7.9	9.6	7.4

Table 5-11.
January 2005 – January 2007 Unemployment Rates (%) (continued)

	Mississippi	Hancock County	Harrison County	Jackson County
Sep-06	6.2	7.7	9.0	7.6
Oct-06	6.1	7.2	8.2	6.7
Nov-06	6.3	6.8	8.3	6.9
Dec-06	6.3	6.6	7.9	6.7
Jan-07	6.7	6.2	6.9	6.4

Source: Bureau of Labor Statistics

Figure 5.2-19 is a map displaying the unemployment rates for Mississippi by county for August, 2005. Before Hurricane Katrina the counties in the study area had unemployment rates lower than the Mississippi unemployment rate.



Source: Bureau of Labor Statistics

Figure 5.2-19. Non-Seasonally Adjusted Unemployment Rates by County for Mississippi

5.2.3.2.3 Income and Poverty

Median income and poverty levels for the U.S., Mississippi and each county in the study area for 2004 are displayed in Table 5-12. Each of the three counties in the study area had a higher median income and a lower poverty rate than that of Mississippi in 2004.

Table 5-12.
2004 Median Income and Poverty Levels

	Median Income	Nominal Poverty	Poverty Rate
United States	$44,334	37,039,804	12.7%
Mississippi	$34,278	549,224	19.3%
Hancock County	$36,285	7,737	16.6%
Harrison County	$35,576	31,809	16.9%
Jackson County	$40,418	20,256	15.0%

Source: U.S. Census Bureau, Small Area Income & Poverty Estimates

5.2.4 Existing (Post-Hurricane Katrina) Environmental Setting

Prior to the storms, Coastal Mississippi had already experienced large population growth over the last few decades. Loss and/or alteration of various habitats types (i.e. barrier islands, submerged aquatic vegetation (SAVs), marsh habitat – freshwater and estuarine, wet pine savannah, etc.) had adverse impacts on both fish and wildlife and also on those habitats upon which they depend. Erosion to the barrier islands could possibly increase salinity; thus, greatly changing ecological habitats that exist, which could lead to saltwater intrusion, increased wave action, and destroying coastal wetlands. Increased salinity within Mississippi Sound would impact shellfish and many other forms of marine life. At the Chandeleur Islands in Louisiana, loss of those island masses allows us to anticipate potential environmental changes. Initial assessments are showing SAVs diminishing, marsh erosion ongoing/accelerating, and wave energy having no natural barrier.

Following Hurricane Katrina, the Commerce Secretary declared a complete fisheries failure due to the extensive devastation to the processing facilities, docks, loss of boats, degradation of habitat, deposition of marine debris, and degraded water quality. Losses to many commercially important fisheries stock, foraging areas, nurseries, and etc. have been felt economically in the region. Increased salinity due to continued degradation of the barrier islands will result in detrimental impacts to the vital economic fisheries industry that the estuarine environment sustains.

Oyster reefs have been seriously impacted by Hurricane Katrina and all reefs in Coastal Mississippi were closed immediately following the storm, with some of them still remaining closed almost 2 years later. There are signs the reefs are beginning some of the healing processes on their own; however, much work will be needed to restore the oyster reefs to their former prime condition. Extensive sampling of the reefs is currently being conducted by the MDMR to provide information needed to plan extensive long-term recovery activities. Initial assessments of the reef conditions are underway but at present, are incomplete. Conditions of the reefs are highly variable. Generally, offshore areas were heavily scoured. Recent very heavy oyster spat set (less than one inch in length) was found in some of these areas with no spat set in other areas. Some light SAVs, marsh grass and drift wood were found. Inshore reefs generally had moderate to very low numbers of live oysters in some areas with other areas revealing no live oysters.

The coastal maritime forests on the barrier islands and also the mainland were almost entirely lost as a result of the storm. Almost 2 years following those events, approximately 90% of this habitat is still lost. Even prior to the storms, but especially after, wet pine savannah wetland habitat has been

under increased developmental pressures due to the extreme and urgent housing need faced by Mississippians as they are trying to rebuild. This habitat is becoming fragmented and with the increased development, fire maintenance is increasingly harder to perform. Due to the nature of the flat coastal plains with little relief, these lands are some of the first to be considered for housing development. These habitats are becoming fragmented causing a loss of wildlife corridors and contiguous expanses of habitat necessary for continued species existence. Coastal Mississippi has lost over half of its wet pine savannahs due to the urbanization throughout the area; thus, creating a threatened ecosystem that in turn is home to many threatened and endangered species. Because of the loss of these habitats, the species dependent upon them are increasingly becoming diminished. As a result of Hurricane Katrina and other storms of 2005, estuarine and freshwater marsh habitats were severely impacted by the debris that landed within its footprints; thus, clogging natural tidal and/or runoff flow. Furthermore, many historical marsh habitats (i.e. Shoreline Park) were noted to have detrimental damage due to its historical filling and development. Following those events, many historical habitats were identified that would benefit Coastal Mississippi upon its conversion back to its natural habitat. In conclusion, the hurricane season of 2005 greatly impacted the environmental setting of Coastal Mississippi.

5.3 Future Without-Project Conditions

5.3.1 Period of Analysis

For sensitivity purposes, the period of analysis used for the MsCIP Comprehensive Plan is a 100-year period, which was then converted to a 50-year period of analysis for those plan elements that would be recommended for construction. The base year used for the MsCIP Comprehensive Plan is the first year of the period of analysis. Typically, the base year is considered to be the first year that full project benefits come online and it is always the year to which benefits and costs of measures are discounted (present-worthed) back to in order to make an even ("apple-to-apples") comparison. The base year for the analysis used for the MsCIP Comprehensive Plan is the year 2012. Figure 5.3-1 depicts the methodology that was used for the 100-year period of analysis. This methodology was also used for the 50-year period of analysis, with the exception of the most likely future being 2061 (50 years), instead of 2111 (100 years).

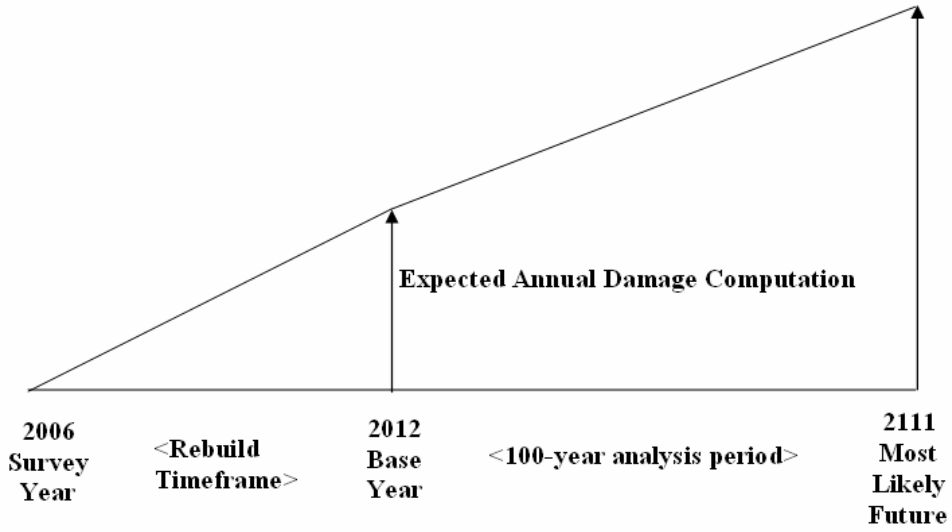


Figure 5.3-1. Period of Analysis used for Flood Damage Reduction and Hurricane and Storm Damage Prevention

5.3.2 Assumptions

The following assumptions were designed to construct the forecast estimate of the of the three county study area. The assumptions were based on discussions with state and local interests, various experts, and past experiences following devastating hurricanes along the northern Gulf Coast such as Hurricanes Camille and Fredrick. Further, these assumptions were based on an existing condition identified by using tax parcel data from the tax assessors of the three coastal counties and by conducting the field inventory to assess the extent of damages and where they occurred. These assumptions drive the future without-project structure inventory that was forecast and evaluated in HEC-FDA along with the hydrodynamic forecast conditions, which can be found in detail in the engineering appendix, to estimate future without-project inundation damages and damages reduced as result of potential measures.

- The base year for which costs and benefits are discounted is 2012.
- The discount rate used for this analysis is the FY-08 discount rate of 4-7/8-percent.
- The period of analysis for screening and sensitivity purposes is 100-years (2012 to 2111), however all measures recommended for construction will be converted back to a 50-year period of analysis (2012 to 2111). A more detailed discussion of this assumption can be found as a sensitivity analysis in chapter VII of this appendix.
- The demands for waterfront and near water living will not decrease in the future as a result of hurricanes (i.e. people will always want to live by the water).
- Only destruction of property occupied prior to Hurricane Katrina will be accounted for in forecasting (i.e. there will be no projection of previously undeveloped land).
- Destruction categories include significant (damaged 50-percent or more and must be completely rebuilt) and moderate to minimal (less than 50-percent rebuilt and can be either repaired or rehabilitated).
- Previously occupied structures that were destroyed as a result of Hurricane Katrina will be redeveloped and the population will return to at least pre-Katrina levels. Redevelopment is defined as the building back of structures that existed before Hurricane Katrina, not development that occurs on land that was undeveloped.
- Full redevelopment of previously occupied structures will occur by the base year 2012.
- Redevelopment of the study area could take the form of residential redevelopment (exactly the way it was pre-Hurricane Katrina) or a mixture of commercial/condominium and residential redevelopment. In addition to redevelopment, it is assumed that relative sea level rise could take the form of base, moderate or high relative sea level rise. The six future scenarios are outlined in the following section.
- Economic cycles such as recessionary and expansionary periods could, and probably will, have an impact on the timing and magnitude of the redevelopment of the coast over the period of analysis, but are not able to be predicted and are not accounted for in the forecast.
- An increase in relative sea level rise will probably occur over the period of analysis.
- Relative sea level rise is not a linear function, meaning that some years may experience more or less than other years. Since the amount of relative sea level rise in any given year is impossible to predict, a linear relationship is used to model relative sea level rise for purposes of forecasting.

- Given the majority of the coast is fronted by man-made seawalls and roadways and the majority of structures are immediately located by the water like other Gulf Coast and Eastern Seaboard communities, effects of future erosion on human development behavior will be none to minimal.

- Effects of future inundation caused by relative sea level rise could have any where from a minimal to a moderate effect on human development behavior, but those effects are currently difficult or impossible to measure and are not account for in this forecasting effort.

- Communities will adopt and adhere to FEMA guidelines under the National Flood Insurance Program (NFIP).

- FEMA guidelines require minimum heights that the first floor elevation must be built to in order to be included in the National Flood Insurance Program (NFIP). For the purposes of the redevelopment projected in this report, houses that will be rebuilt before the start of 2009 are assumed to be rebuilt to the Pre-Hurricane Katrina Base Flood Elevation (BFE) and those that are rebuilt between 2009 and 2011 will be rebuilt to the Advisory Base Flood Elevation (ABFE) as existed May 2007. The BFE and ABFE estimates vary in range of elevation depending on the planning sub-unit in question. Table 5-13 shows these heights by reach.

- Redevelopment is estimated to occur as follows:

Table 5-13.
Assumptions of Structure Redevelopment by Year

Year	Percent Redeveloped	Elevation of Redevelopment
2005	N/A	Hurricane Katrina Landfall (August 29th)
2006	10%	Pre-Hurricane Katrina Base Flood Elevations
2007	25%	Pre-Hurricane Katrina Base Flood Elevations
2008	40%	Pre-Hurricane Katrina Base Flood Elevations
2009	60%	Advisory Base Flood Elevations
2010	80%	Advisory Base Flood Elevations
2011	100%	Advisory Base Flood Elevations
2012	Full Redevelopment	Base Year

- Depth damage characteristics of structures (the percent of structure damage at various levels of inundation) are assumed and used to define economic damage as a result of inundation.

- The depth damage characteristics of structures vary by construction type and are similar to those in other parts for the Gulf Coast, particularly the New Orleans area. It is also assumed that the duration of surge inundation is approximately 24 hours, which is considered short-term duration. The depth-damage relationships are explained in more detail in Addendums A and B.

- Depreciated replacement cost of structures was used unless a structure was destroyed fifty-percent or more due to surge from Hurricane Katrina. For those structures damaged fifty-percent or more and must be rebuilt, full depreciated replacement cost was used to denote the value in the structure inventory.

5.3.3 Scenario Testing

5.3.3.1 Methodology

Forecasting future scenarios is an important part of the Corps planning process. In order to evaluate the true economic value of potential measures over the project life, a forecast is created based on the historic and existing information, as well as quantitative and qualitative assumptions about what may happen within the study area in the future. One method is to identify the 'most likely' future, or the best guess about what may happen based on observed variables and assumptions of both natural and human behaviors. Another method is to conduct scenario planning, where multiple future scenarios are created in order to evaluate what would happen if observed variables or assumptions do not happen as projected. The purpose of scenario planning is to attempt to answer 'what if' questions that arise when making forecasting assumptions and predictions.

For the Mississippi Coastal Improvements Project, the former method was chosen due to the size, scope, and complexity of the overall analysis. The six future without-project scenarios are displayed in table 5-14 summarizes the six future scenarios.

These six future without-project scenarios were based on existing condition characteristics, patterns of rebuilding following historical hurricanes within the specific area such as Hurricane Camille, patterns of rebuilding in other similar parts of the northern Gulf Coastal area such as Gulf Shores and Orange Beach, AL following Hurricane Fredrick, and potential impacts of relative sea level rise over the period of analysis. Following Hurricane Camille, the Mississippi Gulf Coast not only rebuilt the structures and infrastructure it lost to the devastating storm surge, but saw substantial growth in both residential and commercial infrastructure. However, it did not see a major shift in their proportion, i.e., the ratio of residential and commercial infrastructure did not immediately change as a result of a shift in behavior immediately following the storm. In contrast, the effects of Hurricane Fredrick to the Alabama Gulf Coast Communities of Gulf Shores and Orange Beach saw a fundamental shift of infrastructure from typically residential, to condominium and business structures. These two scenarios form the two rebuilding components of the future without-project scenarios; residential (a rebuild of the coastal area based on what existed prior to Hurricane Katrina) and residential and commercial (a rebuild of what type existed prior to Hurricane Katrina with a shift from residential to commercial along the coast.

The other component of the future without-project scenarios is relative sea level rise, or an estimate of the affect of eustatic sea level rise combined with subsidence. In order to evaluate the effects of this component, a range of relative sea level rise was identified and modeled and the details can be found in the engineering appendix. Three potential relative sea level rise settings were identified; base (historical relative sea level rise with no future projection), moderate (historical relative sea level rise and a future projection of up to 2.4-feet depending on location), and high (historical relative sea level rise and a future projection of up to 3.4-feet depending on location). These three components, coupled with the two redevelopment components, form the six future without-project scenarios used in the evaluation of this study.

As with any attempt to project the future, accuracy is limited by a host of factors such as timing (what if a recession hits), reality not fully matching the assumptions used (what if the redevelopment effort doesn't happen as fast as predicted or what if human behavior shifts in a way that was unforeseen), and on. In other words, any attempt to project the future will include some risk and uncertainty and therefore the intent of making these forecasts is to provide an estimate of what the future could be in order to evaluate the impacts of potential actions, not to say this is exactly what is going to happen.

Table 5-14.
Overview of Future Scenarios

Future Scenario	Redevelopment Type	Relative Sea Level Rise	Description
Future Scenario 1	Residential	Historical Only	Rebuild structures as existed pre-Hurricane Katrina with no relative sea level rise over the period of analysis. This future scenario applies to all three planning units.
Future Scenario 2	Mixed Residential & Commercial	Historical Only	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, no relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.
Future Scenario 3	Residential	Expected (up to 2.4-Feet depending on location)	Rebuild structures as existed pre-Hurricane Katrina with up to 2.4-feet relative sea level rise over the This future scenario applies to all three planning units.
Future Scenario 4	Mixed Residential & Commercial	Expected (up to 2.4-Feet depending on location)	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, a up to 2.4-feet relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.
Future Scenario 5	Residential	High Rate (up to 3.4-feet depending on location)	Rebuild structures as existed pre-Hurricane Katrina with up to 3.4-feet of relative sea level rise over the period of analysis. This future scenario applies to all three planning units.
Future Scenario 6	Mixed Residential & Commercial	High Rate (Up to 3.4-feet depending on location)	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, up to3.4-feet of relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.

Future Scenarios One and Two are included only to evaluate the effects of relative sea level rise. These Future scenarios will not be used in the evaluation of potential measures. Futures Three, Four, Five, and Six will be the future scenarios by which potential measures will be evaluated depending on the planning unit.

5.3.3.2 Future Scenario 1

Scenario one is the full redevelopment of structures within the study area by the year 2012. Under this scenario, structures will be rebuilt as they were pre-Katrina. For example, if the structure was a residential structure pre-Katrina it will be rebuilt as a residential structure; commercial back to commercial; etc. It includes 220,776 tax parcels as defined by Hancock (planning unit one), Harrison (planning unit two), and Jackson (planning unit three) Counties, Mississippi. Of those parcels, 138,170 are structures including 22,313 are in planning unit one, 57,587 in planning unit two, and 58,270 in planning unit three. In addition to the redevelopment of structures, this scenario accounts for no relative sea level rise over the 100-year period of analysis (2012–2111). Table 5-15 displays the parcels by planning unit, category of structure, and by one-foot elevation contour. Table 5-16 displays the parcels for all three planning units by structure category and by one-foot elevation contour. Table 5-17 displays the value of structures and their contents by category and planning unit. **Note:** This scenario will not be used to evaluate potential measures in Chapter IV of this appendix because it does not adequately account for the effect of relative sea level rise. However, it will be used as a sensitivity analysis to evaluate the effects of the increment between a no relative sea level rise scenario and the expected relative sea level rise scenario.

Table 5-15.
Futures Without-Project Scenarios One, Three, and Five Inventory Parcels by Planning Unit and by Structure Category

Structure Categories	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Residential	17,907	49,121	49,688	**116,716**
Mobile Homes	498	2,497	3,553	**6,548**
Commercial	3,255	5,618	4,266	**13,139**
Municipal	653	351	763	**1,767**
Vacant Land	22,843	29,984	29,779	**82,606**
Total	**45,156**	**87,571**	**88,049**	**220,776**

Table 5-16.
Futures Without Project Scenarios One, Three, and Five Inventory Cumulative Structures for All Three Planning Units by Structure Category and One-foot Elevation

Estimated First Floor Elevation Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
1-foot	19	1	2	1	**23**
2-foot	115	1	16	4	**136**
3-foot	411	2	42	18	**473**
4-foot	1,015	2	88	34	**1139**
5-foot	2,566	20	143	52	**2,781**
6-foot	3,117	77	196	68	**3,458**
7-foot	3,975	129	270	87	**4,461**
8-foot	5,111	183	350	108	**5,752**
9-foot	6,475	226	463	130	**7,294**
10-foot	8,012	270	576	163	**9,021**
11-foot	10,381	321	730	194	**11,626**
12-foot	14,068	396	1,064	256	**15,784**
13-foot	18,411	507	1,537	352	**20,807**
14-foot	22,416	617	2,128	465	**25,626**
15-foot	31,139	779	3,424	629	**35,971**
16-foot	34,210	878	3,829	692	**39,609**
17-foot	37,925	1,006	4,125	774	**43,830**
18-foot	42,793	1,144	4,771	865	**49,573**
19-foot	47,914	1,368	5,650	942	**55,874**
20-foot	56,895	1,606	7,244	1,089	**66,834**
21-foot	60,673	1,784	7,809	1,154	**71,420**
22-foot	64,417	1,960	8,158	1,221	**75,756**
23-foot	71,143	2,174	8,893	1,293	**83,503**
24-foot	75,711	2,331	9,295	1,345	**88,682**
25-foot	79,957	2,473	9,633	1,392	**93,455**
26-foot	83,944	2,648	9,901	1,428	**97,921**

Table 5-16.
Futures Without Project Scenarios One, Three, and Five Inventory Cumulative Structures for All Three Planning Units by Structure Category and One-foot Elevation (continued)

Estimated First Floor Elevation Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
27-foot	86,948	2,788	10,144	1,463	**101,343**
28-foot	89,743	2,887	10,405	1,487	**104,522**
29-foot	92,130	2,986	10,634	1,502	**107,252**
30-foot	94,042	3,057	10,873	1,521	**109,493**
31-foot	95,586	3,158	11,114	1,535	**111,393**
32-foot	96,621	3,242	11,324	1,545	**112,732**
33-foot	97,531	3,300	11,450	1,555	**113,836**
34-foot	98,165	3,364	11,559	1,572	**114,660**
35-foot	98,669	3,429	11,623	1,584	**115,305**
36-foot	99,075	3,481	11,651	1,590	**115,797**
37-foot	99,498	3,532	11,682	1,598	**116,310**
38-foot	99,952	3,589	11,711	1,600	**116,852**
39-foot	100,478	3,644	11,747	1,605	**117,474**
40-foot	116,716	6,548	13,139	1,767	**138,170**

Table 5-17.
Futures Without-Project Scenarios One, Three, and Five Inventory Structure and Content Values by Category and Planning Unit

	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Structure Values				
Residential	$2,415,885,807	$4,449,184,443	$3,200,940,955	**$10,066,011,205**
Mobile Homes	$8,518,174	$48,312,941	$52,053,731	**$108,884,846**
Commercial	$611,355,705	$4,526,104,161	$2,048,940,654	**$7,186,400,520**
Municipal	$335,220,287	$261,009,884	$303,986,556	**$900,216,727**
Structure Value Subtotal	**$3,370,979,973**	**$9,284,611,429**	**$5,605,921,896**	**$18,261,513,298**
Content Values				
Residential	$2,415,885,807	$4,449,184,443	$3,200,940,955	**$10,066,011,205**
Mobile Homes	$12,606,898	71503152.68	77039521.88	**$161,149,573**
Content Values				
Commercial	$1,213,472.28	$2,388,618,644	$428,362,111	**$2,818,194,227**
Municipal	$135,597,922	$102,609,763	$102,022,049	**$340,229,734**
Content Value Subtotal	**$2,565,304,099**	**$7,011,916,003**	**$3,808,364,637**	**$13,385,584,739**
Total	**$5,936,284,072**	**$16,296,527,432**	**$9,414,286,533**	**$31,647,098,037**

5.3.3.3 Future Scenario 2

Scenario two is the full redevelopment of structures within the study area by the year 2012. Under this scenario, structures away from the water front in Planning Units one and two and all of planning unit three will be rebuilt as they were pre-Katrina. For example, if the structure was a residential structure pre-Katrina it will be rebuilt as a residential structure; commercial structures will be rebuilt back to commercial structures; etc. In addition, structures in planning units one and two, structures

along the Mississippi Sound and Back Bay water fronts will be rebuilt as condominiums and casinos. It includes 220,776 tax parcels as defined by Hancock (planning unit one), Harrison (planning unit two), and Jackson (planning unit three) Counties, Mississippi. Of those parcels, 138,199 are structures including 22,314 are in planning unit one, 57,615 in planning unit two, and 58,270 in planning unit three. In addition to the redevelopment of structures, this scenario accounts for no relative sea level rise over the 100-year period of analysis (2012–2111). Table 5-18 displays the parcels by planning unit, category of structure, and by one-foot elevation contour. Table 5-19 displays the parcels for all three planning units by structure category and by one-foot elevation contour. Table 5-20 displays the value of structures and their contents by category and planning unit. **Note:** This scenario will not be used to evaluate potential measures in Chapter IV of this appendix because it does not adequately account for the effect of relative sea level rise. However, it will be used as a sensitivity analysis to evaluate the effects of the increment between a no relative sea level rise scenario and the expected relative sea level rise scenario.

Table 5-18.
Futures Without-Project Scenarios Two, Four, and Six Inventory Parcels by Planning Unit and by Structure Category

Structure Categories	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Residential	17,757	48,636	49,688	**69,942**
Mobile Homes	498	2,497	3,553	**52,687**
Commercial	3,408	6,101	4,266	**13,775**
Municipal	651	381	763	**1,795**
Vacant Land	22,842	29,956	29,779	**82,577**
Total	**45,156**	**87,571**	**88,049**	**220,776**

Table 5-19.
Futures Without-Project Scenarios Two, Four, and Six Inventory Cumulative Structures for All Three Planning Units by Structure Category and One-foot Elevation

Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
1-foot	19	1	3	1	**24**
2-foot	111	1	17	4	**133**
3-foot	403	2	43	18	**466**
4-foot	1,003	2	89	34	**1,128**
5-foot	2,543	20	144	52	**2,759**
6-foot	3,080	77	197	68	**3,422**
7-foot	3,932	129	271	87	**4,419**
8-foot	5,055	183	351	108	**5,697**
9-foot	6,408	226	464	130	**7,228**
10-foot	7,934	270	577	163	**8,944**
11-foot	10,291	321	730	194	**11,536**
12-foot	13,954	396	1,069	256	**15,675**
13-foot	18,266	507	1,546	352	**20,671**
14-foot	22,220	617	2,147	465	**25,449**
15-foot	30,880	779	3,468	630	**35,757**
16-foot	33,923	878	3,930	692	**39,423**
17-foot	37,611	1,006	4,272	775	**43,664**
18-foot	42,439	1,144	4,949	866	**49,398**

Table 5-19.
Futures Without-Project Scenarios Two, Four, and Six Inventory Cumulative Structures for All Three Planning Units by Structure Category and One-foot Elevation (continued)

Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
19-foot	47,513	1,368	5,840	943	**55,664**
20-foot	56,412	1,606	7,398	1,089	**66,505**
21-foot	60,178	1,784	7,975	1,153	**71,090**
22-foot	63,910	1,960	8,365	1,220	**75,455**
23-foot	70,535	2,174	9,137	1,292	**83,138**
24-foot	75,091	2,331	9,590	1,344	**88,356**
25-foot	79,328	2,473	9,986	1,391	**93,178**
26-foot	83,308	2,648	10,301	1,427	**97,684**
27-foot	86,314	2,788	10,584	1,462	**101,148**
28-foot	89,112	2,887	10,878	1,486	**104,363**
29-foot	91,498	2,986	11,147	1,501	**107,132**
30-foot	93,409	3,057	11,406	1,520	**109,392**
31-foot	94,952	3,158	11,677	1,534	**111,321**
32-foot	95,986	3,242	11,902	1,544	**112,674**
33-foot	96,897	3,300	12,053	1,554	**113,804**
34-foot	97,531	3,364	12,178	1,571	**114,644**
35-foot	98,035	3,429	12,247	1,583	**115,294**
36-foot	98,441	3,481	12,278	1,589	**115,789**
37-foot	98,864	3,532	12,315	1,597	**116,308**
38-foot	99,318	3,589	12,345	1,599	**116,851**
39-foot	99,844	3,644	12,381	1,604	**117,473**
40-foot	116,081	6,548	13,775	1,795	**138,199**

Table 5-20.
Futures Two, Four, and Six Inventory Structure and Content Values by Category and Planning Unit

	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Structure Values				
Residential	$2,390,977,748	$4,402,477,082	$3,200,940,955	**$9,994,395,785**
Mobile Homes	$8,518,168	$48,312,740	$52,053,731	**$108,884,639**
Commercial	$1,500,399,292	$4,233,140,761	$2,048,940,654	**$7,782,480,707**
Municipal	$334,734,608	$261,025,195	$303,986,556	**$899,746,359**
Structure Value Subtotal	**$4,234,629,816**	**$8,944,955,778**	**$5,605,921,896**	**$18,785,507,490**
Content Values				
Residential	$2,390,977,748	$4,402,477,082	$3,200,940,955	**$9,994,395,785**
Mobile Homes	$12,606,888.64	$71,502,855.20	$77,039,521.88	**$161,149,266**
Commercial	$1,473,899,310	$2,498,045,931	$428,362,111	**$4,400,307,352**
Municipal	$135,240,760	$102,280,080	$102,022,049	**$339,542,889**
Content Value Subtotal	$4,012,724,707	$7,074,305,948	$3,808,364,637	**$14,895,395,292**
Total	**$8,247,354,523**	**$16,019,261,726**	**$9,414,286,533**	**$33,680,902,782**

5.3.3.4 Future Scenario 3

Scenario three is the full redevelopment of structures within the study area by the year 2012. Under this scenario, structures will be rebuilt as they were pre-Katrina. For example, if the structure was a residential structure pre-Katrina it will be rebuilt as a residential structure; commercial structures will be rebuilt back to commercial structures; etc. Scenario three is the same structure inventory as scenario one with the addition of a relative sea level rise of 2.4-feet over the 100-year period of analysis (2012–2111). The structure inventory, structure values, and content values for future scenario three are described in detail in above section 5.3.3.2. This scenario will be used to evaluate potential measures in Chapter IV of this appendix.

5.3.3.5 Future Scenario 4

Scenario four is the full redevelopment of structures within the study area by the year 2012. Under this scenario, structures away from the water front in Planning Units one and two and all of planning unit three will be rebuilt as they were pre-Katrina. For example, if the structure was a residential structure pre-Katrina it will be rebuilt as a residential structure; commercial back to commercial; etc. In planning units one and two, structures along the Mississippi Sound and Back Bay water fronts will be rebuilt as condominiums and casinos. Basically, Scenario three is the same structure inventory as scenario one with the addition of a relative sea level rise of up to 2.4-feet over the 100-year period of analysis (2012–2111). The structure inventory, structure values, and content values for future scenario three are described in detail in above section 5.3.3.3. This scenario will be used to evaluate potential measures in Chapter IV of this appendix.

5.3.3.6 Future Scenario 5

Scenario five is the same structure inventory as scenario one with the addition of a relative sea level rise of up to 3.4-feet depending over the 100-year period of analysis (2012–2111). The structure inventory, structure values, and content values for future scenario three are described in detail in above section 5.3.3.2. This scenario will be used to evaluate potential measures in Chapter IV of this appendix.

5.3.3.7 Future Scenario 6

Scenario six is the same structure inventory as scenario two with the addition of a relative sea level rise of up to 3.4-feet over the 100-year period of analysis (2012–2111). The structure inventory, structure values, and content values for future scenario three are described in detail in above section 5.3.3.3. This scenario will be used to evaluate potential measures in Chapter IV of this appendix.

5.3.4 Future Without-Project Surge Risk

5.3.4.1 Maximum Probable Intensity (MPI) Event

Computer simulations have predicted[2] how far inland storm surge will extend if the worse-case hurricane or maximum possible intensity (MPI) event hits the Mississippi coast. The extent of the surge from the MPI event is shown in Figure 5.3-2. The maximum water level of the MPI event along the Mississippi coastline was determined to be approximately 30 feet along the entire western half of the state and east of Pascagoula. The landward extent of the inundation indicates the storm surge reaches Interstate 10 for much of the western portion of the state. Lower peaks near Biloxi and Mobile Bay (24-27 feet) may be attributed to the protection afforded by the barrier islands. The line of defense accordingly approximates the 24 to 30 feet. (NAVD '88 datum) contours.

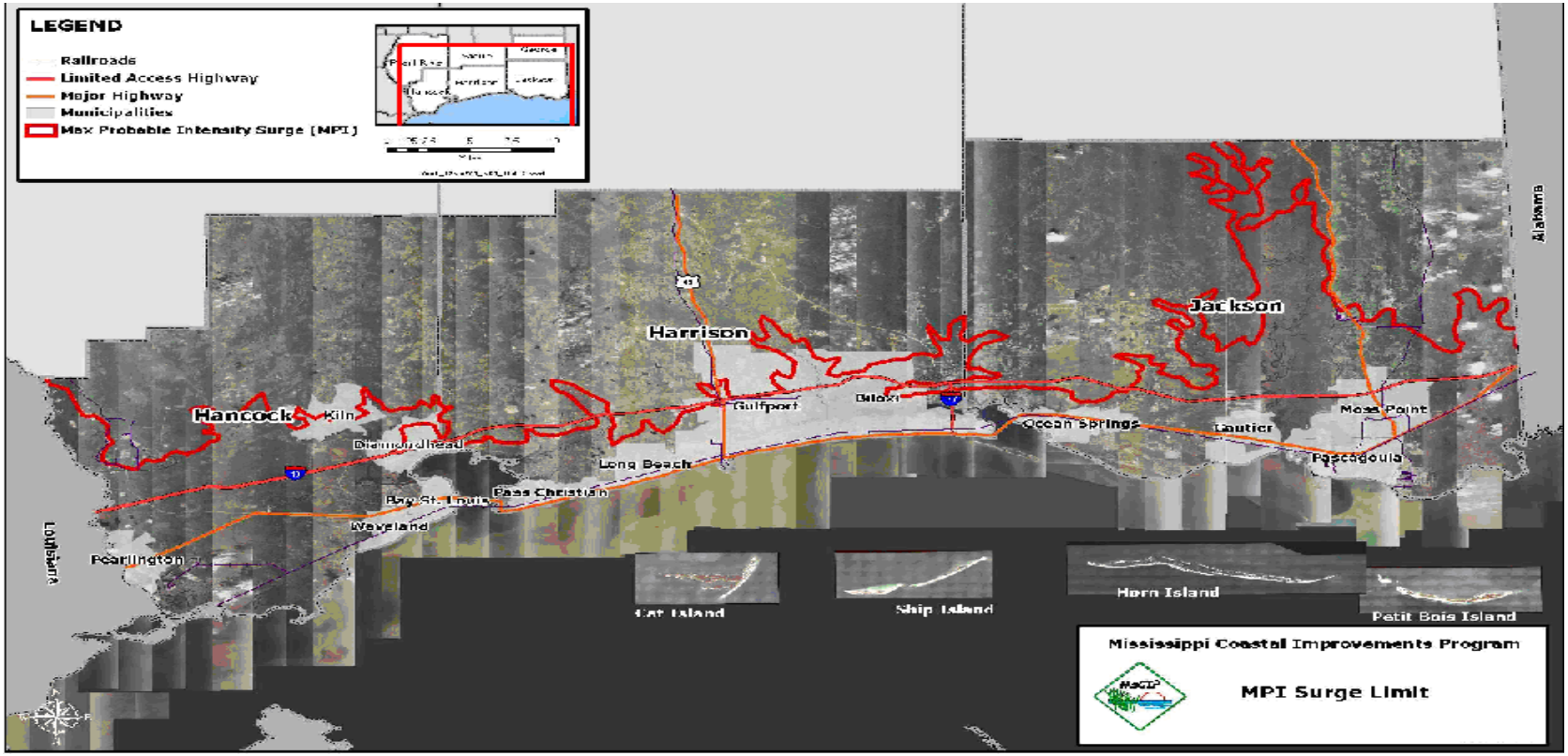


Figure 5.3-2. Maximum Probable Intensity Footprint for the Without Project Condition

[2] Storm surge modeling is described in the MsCIP Comprehensive Plan Engineering Appendix.

Figure 5.3-3 shows the population density of the three planning units within the MPI event footprint.

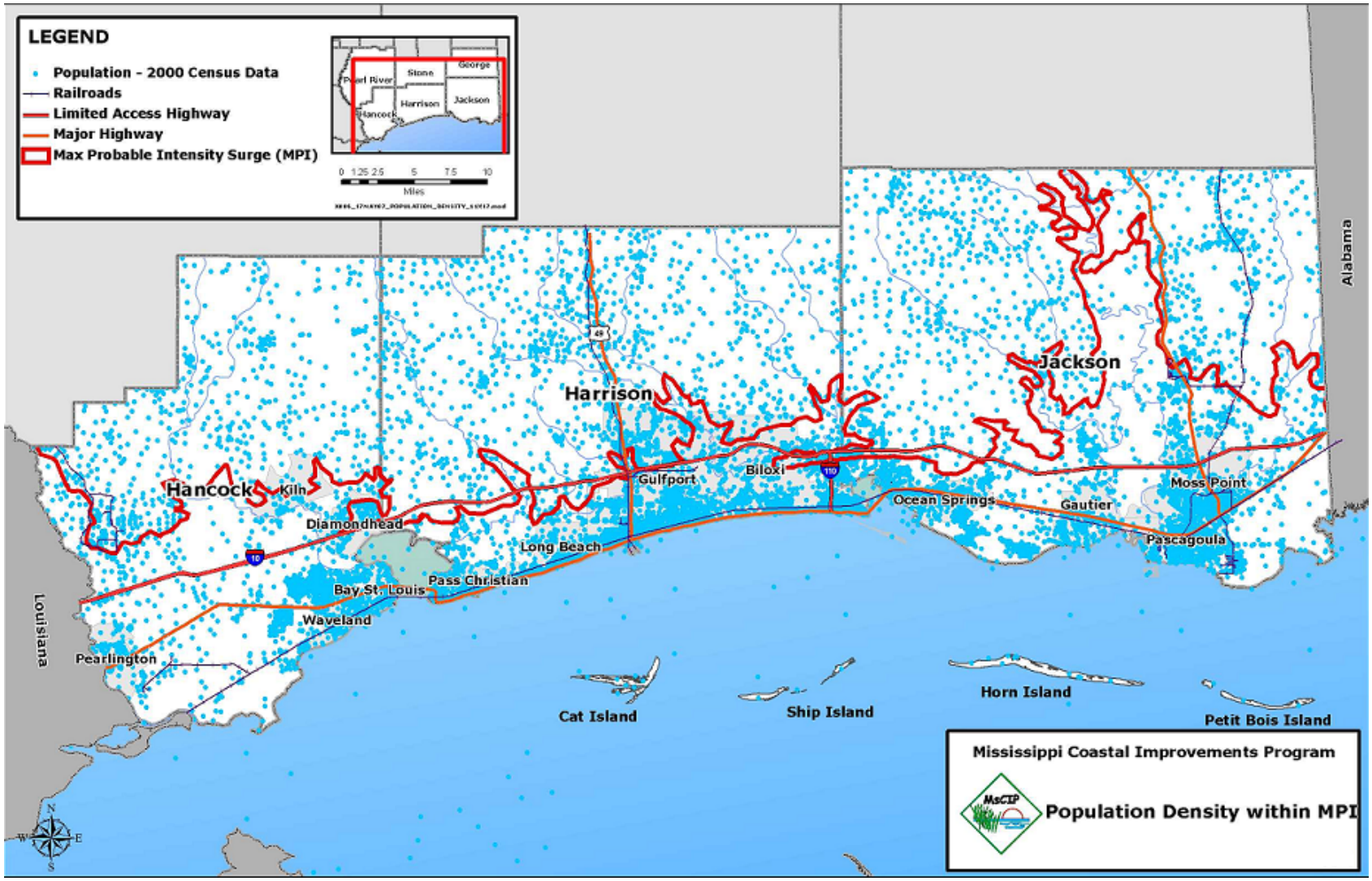


Figure 5.3-3. Population within the Future Without-Project Maximum Probable Intensity Surge Footprint

Figure 5.3-4 shows the various risk zones within the extent of the MPI event.

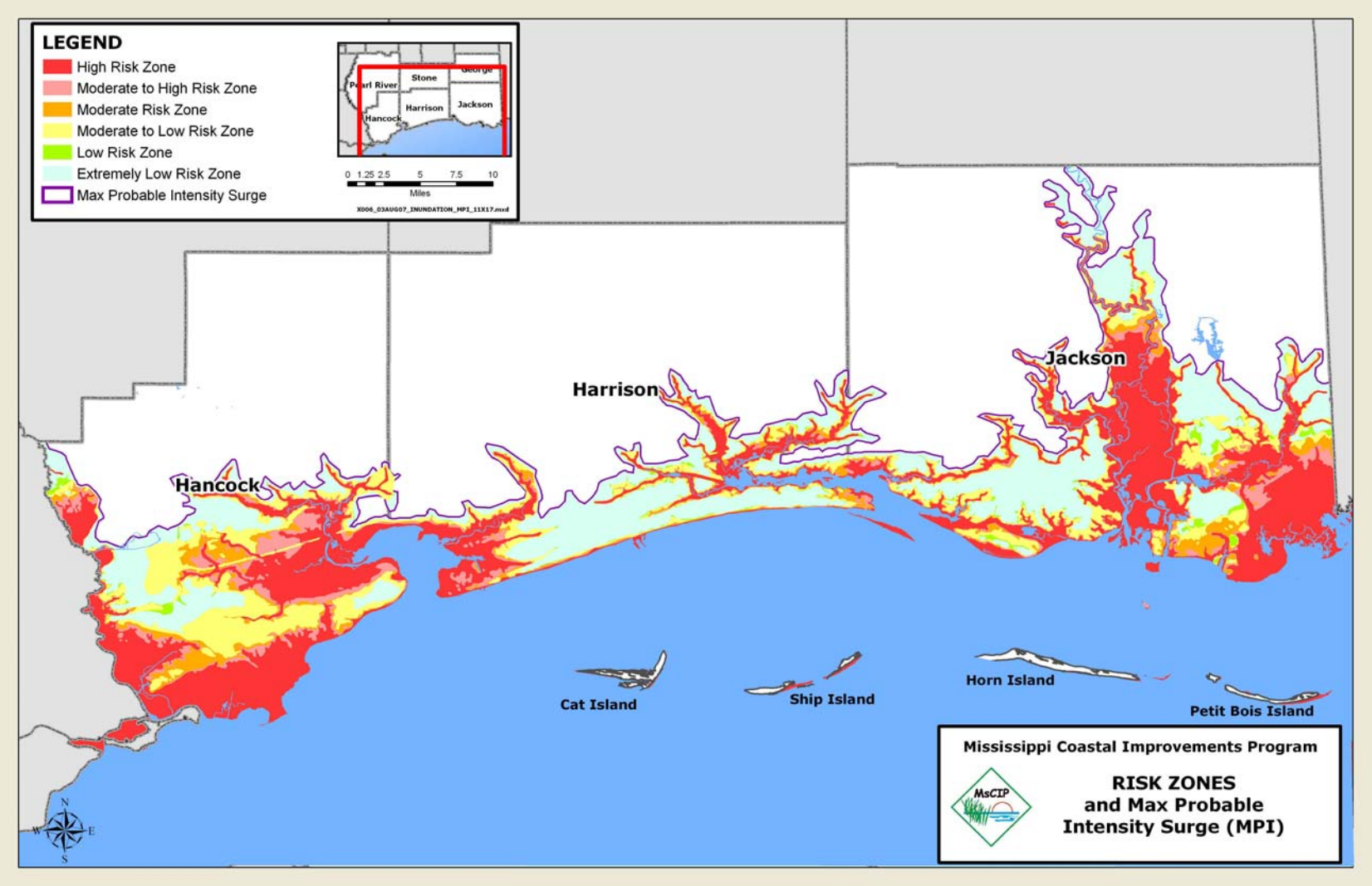


Figure 5.3-4. Risk Zones within the Maximum Probable Intensity Area

5.3.5 Summary of Future Without-Project Damages

This section describes the equivalent annual without-project damages for the entire study area to the 40-foot NAVD88 contour. Future without-project damages for the entire study area were calculated using the HEC-FDA program. Equivalent annual without-project damages were calculated for each of the 54 planning sub-units and each of the six future scenarios. The equivalent annual damages for specific areas, or planning sub-units, will be described in detail in the various sections of Chapter IV of this appendix. Note: The equivalent annual without-project damages calculated at the beach and dune sites will be evaluated on a localized scale using the Beach-FX program. Section 6.2 will describe in detail the equivalent annual without-project damages at the beach and dune sites. The remainder of this section will depict the outputs of the HEC-FDA modeling only.

The results of the without project conditions for all fifty-four planning sub-units in depicted in Table 5-21. The table shows the total equivalent annual without-project damages by planning unit for each of the future scenarios. These values represent the annual damages if no action is taken and if the study area is redeveloped to the levels described in Table 5-14. Figure 5.3-5 shows the without-project damages by future scenario. Table 5-22 shows the expected annual without-project damages by reach and by future scenario.

Table 5-21.
Equivalent Annual Without-Project Damages by Planning Unit and Future Scenario

Without-Project Damages	Future 1[2] Damages	Future 2[2] Damages	Future 3 Damages	Future 4 Damages	Future 5 Damages	Future 6 Damages
Planning Unit One	$198,960,000	$202,060,000	$218,050,000	$222,220,000	$237,310,000	$241,520,000
Planning Unit Two	$91,260,000	$94,680,000	$103,280,000	$107,120,000	$115,470,000	$119,760,000
Planning Unit Three	$88,670,000	$88,670,000	$104,700,000	$104,700,000	$122,420,000	$122,420,000
Total	**$378,890,000**	**$385,410,000**	**$426,030,000**	**$434,040,000**	**$475,200,000**	**$483,700,000**

Damages are rounded to the nearest ten thousand.
1 Futures Two, Four, and Six do not apply to planning unit three, therefore total damages are the same as future scenarios one, three, and five.
2 Future Scenarios one and two will be used to evaluate the impacts of relative sea level rise only, and will not be discussed in the direct evaluation of potential measures detailed in Chapter IV of this appendix.

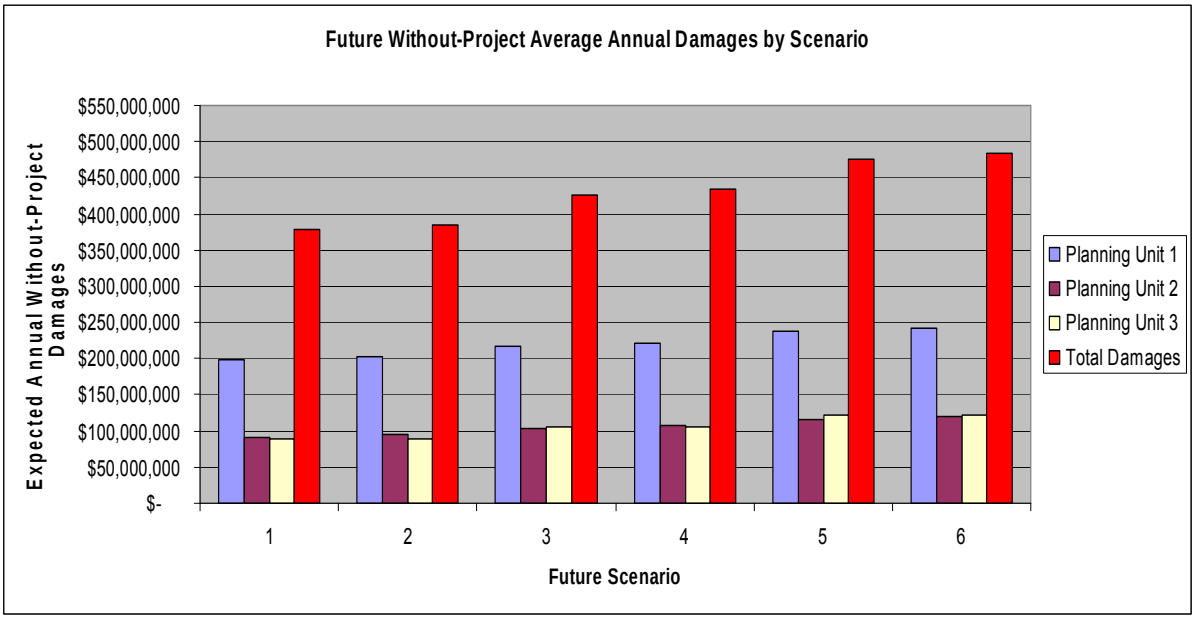


Figure 5.3-5. Without-Project Equivalent Damages by Future Scenario

Table 5-22.
Equivalent Annual Without-Project Damages by Planning Sub-Unit and Future Scenario[1]

Planning Unit and Sub-Unit	Future 1[2] Damages	Future 2[2] Damages	Future 3 Damages	Future 4 Damages	Future 5 Damages	Future 6 Damages
Unit One-Sub-Unit 1	$7,862,850	$7,863,020	$8,526,510	$8,571,980	$9,274,710	$9,275,260
Unit One-Sub-Unit 2	$137,947,140	$139,624,330	$150,862,640	$153,217,360	$163,864,720	$166,246,250
Unit One-Sub-Unit 3	$4,870,480	$5,842,300	$5,364,560	$6,513,000	$6,057,830	$7,287,670
Unit One-Sub-Unit 4	$2,739,650	$3,194,780	$3,014,870	$3,539,920	$3,308,930	$3,890,880
Unit One-Sub-Unit 5	$14,675,170	$14,677,680	$15,937,700	$16,015,090	$17,296,090	$17,300,110
Unit One-Sub-Unit 6	$11,568,960	$11,569,130	$12,885,400	$12,889,540	$14,205,370	$14,206,350
Unit One-Sub-Unit 7	$5,500,120	$5,500,120	$6,409,900	$6,460,160	$6,963,040	$6,963,380
Unit Two Sub-Unit-8	$14,860,070	$15,736,500	$16,671,180	$17,664,090	$18,732,000	$19,881,850
Unit Two Sub-Unit-9	$197,220	$197,220	$222,210	$222,220	$248,550	$248,550
Unit Two Sub-Unit-10	$5,884,170	$6,415,660	$6,616,080	$7,167,230	$7,464,200	$8,032,430
Unit Two Sub-Unit-11	$634,970	$634,990	$713,540	$713,560	$806,760	$806,790
Unit Two Sub-Unit-12	$14,831,530	$14,832,960	$16,886,630	$16,888,210	$19,298,510	$19,300,230

Table 5-22.
Equivalent Annual Without-Project Damages by Planning Sub-Unit and Future Scenario[1]
(continued)

Planning Unit and Sub-Unit	Future 12 Damages	Future 22 Damages	Future 3 Damages	Future 4 Damages	Future 5 Damages	Future 6 Damages
Unit Two Sub-Unit-13	$6,342,540	$6,436,620	$6,995,520	$7,104,440	$7,697,760	$7,821,230
Unit Two Sub-Unit-14	$149,990	$150,010	$174,120	$174,150	$206,540	$206,570
Unit Two Sub-Unit-15	$1,238,660	$1,234,760	$1,395,320	$1,391,460	$1,534,500	$1,532,550
Unit Two Sub-Unit-16	$1,241,620	$1,264,200	$1,417,560	$1,443,940	$1,580,110	$1,611,010
Unit Two Sub-Unit-17	$70	$70	$80	$80	$110	$110
Unit Two Sub-Unit-18	$17,649,830	$18,112,300	$20,105,420	$20,632,810	$22,318,530	$22,907,340
Unit Two Sub-Unit-19	$12,176,200	$12,176,200	$13,540,060	$13,540,060	$14,498,660	$14,498,660
Unit Two Sub-Unit-20	$9,104,980	$10,541,140	$10,619,760	$12,251,380	$12,244,150	$14,073,590
Unit Three Sub-Unit-21	$17,569,340	$17,569,340	$20,025,530	$20,025,530	$22,577,840	$22,577,840
Unit Three Sub-Unit-22	$1,719,390	$1,719,390	$1,958,170	$1,958,170	$2,190,200	$2,190,200
Unit Three Sub-Unit-23	$273,410	$ 273,410	$320,000	$320,000	$374,150	$374,150
Unit Three Sub-Unit-24	$3,819,150	$3,819,150	$4,298,090	$4,298,090	$4,705,940	$4,705,940
Unit Three Sub-Unit-25	$3,280	$3,280	$4,360	$4,360	$7,330	$7,330
Unit Three Sub-Unit-26	$5,416,740	$5,416,740	$6,273,270	$6,273,270	$7,010,490	$7,010,490
Unit Three Sub-Unit-27	$2,146,230	$2,146,230	$2,505,530	$2,505,530	$2,949,790	$2,949,790
Unit Three Sub-Unit-28	$5,233,540	$5,233,540	$5,756,790	$5,756,790	$6,165,720	$6,165,720
Unit Three Sub-Unit-29	$1,137,600	$1,137,600	$1,343,400	$1,343,400	$1,535,650	$1,535,650
Unit Three Sub-Unit-30	$4,920,250	$4,920,250	$5,831,120	$5,831,120	$6,701,750	$6,701,750
Unit Three Sub-Unit-31	$5,307,020	$5,307,020	$6,204,150	$6,204,150	$6,954,320	$6,954,320
Unit Three Sub-Unit-32	$2,548,650	$2,548,650	$3,100,610	$3,100,610	$3,660,240	$3,660,240
Unit Three Sub-Unit-33	$310	$310	$420	$420	$710	$710
Unit Three Sub-Unit-34	$11,550	$11,550	$13,440	$13,440	$17,680	$17,680

Table 5-22.
Equivalent Annual Without-Project Damages by Planning Sub-Unit and Future Scenario[1]
(continued)

Planning Unit and Sub-Unit	Future 12 Damages	Future 22 Damages	Future 3 Damages	Future 4 Damages	Future 5 Damages	Future 6 Damages
Unit Three Sub-Unit-35	$5,400,880	$5,400,880	$6,904,910	$6,904,910	$8,903,510	$8,903,510
Unit One-Sub-Unit 36	$8,908,670	$8,908,670	$9,763,750	$9,663,330	$10,537,160	$10,537,220
Unit One-Sub-Unit 37	$616,980	$616,980	$671,210	$675,150	$731,660	$731,680
Unit One-Sub-Unit 38	$4,267,130	$4,267,280	$4,617,740	$4,677,850	$5,069,830	$5,081,490
Unit Two Sub-Unit-39	$74,950	$74,950	$84,800	$84,800	$96,320	$96,330
Unit Two Sub-Unit-40	$3,780	$3,780	$4,650	$4,650	$5,940	$5,940
Unit Three Sub-Unit-41	$50	$50	$50	$50	$100	$100
Unit Three Sub-Unit-42	$1,040	$1,040	$1,350	$1,350	$2,220	$2,220
Unit Three Sub-Unit-43	$27,680	$27,680	$34,210	$34,210	$44,840	$44,840
Unit Three Sub-Unit-44	$91,160	$91,160	$108,070	$108,070	$132,280	$132,280
Unit Three Sub-Unit-45	$780	$780	$900	$900	$1,300	$1,300
Unit Three Sub-Unit-46	$39,750	$39,750	$44,590	$44,590	$52,110	$52,110
Unit Two Sub-Unit-47	$4,420	$4,420	$5,450	$5,450	$6,530	$6,530
Unit Two Sub-Unit-48	$56,210	$56,310	$65,730	$65,840	$74,870	$74,990
Unit Three Sub-Unit-49	$11,730	$11,730	$13,310	$13,310	$16,180	$16,180
Unit Two Sub-Unit-50	$6,804,480	$6,805,210	$7,764,770	$7,765,580	$8,656,060	$8,656,940
Unit Three Sub-Unit-51	$3,983,600	$3,983,600	$4,878,490	$4,878,490	$5,785,400	$5,785,400
Unit Three Sub-Unit-52	$17,464,120	$17,464,120	$21,199,790	$21,199,790	$27,027,040	$7,027,040
Unit Three Sub-Unit-53	$6,010,820	$6,010,820	$7,133,170	$7,133,170	$7,812,130	$7,812,130
Unit Three Sub-Unit-54	$5,532,370	$5,532,370	$6,744,800	$6,744,800	$7,790,870	$7,790,870
Total	**$378,883,280**	**$385,412,030**	**$426,035,680**	**$434,041,850**	**$475,199,230**	**$483,701,720**

1 Given the magnitude of the future-without project damages depicted in this table, a sensitivity analysis was conducted with regard to multiple criteria including period of analysis and first floor elevation uncertainty. The results of the sensitivity analysis can be found in Chapter VII of this appendix.
2 Future Scenarios one and two will be used to evaluate the impacts of relative sea level rise only, and will not be discussed in the

Table 5-22.
Equivalent Annual Without-Project Damages by Planning Sub-Unit and Future Scenario[1]
(continued)

Planning Unit and Sub-Unit	Future 12 Damages	Future 22 Damages	Future 3 Damages	Future 4 Damages	Future 5 Damages	Future 6 Damages

direct evaluation of potential measures detailed in Chapter IV of this appendix.

5.3.5.1 Future Without-Project Stage-Damage for Selected Reaches

As shown in the previous table, the magnitude of the equivalent annual damages is very large for the six future without-project scenario conditions. Planning sub-units two, five, six, eight, twelve, eighteen, nineteen, twenty-one, and fifty-two each have equivalent annual damages in the tens of millions of dollars. In order to communicate the effects that are being modeled, comparisons of the total present worth of damages by frequency event to the total economic value in the planning sub-units shows the nature of the damages that are being expressed by the HEC-FDA modeling.

This section is intended to dissect those nine planning sub-units for future without-project scenario one. This future scenario was chosen because it is the baseline case upon which the other Future Scenarios were built. It does not include the effects of a different type of redevelopment than what actually existed pre-Hurricane Katrina and it does not include the effects of relative sea level rise. Table 5-23 shows the total economic value input into HEC-FDA for each of these nine reaches.

Table 5-23.
Total Structure and Content Value for Selected Planning Sub-Units

Planning Sub-Unit	Structure Value Thousand $'s	Content Value Thousand $'s	Total Economic Value Thousand $'s
2	$1,359,527.34	$1,969,251.33	$3,328,778.67
5	$313,687.82	$256,492.02	$570,179.84
6	$168,756.85	$154,811.46	$323,568.31
8	$2,995,946.35	$987,316.91	$3,983,263.25
12	$1,174,270.25	$1,594,487.74	$2,768,757.99
18	$706,994.07	$365,494.03	$1,072,488.09
19	$95,273.76	$23,225.26	$118,499.03
21	$1,268,159.01	$761,125.18	$2,029,284.19
52	$909,227.20	$1,641,424.90	$2,550,652.10

Tables 5-24 through 5-32 display the total present worth of the stage damages for the 0.9990 to 0.0010 exceedance probability events. These damages are what the HEC-FDA model uses to calculate equivalent annual damages. Those stage damages are then compared to the total economic value for the reach to show what percentage of damage is expected. In each of the reaches, the 0.0100 to the 0.0010 probability events dominate the damage curve.

Probability and stage expressed in these tables was defined by the MOBILE DISTRICT Engineering Division working in concert with the Engineer Research and Development Center (ERDC). Stage mentioned in the tables is the mean stage for the event; however the HEC-FDA model incorporates uncertainty to two standard deviations, or approximately the 95% confidence level. For more detail about the exceedance probability functions, see the engineering appendix.

Table 5-24.
Stage Damage by Event for Future Scenario One, Planning Unit One, Planning Sub-Unit Two

Total Present Worth Stage Damages							
Exceedance Probability	**Mean Stage[1] (Feet)**	**Residential (Thnds $'s)**	**Commercial (Thnds $'s)**	**Mobile Home (Thnds $'s)**	**Municipal (Thnds $'s)**	**Total (Thnds $'s)**	**Percent Stage Damage to Total Structure and Content Value**
0.9990	2.71	$43,752.65	$6,816.17	$165.43	$913.49	$51,650.45	1.55%
0.2000	6.12	$117,474.39	$30,251.34	$794.75	3,$120.67	$151,647.27	4.56%
0.1000	7.28	$144,237.52	$42,772.81	$1,066.45	$4,059.85	$192,143.91	5.77%
0.0400	10.60	$247,259.36	$113,942.01	$2,158.47	$8,698.01	$372,068.45	11.18%
0.0200	14.50	$382,169.71	$247,948.38	$3,271.80	$16,782.18	$650,186.57	19.53%
0.0100	17.50	$516,672.42	$386,292.25	$4,052.87	$25,211.05	$932,246.09	28.01%
0.0040	20.39	$658,732.22	$531,087.42	$4,762.79	$34,179.58	$1,228,782.40	36.91%
0.0020	22.40	$781,660.37	$655,195.97	$5,278.95	$41,791.58	$1,483,949.27	44.58%
0.0010	24.00	$897,503.25	$766,823.05	$5,680.46	$48,926.85	$1,718,957.61	51.64%

1/ Exceedance probability functions go to two standard deviations over the mean stage in the HEC-FDA model.
2/ Explanation of the exceedance probability function can be found in the engineering appendix.

Table 5-25.
Stage Damage by Event for Future Scenario One, Planning Unit One, Planning Sub-Unit Five

Total Present Worth Stage Damages							
Exceedance Probability	**Mean Stage[1] (Feet)**	**Residential (Thnds $'s)**	**Commercial (Thnds $'s)**	**Mobile Home (Thnds $'s)**	**Municipal (Thnds $'s)**	**Total (Thnds $'s)**	**Percent Stage Damage to Total Structure and Content Value**
0.9990	2.71	$2,831.63	$159.23	$0.37	$3,252.07	$6,246.01	1.10%
0.2000	6.12	$8,546.12	$560.27	$2.54	$6,998.57	$16,113.62	2.83%
0.1000	7.09	$11,167.39	$626.61	$4.12	$8,004.18	$19,809.39	3.47%
0.0400	9.60	$20,645.22	$990.55	$11.89	$10,300.30	$31,957.56	5.60%
0.0200	13.50	$49,121.31	$1,806.15	$103.87	$13,938.97	$64,983.80	11.40%
0.0100	16.00	$77,080.05	$2,724.47	$307.90	$17,026.23	$97,154.65	17.04%
0.0040	18.42	$104,263.11	$3,947.35	$647.18	$20,769.96	$129,646.02	22.74%
0.0020	20.10	$134,148.90	$5,993.35	$1,251.67	$26,311.70	$167,725.72	29.42%
0.0010	21.40	$157,207.12	$7,381.61	$1,651.89	$29,674.20	$195,936.22	34.36%

1/ Exceedance probability functions go to two standard deviations over the mean stage in the HEC-FDA model.
2/ Explanation of the exceedance probability function can be found in the engineering appendix.

Table 5-26.
Stage Damage by Event for Future Scenario One, Planning Unit One, Planning Sub-Unit Six

Total Present Worth Stage Damages							
Exceedance Probability	**Mean Stage[1] (Feet)**	**Residential (Thnds $'s)**	**Commercial (Thnds $'s)**	**Mobile Home (Thnds $'s)**	**Municipal (Thnds $'s)**	**Total (Thnds $'s)**	**Percent Stage Damage to Total Structure and Content Value**
0.9990	2.71	$4,155.33	$0	$0	$0	$4,158.04	1.29%
0.2000	6.12	$13,762.69	$0	$0	$0	$13,768.81	4.26%
0.1000	7.09	$18,088.33	$0	$0	$0	$18,095.42	5.59%
0.0400	9.60	$31,662.57	$7.83	$0.94	$8.61	$31,689.55	9.79%
0.0200	13.50	$56,978.26	$139.11	$14.36	$146.16	$57,291.39	17.71%
0.0100	16.00	$73,714.92	$453.88	$44.47	$449.30	$74,678.57	23.08%
0.0040	18.42	$88,892.40	$1,035.06	$98.80	$1,007.65	$91,052.33	28.14%
0.0020	20.10	$106,163.34	$2,065.55	$190.31	$1,964.42	$110,403.72	34.12%
0.0010	21.40	$115,324.45	$3,683.34	$239.23	$2,475.17	$121,743.59	37.63%

1/ Exceedance probability functions go to two standard deviations over the mean stage in the HEC-FDA model.
2/ Explanation of the exceedance probability function can be found in the engineering appendix.

Table 5-27.
Stage Damage by Event for Future Scenario One, Planning Unit Two, Planning Sub-Unit Eight

Total Present Worth Stage Damages							
Exceedance Probability	**Mean Stage[1] (Feet)**	**Residential (Thnds $'s)**	**Commercial (Thnds $'s)**	**Mobile Home (Thnds $'s)**	**Municipal (Thnds $'s)**	**Total (Thnds $'s)**	**Percent Stage Damage to Total Structure and Content Value**
0.9990	2.71	$2,141.84	$54.64	$44.53	$202.54	$2,446.26	0.06%
0.2000	6.12	$9,323.46	$214.76	$129.53	$707.99	$10,381.86	0.26%
0.1000	7.22	$13,281.91	$289.37	$170.76	$923.10	$14,672.36	0.37%
0.0400	10.30	$33,548.77	$581.58	$319.65	$1,790.40	$36,250.70	0.91%
0.0200	14.10	$88,836.15	$5,206.34	$585.72	$3,347.80	$97,990.11	2.46%
0.0100	17.10	$155,514.48	$26,941.23	$973.69	$4,353.88	$187,800.38	4.71%
0.0040	20.11	$247,538.39	$103,117.93	$1,785.00	$5,143.68	$357,605.11	8.98%
0.0020	22.20	$325,623.37	$216,476.56	$2,744.81	$5,560.92	$550,427.86	13.82%
0.0010	23.80	$392,965.09	$337,060.26	$3,681.36	$5,811.47	$739,541.98	18.57%

1/ Exceedance probability functions go to two standard deviations over the mean stage in the HEC-FDA model.
2/ Explanation of the exceedance probability function can be found in the engineering appendix.

Table 5-28.
Stage Damage by Event for Future Scenario One, Planning Unit Two, Planning Sub-Unit Twelve

Total Present Worth Stage Damages							
Exceedance Probability	**Mean Stage[1] (Feet)**	**Residential (Thnds $'s)**	**Commercial (Thnds $'s)**	**Mobile Home (Thnds $'s)**	**Municipal (Thnds $'s)**	**Total (Thnds $'s)**	**Percent Stage Damage to Total Structure and Content Value**
0.9990	2.71	$1,988.77	$47.46	$3.30	$2,084.47	$4,126.71	0.15%
0.2000	6.12	$8,560.61	$987.48	$27.34	$4,825.86	$14,407.41	0.52%
0.1000	7.06	$12,432.19	$1,831.97	$45.28	$5,619.54	$19,936.04	0.72%
0.0400	8.80	$20,819.74	$4,389.53	$92.88	$6,777.05	$32,088.00	1.16%
0.0200	11.60	$52,597.25	$17,540.91	$306.00	$9,567.96	$80,023.72	2.89%
0.0100	13.70	$88,637.76	$38,709.85	$602.27	$12,242.46	$140,206.04	5.06%
0.0040	15.77	$137,378.09	$74,366.99	$1,064.98	$15,937.42	$228,763.25	8.26%
0.0020	17.20	$180,500.95	$110,520.89	$1,533.91	$19,497.52	$312,070.47	11.27%
0.0010	18.30	$211,794.19	$139,076.04	$1,901.68	$22,109.50	$374,899.71	13.54%

1/ Exceedance probability functions go to two standard deviations over the mean stage in the HEC-FDA model.
2/ Explanation of the exceedance probability function can be found in the engineering appendix.

Table 5-29.
Stage Damage by Event for Future Scenario One, Planning Unit Two, Planning Sub-Unit Eighteen

Total Present Worth Stage Damages							
Exceedance Probability	**Mean Stage[1] (Feet)**	**Residential (Thnds $'s)**	**Commercial (Thnds $'s)**	**Mobile Home (Thnds $'s)**	**Municipal (Thnds $'s)**	**Total (Thnds $'s)**	**Percent Stage Damage to Total Structure and Content Value**
0.9990	1.89	$1,196.85	$814.40	$0.45	$0	$2,013.59	0.19%
0.2000	4.52	$4,134.09	$4,428.21	$2.21	$0.03	$8,566.85	0.80%
0.1000	5.67	$5,769.70	$7,318.97	$3.31	$0.05	$13,097.70	1.22%
0.0400	9.10	$14,765.74	$29,763.69	$12.16	$12.75	$44,563.44	4.16%
0.0200	12.80	$30,337.62	$78,692.33	$25.27	$99.03	$109,167.05	10.18%
0.0100	15.70	$52,765.43	$137,070.85	$36.73	$338.35	$190,227.06	17.74%
0.0040	18.53	$85,274.97	$223,677.63	$49.13	$858.62	$224,603.91	20.94%
0.0020	20.50	$110,187.46	$294,474.00	$56.52	$1,289.90	$406,028.38	37.86%
0.0010	22.30	$128,969.02	$346,487.93	$60.90	$1,649.46	$477,189.61	44.49%

1/ Exceedance probability functions go to two standard deviations over the mean stage in the HEC-FDA model.
2/ Explanation of the exceedance probability function can be found in the engineering appendix.

Table 5-30.
Stage Damage by Event for Future Scenario One, Planning Unit Two, Planning Sub-Unit Nineteen

Total Present Worth Stage Damages							
Exceedance Probability	**Mean Stage[1] (Feet)**	**Residential (Thnds $'s)**	**Commercial (Thnds $'s)**	**Mobile Home (Thnds $'s)**	**Municipal (Thnds $'s)**	**Total (Thnds $'s)**	**Percent Stage Damage to Total Structure and Content Value**
0.9990	1.89	$417.12	$3,064.00	$0	$0	$3,483.01	2.94%
0.2000	4.52	$1,400.28	$9,518.44	$0	$0	$10,923.24	9.22%
0.1000	5.67	$1,913.34	$12,702.56	$0	$0	$14,621.57	12.34%
0.0400	9.00	$4,202.27	$24,542.56	$0	$0	$28,753.83	24.27%
0.0200	12.50	$6,385.52	$32,868.82	$0	$0	$39,266.84	33.14%
0.0100	15.50	$7,651.28	$38,032.17	$0	$0	$45,698.95	38.56%
0.0040	18.33	$8,282.91	$42,794.02	$0	$0	$51,095.26	43.12%
0.0020	20.30	$8,574.57	$48,380.46	$0	$0	$56,975.33	48.08%
0.0010	22.10	$8,733.57	$55,938.36	$0	$0	$64,694.03	54.59%

1/ Exceedance probability functions go to two standard deviations over the mean stage in the HEC-FDA model.
2/ Explanation of the exceedance probability function can be found in the engineering appendix.

Table 5-31.
Stage Damage by Event for Planning Unit Three, Planning Sub-Unit Twenty-One

Total Present Worth Stage Damages							
Exceedance Probability	**Mean Stage[1] (Feet)**	**Residential (Thnds $'s)**	**Commercial (Thnds $'s)**	**Mobile Home (Thnds $'s)**	**Municipal (Thnds $'s)**	**Total (Thnds $'s)**	**Percent Stage Damage to Total Structure and Content Value**
0.9990	1.89	$1,489.63	$1,351.47	$0.02	$69.50	$2,912.51	0.14%
0.2000	4.52	$5,105.26	$5,413.10	$0.20	$297.05	$10,820.13	0.53%
0.1000	5.67	$7,357.69	$8,197.76	$0.35	$440.67	$16,002.14	0.79%
0.0400	9.20	$22,551.01	$27,942.77	$2.85	$1,363.10	$51,868.93	2.56%
0.0200	12.90	$53,793.29	$78,582.18	$19.28	$2,728.38	$135,136.03	6.66%
0.0100	16.00	$104,083.69	$153,498.33	$88.03	$4,735.96	$262,422.01	12.93%
0.0040	18.95	$155,294.94	$211,865.24	$217.60	$7,192.37	$374,589.10	18.46%
0.0020	21.00	$225,520.81	$282,660.42	$457.75	$11,494.07	$520,154.05	25.63%
0.0010	22.90	$278,089.23	$333,611.61	$642.16	$15,032.83	$627,398.73	30.92%

1/ Exceedance probability functions go to two standard deviations over the mean stage in the HEC-FDA model.
2/ Explanation of the exceedance probability function can be found in the engineering appendix.

Table 5-32.
Stage Damage by Event for Future Without-Project Scenario One, Planning Unit Three, Planning Sub-Unit Fifty-Two

Total Present Worth Stage Damages							
Exceedance Probability	**Mean Stage[1] (Feet)**	**Residential (Thnds $'s)**	**Commercial (Thnds $'s)**	**Mobile Home (Thnds $'s)**	**Municipal (Thnds $'s)**	**Total (Thnds $'s)**	**Percent Stage Damage to Total Structure and Content Value**
0.9990	2.06	$3,899.74	$14.64	$0.10	$4.29	$3,920.83	0.15%
0.2000	4.08	$9,646.99	$154.08	$1.32	$38.91	$9,845.38	0.39%
0.1000	6.04	$22,131.53	$973.43	$5.41	$189.83	$23,306.24	0.91%
0.0400	7.70	$38,867.81	$2,450.39	$12.89	$443.27	$41,782.06	1.64%
0.0200	11.20	$116,418.24	$15,160.58	$62.18	$2,329.48	$133,981.68	5.25%
0.0100	13.90	$211,730.44	$40,212.52	$148.06	$5,866.14	$257,971.06	10.11%
0.0040	16.44	$329,875.80	$85,879.90	$264.00	$11,561.68	$427,597.82	16.76%
0.0020	18.20	$425,218.57	$129,392.54	$350.77	$16,688.20	$571,668.28	22.41%
0.0010	19.80	$489,727.78	$159,839.78	$402.18	$20,420.62	$670,410.16	26.28%

1/ Exceedance probability functions go to two standard deviations over the mean stage in the HEC-FDA model.
2/ Explanation of the exceedance probability function can be found in the engineering appendix.

5.3.6 Impacts of Redevelopment Scenarios on Equivalent Annual Without-Project Damages

The two redevelopment scenarios, as previous discussed, are the redevelopment of the area back to the same way it was pre-Hurricane Katrina (residential redevelopment) and a redevelopment of the way the area was pre-Hurricane Katrina with commercial/condominium redevelopment (mixed redevelopment) along the water fronts of planning units one and two. The impacts of different redevelopment and the corresponding relationship to damages is a combination of different structure and content values that would could occupy the same space (five single family residences versus and condominium) and the depth-damage relationship of those different structures. The measurement of impacts from various redevelopment scenarios can be expressed by comparing the residential redevelopment to the mixed redevelopment for a given relative sea level rise scenario, or future scenario one versus future scenario two, future scenario three versus future scenario four, and future scenario five versus future scenario six. Tables 5-33 and figure 5.3-6 show the comparison of future scenario one to future scenario two, table 5-34 and figure 5.3-7 show the comparison of future scenario three to future scenario four, and table 5-35 and figure 5.3-8 compare future scenario five to future scenario six.

Table 5-33.
Comparison of Residential Redevelopment vs. Mixed Redevelopment for Expected Relative Sea Level Rise

Without-Project Damages	Future 1[1] Damages	Future 2[1] Damages	% Change from Future One
Planning Unit One	$198,960,000	$202,060,000	1.56%
Planning Unit Two	$91,260,000	$94,680,000	3.75%
Planning Unit Three	$88,670,000	$88,670,000	0.00%
Total	**$378,890,000**	**$385,410,000**	**1.72%**

Damages are rounded to the nearest ten thousand.
1 Future Scenarios one and two are used here to evaluate the impacts redevelopment only, and will not be discussed in the direct evaluation of potential measures detailed in Chapter IV of this appendix.

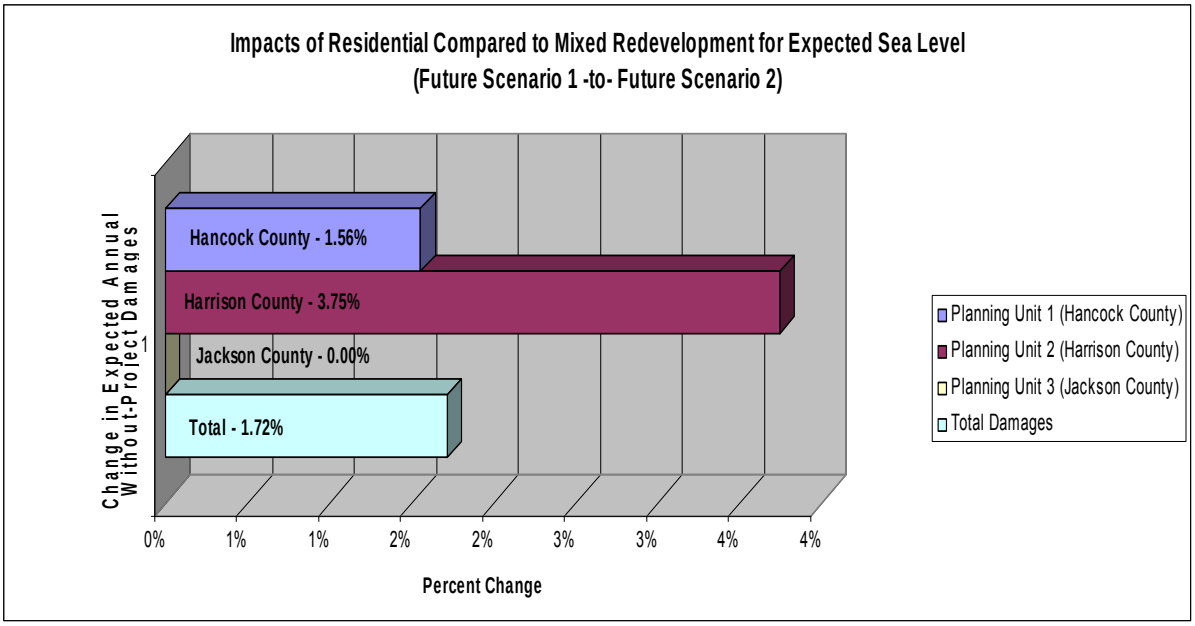


Figure 5.3-6. Impacts of Residential Compared to Mixed Redevelopment for Expected Relative Sea Level

Table 5-34.
Comparison of Residential Redevelopment vs. Mixed Redevelopment for Expected Relative Sea Level Rise

Without-Project Damages	Future 3 Damages	Future 4 Damages	% Change from Future One
Planning Unit One	$ 218,050,000	$ 222,220,000	1.91%
Planning Unit Two	$ 103,280,000	$ 107,120,000	3.72%
Planning Unit Three	$ 104,700,000	$ 104,700,000	0.00%
Total	**$ 426,030,000**	**$ 434,040,000**	**1.88%**

Damages are rounded to the nearest ten thousand.

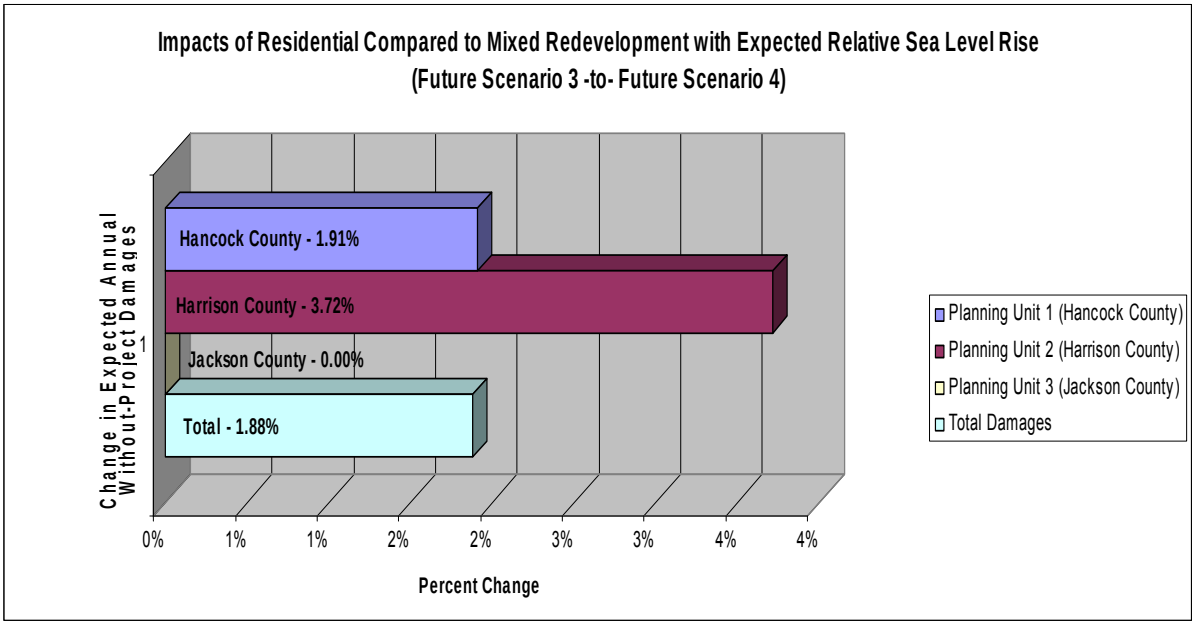


Figure 5.3-7. Impacts of Residential Compared to Mixed Redevelopment for Expected Relative Sea Level Rise

Table 5-35
Comparison of Residential Redevelopment vs. Mixed Redevelopment for Expected Relative Sea Level Rise

Without-Project Damages	Future 4 Damages	Future 6 Damages	% Change from Future One
Planning Unit One	$222,220,000	$241,520,000	1.77%
Planning Unit Two	$107,120,000	$119,760,000	3.72%
Planning Unit Three	$104,700,000	$122,420,000	0.00%
Total	**$434,040,000**	**$483,700,000**	**1.79%**

Damages are rounded to the nearest ten thousand.

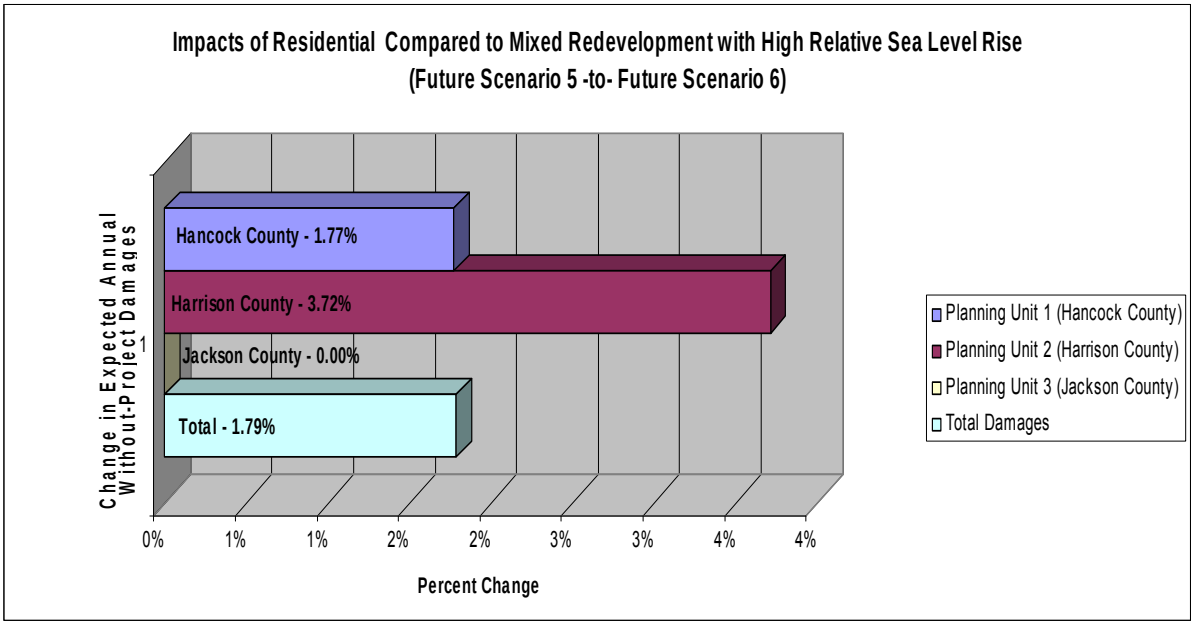


Figure 5.3-8. Impacts of Residential Compared to Commercial Redevelopment for High Relative Sea Level Rise

5.3.7 Impacts of Relative Sea Level Rise on Equivalent Annual Without-Project Damages

The impact of relative sea level rise over the period of analysis is the increase in damages when everything but relative sea level rise remains constant. This can be evaluated by comparing futures one, three and five against each other and futures two, four, and six against each other. The impact of relative sea level rise when compared to futures one, three, and five shows the effects that could be expected if the study area rebuilds exactly the way it was pre-Hurricane Katrina. The impact of relative sea level rise as compared to futures two, four, and six represent what could be expected given the rebuilding of the study area to a mixture of its pre-Hurricane Katrina setting with the shift from a residential coastline in planning units one and two to a commercial and condominium setting.

The increased equivalent annual damages are the direct effect of several phenomenon's' that result from the increased inundation. First, the higher water levels attributed to the expected relative sea level rise (Futures three and four - 2.0-feet) and high sea level rise (Futures five and six - 3.4-feet) would cause more damage to structures and their contents that would already be expected to be impacted under the existing relative sea level scenarios (Futures one and two). The second effect of increased relative sea level rise is that there would be damages to structures and their contents that would not be expected under the existing relative sea level rise scenarios, or completely new damage specifically attributable to the increased relative sea level rise. Table 5-36, figure 5.3-9, and figure 5.3-10 compares the effects of relative sea level rise on futures one, three, and five. Table 5-37, figure 5.3-11, and figure 5.3-12 compares its effects on futures two, four, and six.

Table 5-36.
Impacts of Relative Sea Level Rise on Futures One, Three, and Five

Without-Project Damages	Future 1[2] Damages	Future 3 Damages	% Change from Future One	Future 5 Damages	% Change from Future One
Planning Unit One	$198,960,000	$218,050,000	9.59%	$237,310,000	19.28%
Planning Unit Two	$91,260,000	$103,280,000	13.17%	$115,470,000	26.53%
Planning Unit Three	$88,670,000	$104,700,000	18.08%	$122,420,000	38.06%
Total	**$378,890,000**	**$426,030,000**	**12.44%**	**$475,200,000**	**25.42%**

Damages are rounded to the nearest ten thousand.
1 Future Scenario one is used here to evaluate the impacts of relative sea level rise only, and will not be discussed in the direct evaluation of potential measures detailed in Chapter IV of this appendix.

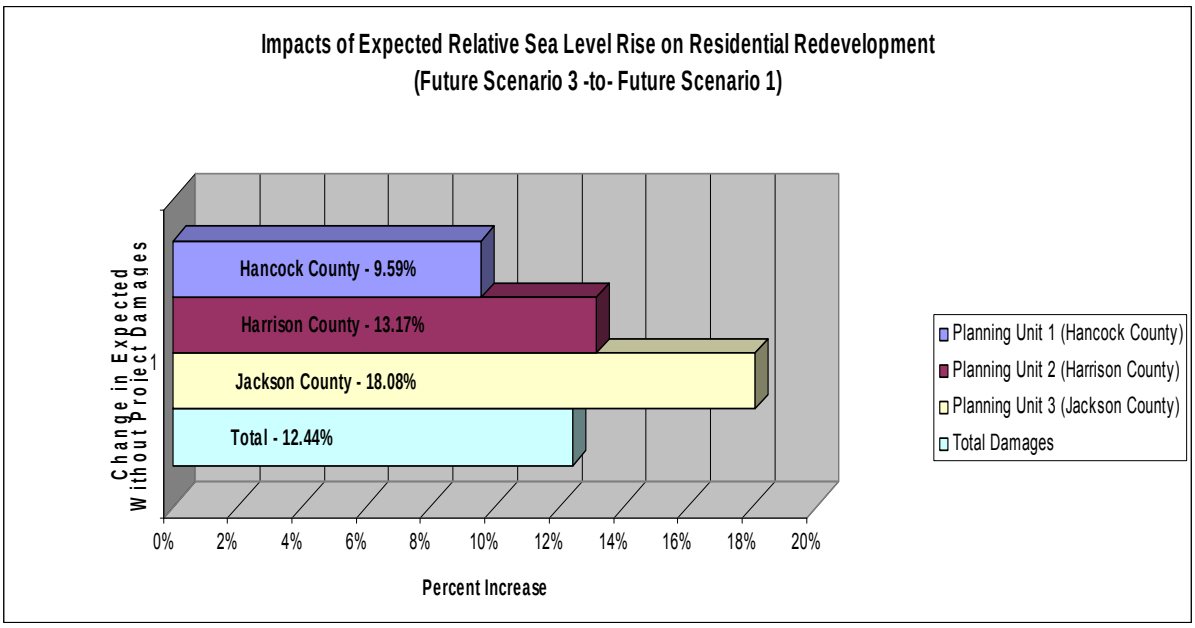


Figure 5.3-9. Impacts of 2.0-feet of relative sea level rise on a residential redevelopment

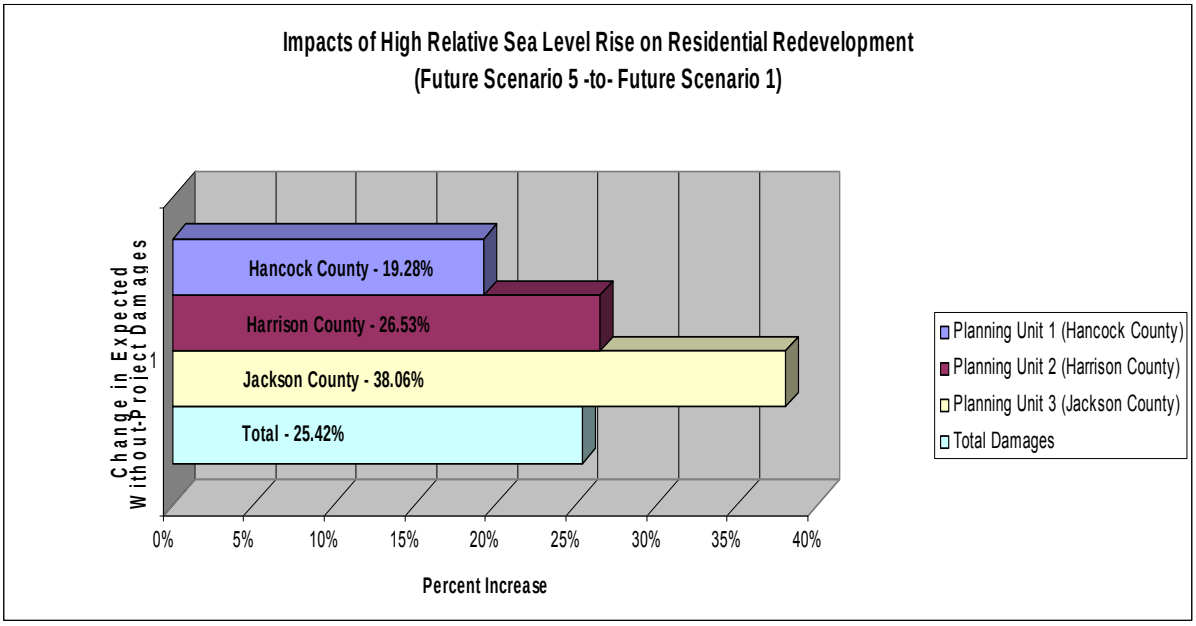


Figure 5.3-10. Impacts of 3.4-feet of relative sea level rise on a residential redevelopment

Table 5-37.
Equivalent Annual Without-Project Damages by Planning Unit and Future Scenario

Without-Project Damages	Future 2[2] Damages	Future 4 Damages	% Change from Future Two	Future 6 Damages	% Change from Future Two
Planning Unit One	$202,060,000	$222,220,000	9.98%	$ 241,520,000	19.53%
Planning Unit Two	$94,680,000	$107,120,000	13.14%	$ 119,760,000	26.49%
Planning Unit Three	$88,670,000	$104,700,000	18.08%	$ 122,420,000	38.06%
Total	**$385,410,000**	**$434,040,000**	**12.62%**	**$ 483,700,000**	**25.50%**

Damages are rounded to the nearest ten thousand.
1 Futures Two, Four, and Six do not apply to planning unit three, therefore total damages are the same as future scenarios one, three, and five for planning unit three.
2 Future Scenario two is used here to evaluate the impacts of relative sea level rise only, and will not be discussed in the direct evaluation of potential measures detailed in Chapter IV of this appendix.

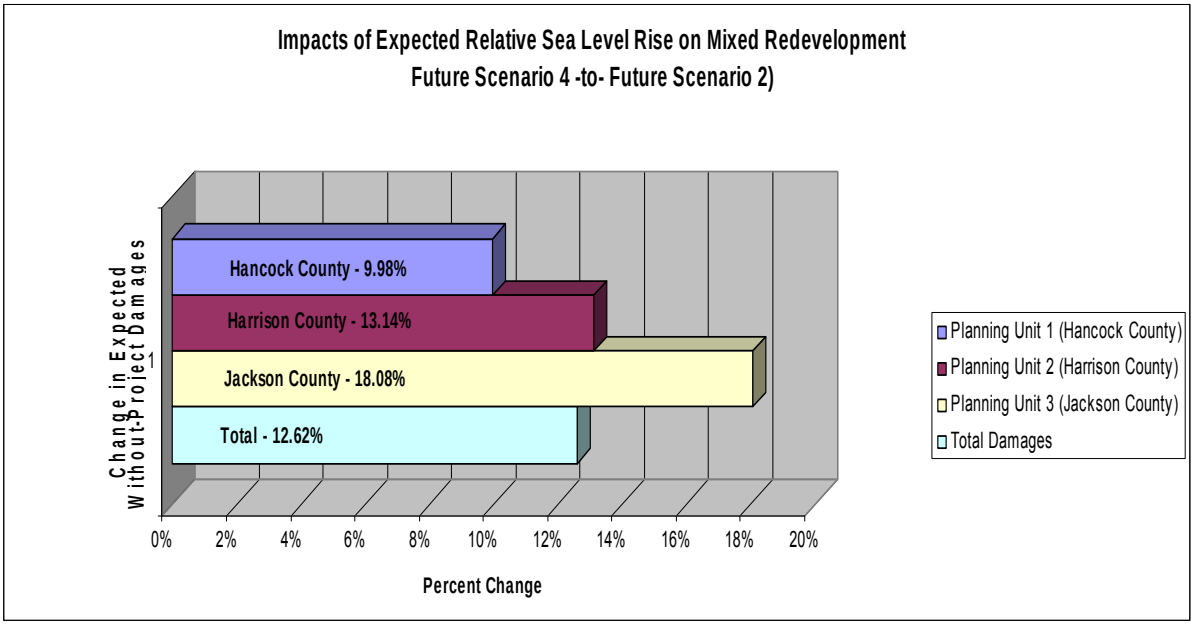


Figure 5.3-11. Impacts of 2.0-feet of relative sea level rise on a mixed redevelopment

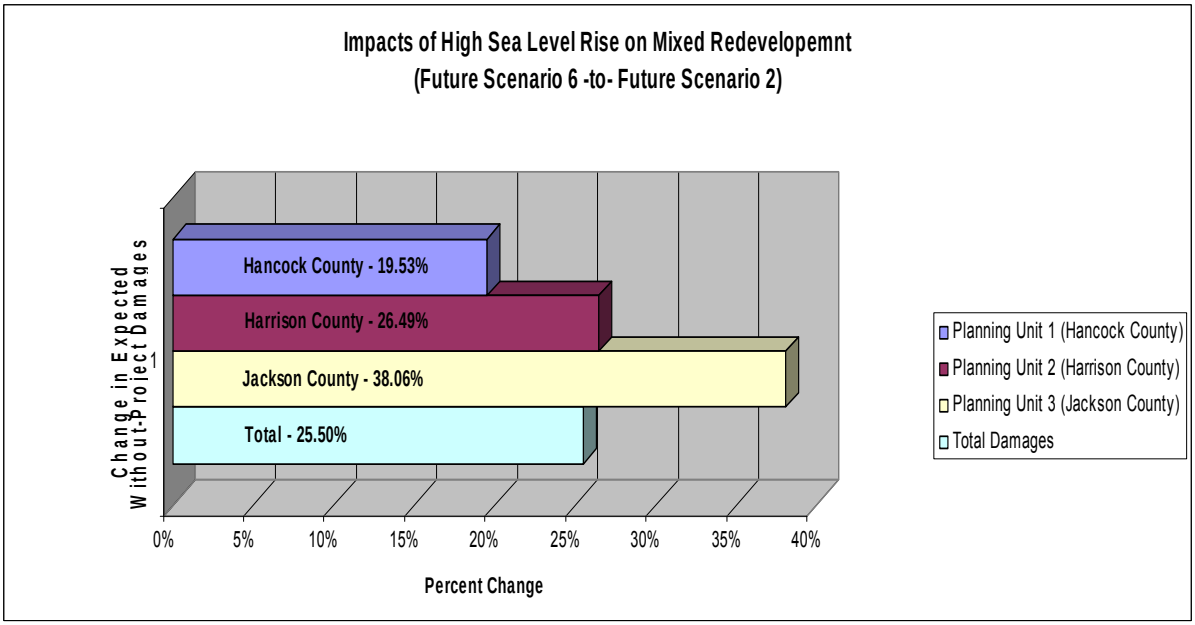


Figure 5.3-12. Impacts of 2.0-feet of relative sea level rise on a mixed redevelopment

CHAPTER VI. DEVELOPMENT AND EVALUATION OF MEASURES

This section describes steps three and four of the Corps six step planning process. These steps are the development of potential measures and the evaluation of those measures as compared to the without project conditions. Initial analysis yielded an extensive list of potential measures that were appropriate to a given site or problem area. The sites/problem areas are illustrated in the Main Report. The development of preliminary measures for structural and non-structural damage reduction is discussed in detail in the Engineering Appendix. The development of preliminary measures for ecosystem restoration and saltwater intrusion remediation is discussed in detail in the Environmental Appendix.

Many measures were initially evaluated and screened, based on technical or environmental criteria, and are not discussed here. Those measures that were found to be technically sound for a particular application, and environmentally sound, in regards to potential impacts to environmental resources, were forwarded for consideration, into the next phase of analysis. Measures forwarded into Round 2 of the evaluation and screening process were developed to a greater level of detail, to allow more detailed comparison, and potential modification for further study. The development of more detail included preliminary design and cost estimation, coastal, hydrologic and/or hydraulic analysis and design, environmental analysis, and determination of potential damages prevented, residual damages, and other factors. This latter process is discussed in more detail in the main report.

6.1 Overview of Benefits and Cost Evaluation

This section describes an overview of the methodology and steps taken in the calculation of benefits and costs. The principles for the overall process are the same no matter the area in question. Since the scope and scale of the comprehensive plan is so extensive, the methodologies utilized will be described here, and then summary tables and paragraphs will be used in the following sections that describe the evaluation of the various measures.

6.1.1 Calculation of National Economic Development Benefits

Except for the Beach and Dune placement measures described in detail in section 6.3, all of the surge inundation reduction benefits for the various measures were evaluated using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) program. For the analyses in this comprehensive plan, National Economic Development (NED) benefits are the reduced inundation damages of assets and their contents when one of the potential measures is in place. Typically, NED benefits are annualized over the period of the analysis (average annual benefits) and then compared to annualized costs over the period of analysis (average annual costs). This comparison is commonly known as the benefit-to-cost ratio (BCR). For purposes of this analysis, no benefit-to-cost ratios will be calculated as per the Congressional language authorizing this study. The Coastal Mississippi Comprehensive Plan Report was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states: "…***that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project plan features based upon maximizing net national economic development benefits…"*** More detail on the authorizing language can be found in the MsCIP Comprehensive Plan Main Report.

Equivalent annual flood damages for the various measures and alternatives at each area were evaluated and compared to the applicable future without project scenarios previously described in Chapter V. As previously noted, the six future without project scenarios combine various types of relative sea level rise with two types of redevelopment (see section 5.3 for more detail). The HEC-FDA model calculates damages reduced for a base year and a most likely future year and interpolates damages between the two points to determine equivalent annual damages. The model was set up so the exceedance probability function for the base year does not incorporate relative sea level and the function for the most likely future year does include the relative sea level rise adjustment. This allows the model to determine the damages between the two points.

Equivalent annual damages are calculated as:

Equivalent annual damages (EAD) = Present Worth of Total Damages x Capital Recovery Factor

Capital Recovery Factor (CRF) = i / (1-(1+i) ^-n)

Where:

i = interest rate

n = period of analysis

Figure 6.1-1 shows the linear interpretation used by HEC-FDA to calculate equivalent annual damages. The same methodology was used when converting projects recommended for construction to a 50-year period of analysis.

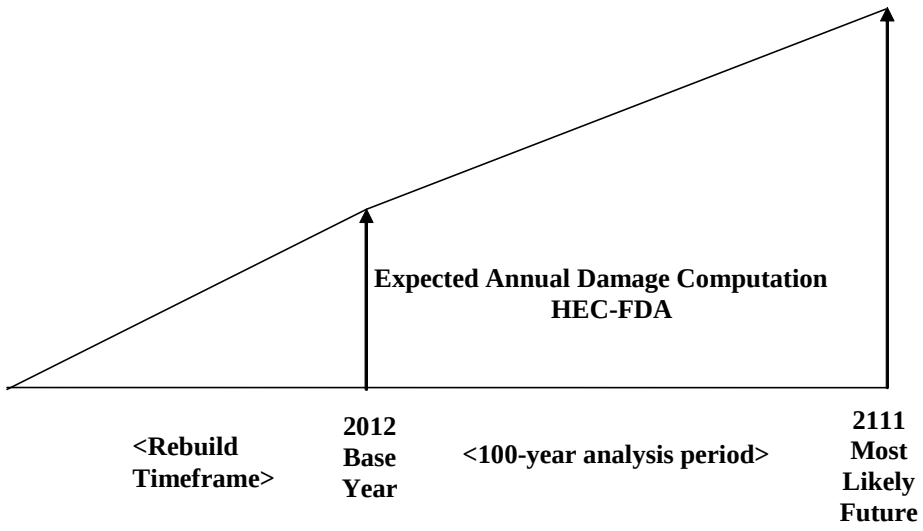


Figure 6.1-1. Linear Interpretation of Equivalent annual damages

6.1.2 Calculation of Costs

This section describes the use of cost estimates in the evaluation of the measures and alternatives. The methodology and application will be described here, and the sections describing the specific measures and alternatives at each site will show summaries of the costs. Detailed line item cost estimates can be found in the MsCIP Comprehensive Plan Cost Appendix.

6.1.2.1 Implementation Costs

Rough Order Magnitude (ROM) implementation costs were developed for each of the different measures and alternatives evaluated at each of the areas. The MOBILE DISTRICT Engineering Division developed the costs for structural measures and the Corps of Engineers Nonstructural Flood proofing Committee (NSFPC) developed the costs for the nonstructural measures. Savannah District Real Estate Division provided the real estate portions of each of the plans. All costs shown are in October 2007 price levels unless otherwise stated. Detailed cost estimates can be found in the cost estimating appendix to the MsCIP Comprehensive Plan Report.

6.1.2.2 Average Annual Implementation Costs

Average annual implementation costs were calculated for each of the measures and alternatives are calculated as:

Average Annual Implementation Cost = (Total Present Worth of Implementation Costs + IDC) x Capital Recovery Factor

Typically, costs are associated to the years they would be expended in should the project be constructed. Those expenditures are then brought back to the same fiscal year (FY) as the benefits in order for a direct and accurate comparison. This methodology was used for all measures and alternatives that will be recommended for construction. For those measures and alternatives that will be recommended for further study, the timing of expenditures have not yet been identified; therefore the total implementation cost act as the total present worth of the implementation costs and will be multiplied by the capital recovery factor to get the average annual implementation cost values.

Interest during construction is an added economic cost because it is the opportunity cost of having construction monies tied up until the measure becomes fully operational. Interest during construction was calculated based on the following formula:

$IDC^3 = \sum$ (Monthly Expenditure x Interest Rate Factor)

Monthly Expenditure = Implementation Cost / D

Interest Rate Factor = $(1+ I_M)$ ^ $(D – M)) - 1$

Where:

I_M = Interest Rate Factor = (Discount Rate / 12)

D = Total Construction Duration

M = Elapsed Time (Months) of Construction

Interest during construction was calculated for all measures and alternatives that will be recommended for construction. Due to the size and scope of the comprehensive effort, at this point in the analysis, the length of construction for many of the measures and alternatives has not been identified; interest during construction was not calculated for all of measures. Further study would be required in order to calculate interest during construction for those measures and alternatives not ready for construction recommendation. The main report details the measures and alternatives and their respective plan features.

[3] IDC was calculated based on Corps of Engineers National Economic Development Procedures Manual--Urban Flood Damage.

6.1.2.3 Operation and Maintenance Costs

Operation and Maintenance (O&M) costs were identified for each of the potential measures and alternatives. O&M costs for the structural solutions are described in the engineering appendix and the cost estimating appendix and are generally two-percent of the contract cost of the structure. O&M costs for the nonstructural measures and alternatives are described in the nonstructural appendix and are mostly based on the up keep of remaining lands associated with acquisition measures. All O&M costs shown for are annual costs and are typically borne by the local sponsor.

6.1.2.4 Total Average Annual Costs

Total average annual costs were calculated for each of the measures and alternative plans. Total average annual costs are the sum of the average annual implementation cost plus annual operation and maintenance cost.

6.1.3 Calculation of Regional Economic Development Benefits

This section describes the methodology and steps used to evaluate the regional economic development impacts attributable to each of the various measures and plans. The Economic Impact Forecasting System (EIFS) model was used in this analysis. Chapter III describes the background EIFS model. The methodology and application will be described here, and the sections describing the specific measures and alternatives at each site will show summaries of the costs.

6.1.3.1 Methodology

Impacts on business, employment, income, and population were evaluated using the Economic Impact Forecast System (EIFS), an economic analysis tool that, given the inputs for a particular project proposal, will asses potential impacts on four indicators of a local economy. EIFS is based on regional economic theory and provides regional economic analyses to planners and analysts. It draws information from a tailored socioeconomic database for any county in the United States. The database items are extracted from: Economic Censuses (wholesale, retail, services, and manufacturers), Census of Agriculture, the Bureau of Economic Analysis (BEA) employment and income time series, the BEA labor time series, and the County Business Patterns (CBP). The entire system-models, tools, and database-is then available to assess potential impacts on four indicators of a local economy: business volume, employment, personal income, and population.

6.1.3.2 EIFS Model Assumptions

EIFS assumes that the infrastructure pre-Katrina is intact, in-place, and functioning as a wholesome economic unit in the region of influence. The fact is that under existing conditions many of the established economic infrastructure is not present but transient. In some cases, rebuilt economic units have moved into fill that deficit to provide the goods and services. The assumption of this analysis assumes that the last or destroyed infrastructure will be rebuilt or replaced in the near-term and will not significantly reduce the impacts and outputs forecasted in this investigation.

6.1.3.3 Summary Explanation of the EIFS Model Inputs and Outputs

6.1.3.3.1 EIFS Model Inputs

The two data sources used as inputs for the EIFS model were the implementation cost and O&M cost for each of the measures and alternatives. Each of the cost inputs used was in present worth dollars, not average annual. Present worth costs were used because it is the actual estimated

amount that will be spent to implement, operate, and maintain the measure or alternative and that is what will drive the regional impacts.

6.1.3.3.2 EIFS Model Outputs

- Change in Sales Volume

Changes in local business activity include direct sales volume and induced volume. Direct sales volume is the change in the dollar value of sales in the retail and wholesale trade sector and receipts in the service sector resulting from local purchases by people as well as construction and procurement expenditures. Induced sales volume is the additional sales activity generated as a result of the direct change in sales.

- Income

Changes in income represent the wage and salary payments made to construction workers and to the resident workforce.

- Employment

Employment changes include both direct and indirect changes, as well as short and long term changes. The direct long-term change in local employment is the increase in employment associated with construction. Subsequent indirect increases in employment are produced by the multiplier effect resulting from increased spending by the additional staff and construction employees.

6.2 Evaluation of Barrier Island Measures

6.2.1 General Description

The coastline of mainland Mississippi is bordered on the south by the Mississippi Sound, a shallow body of water that separates the coast from four barrier islands that lie several miles to the south. These barrier islands are located along a littoral drift zone that moves sand westward creating three elongated islands and then westward toward Cat Island, where littoral currents are not as well defined. Cat Island has a different origin than the other islands and is a remnant of a lobe of the St. Bernard Delta that was created by the Mississippi River. Wave action has created a beach on the eastern side of the island forming a distinctive T-shape. From west to east, the islands are Cat, Ship (now actually two islands, West and East Ship Island), Horn and Petit Bois. The western ends of both Petit Bois and Ship Islands have migrated to maintained navigation channels and the continuing littoral drift of the sand into the channels is causing an artificial termination of the migration. A new island has emerged on the west side of the channel from Petit Bois Island, created from the dredged sand coming from island that is disposed of on the west side of the channel.

6.2.1.1 Location

The barrier islands of Mississippi are located 10 to 15 miles south of the mainland. Currently, there are five islands in the chain that extends for 45 miles west from a point south of the Alabama – Mississippi state line along the coast. Currently, Ship Island exists as two islands separated by a shallow sand bar. It was breached during Hurricane Camille in 1969 and remains today as West and East Ship Island. Two maintained navigation channels pass through the chain of islands. The Gulfport channel passes near the west end of West Ship Island and the Pascagoula channel passes near the end of Petit Bois Island. The present day location of the channels prevents any further westward migration of either island.

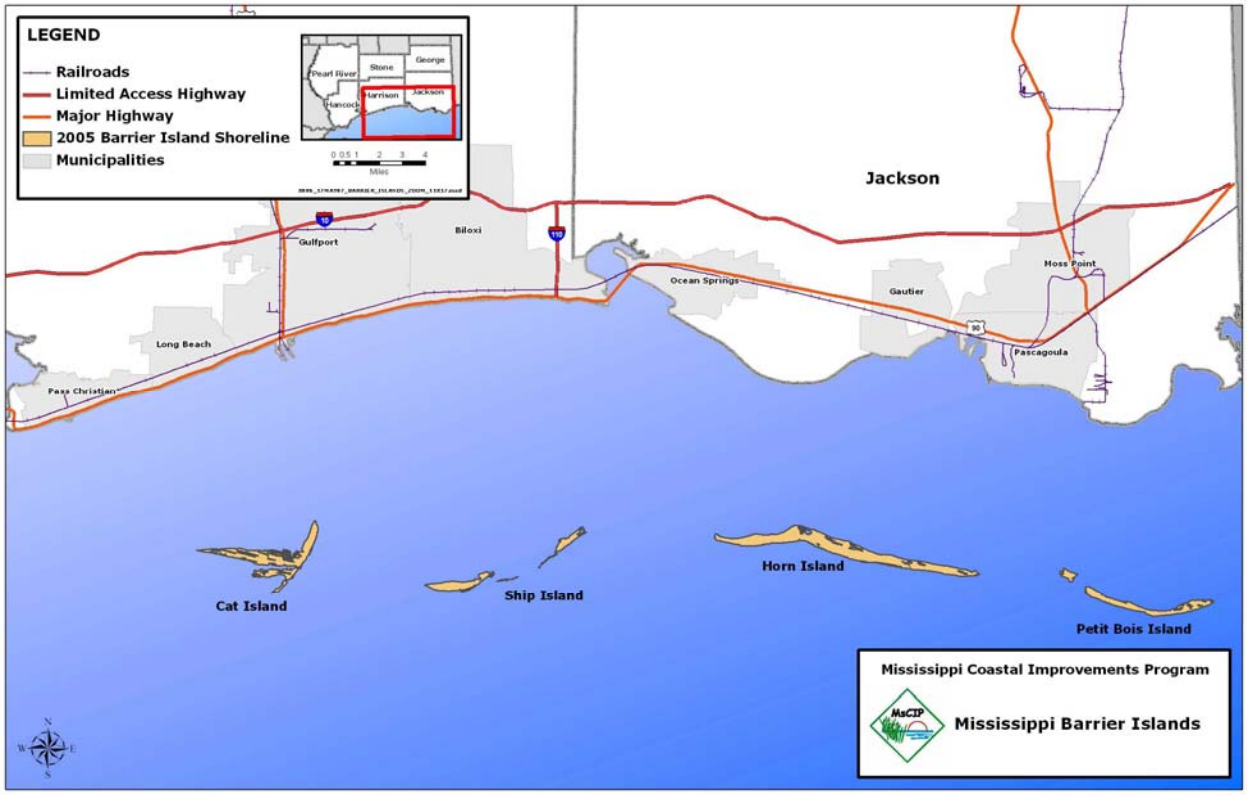


Figure 6.2.1-1. Location of the Mississippi Barrier Island

6.2.1.2 Historic Conditions (Pre-Hurricane Katrina)

6.2.1.2.1 Historic Fisheries

The value of the fisheries that are harvested from the Mississippi Sound has been an integral aspect of the local economy for decades. The industry has seen a significant rise in value since the 1970's, as is shown in table 6.2-1. The table and figure also show the effects of increased salinity on the system.

Table 6.2-1.
Historic Landings and Value of All Fisheries from Mississippi Sound

Year	Metric Tons	Pounds	% Change Pounds Since 1975	Value ($)	% Change Value ($) Since 1975
1975	138,690.7	305,757,600	N/A	$14,347,114	N/A
1976	130,708.7	288,160,500	-3%	$21,008,332	89%
1977	141,972.6	312,992,800	5%	$25,516,974	130%
1978	142,684.9	314,563,068	6%	$25,461,768	129%
1979	151,465.0	333,919,773	12%	$32,199,124	190%
1980	126,493.7	278,868,057	-6%	$24,866,290	124%
1981	95,263.2	210,017,239	-29%	$22,696,940	104%
1982	151,472.3	333,935,723	12%	$34,431,141	210%
1983	174,631.7	384,993,091	29%	$43,993,751	296%

Table 6.2-1.
Historic Landings and Value of All Fisheries from Mississippi Sound (continued)

Year	Metric Tons	Pounds	% Change Pounds Since 1975	Value ($)	% Change Value ($) Since 1975
1984	196,038.3	432,186,113	45%	$43,516,262	292%
1985	199,368.2	439,527,147	48%	$37,992,383	242%
1986	169,477.6	373,630,286	25%	$42,114,062	279%
1987	180,987.9	399,006,020	34%	$44,856,157	304%
1988	133,662.3	294,671,899	-1%	$43,744,133	294%
1989	122,979.5	271,120,626	-9%	$43,488,151	292%
1990	131,213.2	289,272,701	-3%	$39,748,280	258%
1991	97,280.4	214,464,348	-28%	$32,222,731	190%
1992	76,880.8	169,491,372	-43%	$29,986,817	170%
1993	83,485.4	184,051,940	-38%	$30,638,289	176%
1994	99,875.3	220,185,111	-26%	$36,930,906	233%
1995	65,725.1	144,897,569	-51%	$41,704,923	276%
1996	73,703.7	162,487,111	-45%	$35,120,373	216%
1997	81,842.8	180,430,714	-39%	$47,742,072	330%
1998	95,585.2	210,727,081	-29%	$48,402,305	336%
1999	121,378.6	267,591,178	-10%	$48,608,616	338%
2000	98,777.0	217,763,858	-27%	$58,751,487	429%
2001	97,034.6	213,922,401	-28%	$50,632,920	356%
2002	98,869.5	217,967,609	-27%	$47,565,219	328%
2003	96,828.8	213,468,811	-28%	$46,148,637	316%
2004	83,261.5	183,558,261	-38%	$43,618,143	293%

Source: Values were collected from the National Marine Fisheries website - http://www.st.nmfs.gov/st1/commercial/index.html

6.2.1.3 Existing Condition (Post-Hurricane Katrina)

6.2.1.3.1 Damage to Structures

The three coastal Mississippi counties suffered tremendous devastation from Hurricane Katrina's surge. It is estimated that 32,446 structures were significantly destroyed (at least fifty-percent or more), with another 15,000 to 25,000 suffering moderate to minimal inundation damage. Of the structures sustaining significant destruction, 9,555 were in planning unit one, 16,528, in planning unit two, and 6,363 in planning unit three. Of those significant loss structures, approximately 19,000 claims were paid out by the Federal Emergency Management Agency's (FEMA's) National Flood Insurance Program (NFIP) totally over $2.3 Billion dollars, with the average claim around $137,000. Currently, no accurate data exists for uninsured losses, but estimates range in the billions of dollars. Table 1 displays the significantly damaged structures by planning unit and by structure category. Table 6.2-2 shows the severely damaged structure by planning unit.

Table 6.2-2.
Structures Damaged 50% or More by Planning Unit and by Category

	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Commercial	1,267	1,794	378	3,439
Residential	8,099	14,500	5,780	28,379
Municipal	127	89	136	352
Mobile Home	62	145	69	276
Total	**9,555**	**16,528**	**6,363**	**32,446**

Source: Estimated from field inventory cluster sampling.

6.2.1.3.2 Damage to Barrier Islands

Immediately following Hurricane Katrina, most of the effort was spent protecting human life and securing structures throughout the impacted areas on the mainland; therefore, few assessments of the vegetation impacts exist, especially on the barrier islands. For the barrier island system, most all of the marsh vegetation recovered several months following Hurricane Katrina. The predominant vegetation that has long-term impacts consists of those pines found in the maritime forests. It is estimated that about 75% of these pine species were killed following the hurricane season of 2005, with most that attributable to Hurricane Katrina. The emergent marsh habitat is thriving so well it actually looks as though hurricanes never past through the barrier island system. The sea oats are still found in small patches due to the reduced dune system. Any measure that includes the planting of marsh vegetation will have to consider the current population of nutria that inhabits the islands. These exotic animals from South America can destroy attempts to establish marsh planting and any program should include the control of these rodents.

As is typical of most barrier island systems, the Mississippi islands are an ever-changing and dynamic landscape. Data shows that the islands have lost approximately 20 to 25 percent of their land mass since pre-Camille times. The islands have been heavily influenced by the various hurricanes including even the lower intensity ones. Hurricane George, in 1998, even though a small hurricane, proved to be devastating to the islands due heavy erosion from waves. Many of the higher dunes systems on the islands were destroyed and much of the elevation the islands once had is gone. Most of the islands are now very susceptible to over-wash during storms. Another result of being submerged during Hurricane Katrina was the loss of much of the maritime pine forest that existed on the islands. The trees, mostly now dead from the salt water submergence, played a major role in preventing erosion both from wind and any surges against the islands.



Figure 6.2.1-2. Photo of the south beach at Horn Island. Pre-existing dunes have been destroyed by numerous hurricanes over the last several years

6.2.1.2 Without-Project Condition

6.2.1.2.3 Equivalent annual damages

As previously described in Chapter V, six future without-project scenarios were developed, based on the existing condition characteristics, for the evaluation of future without-project conditions. The six scenarios were evaluated over a 100-year period of analysis from the base year 2012 (2012–2111) and using the FY08 federal discount rate of four-and-seven-eighths (4.875) percent. The six future scenarios include two redevelopment scenarios (residential and mixed-residential and commercial) and three relative sea level rise scenarios (base sea level, expected relative sea level rise, and high relative sea level rise) for a total of six different future scenarios. Scenario one is a residential redevelopment with no relative sea level rise over the 100-year period of analysis, scenario two is a mixed residential and commercial redevelopment with no relative sea level rise, scenario three is a residential redevelopment with an expected relative sea level rise, scenario four is a mixed residential and commercial redevelopment and an expected relative sea level rise, scenario five is a residential redevelopment with a high relative sea level rise, and scenario six is a mixed residential and commercial redevelopment with a high relative sea level rise. Table 6.2-3 shows the equivalent annual damages for the six future without-project scenarios.

Table 6.2-3.
Equivalent Annual Without-Project Damages by Planning Unit and Future Scenario

Without-Project Damages	Future 1[2] Damages	Future 2[2] Damages	Future 3 Damages	Future 4 Damages	Future 5 Damages	Future 6 Damages
Planning Unit One	$198,960,000	$202,060,000	$218,050,000	$222,220,000	$237,310,000	$241,520,000
Planning Unit Two	$91,260,000	$94,680,000	$103,280,000	$107,120,000	$115,470,000	$119,760,000
Planning Unit Three	$88,670,000	$88,670,000	$104,700,000	$104,700,000	$122,420,000	$122,420,000
Total	**$378,890,000**	**$385,410,000**	**$426,030,000**	**$434,040,000**	**$475,200,000**	**$483,700,000**

Damages are rounded to the nearest ten thousand.
1 Futures Two, Four, and Six do not apply to planning unit three, therefore total damages are the same as future scenarios one, three, and five.
2 Future Scenarios one and two will be used to evaluate the impacts of relative sea level rise only, and will not be discussed in the direct evaluation of potential measures detailed in Chapter IV of this appendix.

These equivalent annual without-project damages are those that would be expected to occur over the period of analysis should the barrier islands remain in their existing state, however, recent data collected by the USGS, and analysis of historical data by the Corps and others, suggests that this may not be the case. The long-term trends exhibited by the Barrier Islands and wetlands of Louisiana, and the coastal areas of Alabama and the panhandle of Florida, suggest that the regional sediment budget of the Northern Gulf of Mexico is not sufficient to restore and/or maintain these areas in their existing condition. Although no one study or investigator has suggested a time frame for the demise of these features, it is increasingly evident that their effectiveness at reducing storm surge and wave energies has been reduced significantly in the last 50 years. This has been exhibited most dramatically after Katrina in reduction of Barrier Island extent [note – look at Bob Morten's report].

Unfortunately, due to severe timing and funding constraints pertaining to the MsCIP Comprehensive Plan and the complexity of modeling various states of the barrier islands, only a sensitivity analysis was conducted to roughly capture the increased inundation risk of the further degradation of the islands. The data from that sensitivity analysis indicates that further loss of the barrier islands could result in as much as ten-feet of additional wave damage to structures and their contents. This loss of surge protection could actually increase the total equivalent annual damages over the project life by as much as an additional eight to nine-percent. Table 6.2-4 displays the anticipated effects of increased damages due to further loss of the barrier islands.

Table 6.2-4.
Increase in Equivalent Annual Without-Project Damages by Planning Unit and Future Scenario due to Further Degradation of the Barrier Islands

Without-Project Damages	Future 1[2] Damages	Future 2[2] Damages	Future 3 Damages	Future 4 Damages	Future 5 Damages	Future 6 Damages
Planning Unit One with Islands	$198,960,000	$202,060,000	$218,050,000	$222,220,000	$237,310,000	$241,520,000
% Increase without Islands	0%	0%	0%	0%	0%	0%
$ Increase without Islands	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Planning Unit Two with Islands	$91,260,000	$94,680,000	$103,280,000	$107,120,000	$115,470,000	$119,760,000
% Increase without Islands	7%	7%	7%	7%	7%	7%
$ Increase without Islands	**$6,388,200**	**$6,627,600**	**$7,229,600**	**$7,498,400**	**$8,082,900**	**$8,383,200**
Planning Unit Three with Islands	$88,670,000	$88,670,000	$104,700,000	$104,700,000	$122,420,000	$122,420,000
% Increase without Islands	10%	10%	10%	10%	10%	10%
$ Increase without Islands	**$8,670,000**	**$8,670,000**	**$10,470,000**	**$10,470,000**	**$12,242,000**	**$12,242,000**
Total $ Increase without Islands	**$15,058,200**	**$15,297,600**	**$17,699,600**	**$17,968,400**	**$20,324,900**	**$20,625,200**

Damages are rounded to the nearest ten thousand.
1/ Futures Two, Four, and Six do not apply to planning unit three, therefore total damages are the same as future scenarios one, three, and five.
2/ Future Scenarios one and two will be used to evaluate the impacts of relative sea level rise only, and will not be discussed in the direct evaluation of potential measures detailed in Chapter IV of this appendix.

6.2.1.2.3 Loss of Fisheries

Marine resources harvested from the Mississippi Sound are crucial to the economy of the three coastal counties and the state of Mississippi. It is estimated that in 2004, approximately 4,800 jobs and $300 million in gross annual revenue were dependent on fisheries from the sound. Various species harvested include oysters, bluefish, drum sea trout, sea catfish, white and brown shrimp, mullet, and snapper. According to National Marine Fisheries, total landings in 2004, the most accurate pre-Katrina data available, included 83,262 metric tons (183,558,261 pounds) for an estimated landing value of $43,618,143. In 2004, oyster production from the Mississippi Sound accounted for 8-percent of national oyster production and 11-percent of eastern oyster production. Comparison of pre-Katrina and post-Katrina landings provides a sharp comparison of what Mississippi Sound provided the State of Mississippi in terms of economic benefits, and what was lost as a result of the hurricane.

Comparison of the nearest full year (use of 2005 is problematic due to the fact that the hurricanes occurred mid-year) of monetary benefits due to commercial fish and shellfish landings, on either side of the hurricanes of 2005, provides the following insight into losses caused by those hurricanes. Table 6.2-5 shows an example of the devastating impacts of increased salinity in the Mississippi Sound due to Hurricane Katrina. If the islands continue to degrade, a point will be reached where the

salinity would kill the entire oyster and shrimp harvesting and the majority of all other existing fisheries as well. More detail about the devastating impacts of island degradation can be found in the environmental appendix.

Table 6.2-5.
Loss of Shrimp, Oysters, and other Species Due to Hurricane Katrina

Species	2004	2006	Loss
Shrimp	$26,353,576	$11,854,449	$14,499,127
Oysters	$6,073,242	$1,447,132*	$4,626,110
All Species Listed Above	$43,618,143	$21,741,108	$21,877,035

6.2.1.2.4 Loss of Recreation

This section describes the without-project recreation conditions for the barrier islands, which are the continued degradation of the islands and loss of all recreational use as a result of the continued degradation. Typically, recreational uses on the islands include general recreation such as boating, sightseeing, picnicking, swimming, and fishing from banks and boats. Additionally, the western portion of Ship Island, known as West Ship Island, is the home to two historic sites; Fort Massachusetts and the French Warehouse. Ship Island, the second island from the west in figure 6.2.1-1 above, was split into two islands by Hurricane Camille.

Visitors attend West Ship Island by using a commercial company called Ship Island Excursions or privately owned recreation boats. The island and facilities are run by the National Park Service. Table 6.2-6 below shows annual statistics estimated by the Park Service from 1989 through 2006.

Table 6.2-6.
Annual Ship Island Visitation

Year	Annual Visitation	Change from Previous Year (%)
1989	45,386	N/A
1990	54,661	20.436%
1991	49,301	-9.806%
1992	51,623	4.710%
1993	49,432	-4.244%
1994	51,059	3.291%
1995	53,793	5.355%
1996	59,724	11.026%
1997	58,969	-1.264%
1998	59,917	1.608%
1999	65,657	9.580%
2000	66,609	1.450%
2001	63,059	-5.330%
2002	62,720	-0.538%
2003	65,327	4.157%
2004	62,135	-4.886%
2005	41,453	-33.286%
2006	20,340	-50.932%

As the table shows, annual attendance to West Ship Island was relatively stable until the Island was impacted by Hurricane Katrina. Attendance in 2006 plummeted by more than 67-percent from its 2004 pre-Katrina level. The average yearly attendance for the five year period pre-Hurricane Katrina (2000-2004) was 63,970 visitors. Since there is little other data available on the recreational use of the barrier islands, and due to the timing constraints of this study, this number was used to estimate the annual recreational use.

Based on 63,970 annual user days, a unit day value (UDV) analysis was conducted to determine the monetary recreational value of use of the barrier islands. The UDV method relies on expert or informed opinion and judgment to estimate the average willingness to pay of recreational users. Interviews conducted pertaining to the without-project condition relied on expert or informed opinion and judgment to approximate the average willingness to pay of users of West Ship Island.

The guidelines for assigning points to general recreation include five categories:

- The quality of the recreational experience as affected by congestion,
- Availability of substitute areas in terms of travel time,
- Carrying capacity determined by level of facility development,
- Accessibility as affected by road and parking conditions, and
- Environmental quality based on aesthetics.

A resource is then rated on a 100-point scale. The total possible points that can be assigned to each criterion are as follows:

- Recreational Experience – 30,
- Availability of Opportunity – 18,
- Carrying Capacity – 14,
- Accessibility – 18, and
- Environmental - 20.

The conversion of points to dollar values for general recreation is expressed in two activity categories: general recreation and general fishing and hunting. Hence, points are expressed in the same manner. Therefore, for this project, general recreation includes boating, sightseeing, picnicking, swimming, and the visitation of the historical Fort Massachusetts and the French Warehouse. General fishing and hunting includes fishing from banks and boats. Table 6.2-7 summarizes the point value system as defined by EGM 08-02.

Table 6.2-7.
Guidelines for Assigning Points for General Recreation

Criteria	Judgment Factors				
Recreation experience[1] **Total Points: 30**	Two general activities[2]	Several general activities	Several general activities; one high quality value activity[3]	Several general activities; more than one high quality value activity	Numerous high quality value activities; some general activities
Point Value:	0-4	5-10	11-16	17-23	24-30
Availability of opportunity[4] **Total Points: 18**	Several within 1 hr. travel time; a few within 30 min. travel time	Several within 1 hr. travel time; none within 30 min. travel time	One or two within 1 hr. travel time; none within 45 min. travel time	None within 1 hr. travel time	None within 2 hr. travel time
Point Value:	0-3	4-6	7-10	11-14	15-18
Carrying Capacity[5] **Total Points: 14**	Minimum facility for development for public health and safety	Basic facility to conduct activity(ies)	Adequate facilities to conduct without deterioration of the resource or activity experience	Optimum facilities to conduct activity at site potential	Ultimate facilities to achieve intent of selected alternative
Point Value:	0-2	3-5	6-8	9-11	12-14
Accessibility **Total Points: 18**	Limited access by any means to site or within site	Fair access, poor quality roads to site; limited access within site	Fair access, fair road to site; fair access, good roads within site	Good access, good roads to site; fair access, good roads within site	Good access, high standard road to site; good access within site
Point Value:	0-3	4-6	7-10	11-14	15-18
Environmental **Total Points: 20**	Low aesthetic factors6 that significantly lower quality[7]	Average aesthetic quality; factors exist that lower quality to minor degree	Above average aesthetic quality; any limiting factors can be reasonably rectified	High aesthetic quality; no factors exist that lower quality	Outstanding aesthetic quality; no factors exist that lower quality
Point Value:	0-2	3-6	7-10	11-15	16-20

Table 6.2-8 shows the average respondent values for the value of recreational use of the barrier islands. Notes from those interviews include overwhelming high aesthetic value, general uses except for the ability to visit the historical Fort Massachusetts and French Warehouse, fair to good accessibility, and adequate to optimum facilities at the site.

Table 6.2-8.
Point Value of Recreational Use

	Recreational Experience	Availability of Opportunity	Carrying Capacity	Accessibility	Environmental	Totals
Average Respondent	10.00	3.00	8.00	10.00	20.00	**51.00**

Table 6.2-9 shows the conversion of points to FY 2008 dollar based on EGM 08-02.

Table 6.2-9.
Point Value of Recreational Use

Point Values	General Recreation Values	General Fishing and Hunting Values	Specialized Fishing and Hunting Values	Specialized Recreation Values other than Fishing and Hunting
0	$3.40	$4.89	$23.81	$13.82
10	$4.04	$5.53	$24.44	$14.67
20	$4.46	$5.95	$24.87	$15.73
30	$5.10	$6.59	$25.51	$17.00
40	$6.38	$7.23	$26.14	$18.07
50	$7.23	$7.86	$28.69	$20.40
60	$7.86	$8.71	$31.24	$22.53
70	$8.29	$9.14	$33.16	$27.21
80	$9.14	$9.78	$35.71	$31.67
90	$9.78	$9.99	$38.26	$36.13
100	$10.20	$10.20	$40.38	$40.38

Table is from EGM 08-02 "Unit Day Values for Recreation, Fiscal Year 2008"

The general recreation score of 51 translates to unit day value of $7.29. The average annual benefits were calculated by multiplying the UDV by the annual visitor occasions. Using the estimated 63,970 annual users and the interpolated $7.29 unit day value, the average annual recreation loss of continuing to allow the islands to degrade is $466,341

6.2.2 List of Measures

Measure A – Restore Island Footprint

The pre-Camille footprint of the islands was obtained from historical records and the amount of area that has been lost to coastal erosion since that time was computed. Without accurate topography of the islands and an assumption was made that some dunes had a top of elevation of 20 feet NAVD88. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations.

Several approaches to restoration of the islands were considered. This measure will only include new land mass that is being added to the islands by using sand dredged and transported from an off-shore location. The shaping of the sand into beaches, dunes and marsh areas will not affect the existing islands other than that narrow strip of land that will form the boundary between the existing island and the new land mass. This measure can be used in combination with other measures under this line of defense should it be desired to restore habitat on the existing islands.

Restoration of Ship Island to a pre-Camille configuration includes closing the post-Katrina, 3-mile long breach to a 2000-foot width and with elevation 20.0-foot NAVD88 dunes, along with some rebuilding of the other islands to a larger land area. The land mass of each of the islands was estimated in a pre-Hurricane Camille condition using historical aerial photography.

Measure B – Replenish Sand in Littoral Zone, Inland Source

Another consideration to help restore the islands is to supplement the sand in the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system.

The construction of inland waterways in Alabama and Mississippi has resulted in continuing maintenance dredging to maintain the channel depths and alignments. Dredging of some of the areas along the river has produced large quantities of sand that have potential use for replenishment of littoral zones such as are found along the Mississippi Barrier Islands. This dredged material, approximately 30 million cubic yards, is now accumulated in disposal areas along the banks of the rivers.

Measure C – Replenish Sand in Select Littoral Zones, Offshore and Inland River Sources

Another consideration to help restore the islands is to supplement the sand into specific areas of the littoral system with sand obtained from both Inland and offshore borrow areas. Like Measure B, this could be accomplished by adding sand in specific locations based on sediment transport modeling. The general locations for this measure were based on islands that have migrated westward to alignments of maintained navigation channels causing an artificial termination of further migration. Placing sand into these locations would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. While this process would not directly affect the present-day islands, it would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system. The sand that could be used in this measure may come from the same offshore borrow area as Measure A, the St. Bernard Shoals located about 45 miles south of the barrier islands as well as the inland river systems as described in Measure B.

Measure D – Environmental Restoration w/ 2-foot Dune

This measure would involve environmental restoration of the islands consisting of shaping existing sand into low dunes on the beaches with planted vegetation and planting of maritime forests on the existing islands where they were mostly destroyed by Hurricane Katrina.

Despite continual changes that occur, the barrier islands remain to buffer the mainland from storms and provide habitat for the rich, diverse wildlife residing within the area. On the southern portion of the islands, sea oats primarily, which are tolerant of high salt levels, thrive on the dune system which is located behind the beach area. Behind the primary dunes, trees and shrubs, such as short-leaf and long-leaf pines, can be found in the maritime forest. In the island interiors, emergent marshes collect fresh rainwater to help support its inhabitants

A restoration measure with the least impact on the existing post-Katrina islands would be to re-establish the vegetation that was destroyed. This measure could involve restoration of the existing islands through adding sand dunes on the beaches along with planted vegetation (i.e. *Uniola paniculata*), planting of marshes (i.e. *Spartina alterniflora*, *Juncus roemerianus*, and *Spartina patens*) and maritime forests (i.e. *Pinus elliottii Engelm*, *Serenoa repens, Sabal minor*, etc.), and planting sea grasses (i.e. *Diplanthera wrightii, Cymodocea manatorum, Thalassia testudinum*, and *Ruppia maritime*) in the near-shore areas of the islands. Foremost, the vegetation would restore the island's natural setting, which allows for the diverse array of flora and fauna to persist. This plan would not involve adding any land mass to the islands other than the possibility of adding to the dune system. Vegetation would aid in reducing erosion from wind; thus helping in maintaining the stability of the

islands. The vegetation would also aid in preventing erosion in the event that the islands gets overtopped by storm surge in a large hurricane.

Measure E – Environmental Restoration w/ 6-foot Dune

This measure would involve environmental restoration of the islands consisting of adding sand onto the existing beaches in sufficient quantities to construct a dune approximately 6 feet high. The dunes on the beaches would be planted with vegetation along with the planting of maritime forests on the existing islands where they were mostly destroyed by Hurricane Katrina. The sand required to construct a dune of this size would be more than could be removed from the existing beach berm and would come from the same offshore borrow area as the sand used in Measure A. Placement of the sand would require moving the sand from a hopper dredge to a staging area on the beach, then moving the sand to the area of placement along the beach.

Measure F – Environmental Restoration of Sea Grass Beds

This measure would involve environmental restoration of the sea grass beds that have historically existed on the north side of the islands in the Mississippi Sound. Knowledge of submerged aquatic vegetation (SAVs) is limited to reports by Humm (1956) and Humm and Caylor (1957) before the Gulf of Mexico Estuarine Inventory (GMEI) Study (1973). They reported the occurrence of five flowering species known as “seagrasses” and 77 algal species all along the Mississippi barrier islands. Studies carried out by the GMEI personnel revealed that there were about 17,000 acres of SAVs in Mississippi Sound prior to Hurricane Katrina. Information obtained from MDMR indicated that since Hurricane Camille in 1969, 8,800 acres of SAVs have been lost. Using maps from MDMR, fifty percent of the total lost acreage would be replaced throughout the previous range to help restore this valuable habitat under this measure.

Measure G – Restore Ship Island Breach

The most predominate affect of Hurricane Katrina on the Mississippi Barrier Islands was the large increase in size of the breach in Ship Island commonly known as the Camille Cut. The pre-Camille footprint of Ship Island was obtained from historical records. This data showed the area that was breached during Hurricane Camille forming two separate islands. West and East Ship Island has two major historic sites that are in danger from the continuing erosion of the barrier islands. Current studies by the Corps indicate that restoring the two islands to a single island, pre-Camille condition may prevent the rapid erosion of the beaches that is now occurring as well as helping to provide wave erosion on the mainland. Estimates indicated that the total restoration of Ship Island to a single land mass off the Mississippi coast will involve approximately 8 million cubic yards of sand. As happened during Hurricane Camille, the breach was opened during Hurricane Katrina leaving two islands with approximately three miles of open water between the remaining portions. This portion of the island has also been breached during other prior hurricanes and while most of the island has reformed to a low bar over time, it never gained enough sand to form dunes and establish vegetation along this center portion.

Fort Massachusetts is located on the northern shore of West Ship and the French Warehouse is located on the northern shore of East Ship Island. Both of these sites are endangered by on-going erosion of the shoreline with Mississippi Sound. Another site, known as the Quarantine Station, has already been lost to erosion.

Measure H – Comprehensive Measure

This plan is a physical implementation combination of measures C and G.

6.2.3 With-Project Conditions

The benefits attributable to the proposed barrier island measures are those avoided future losses should no action be taken. Implementation of the measures would result in the avoidance of increased surge damages due to amplified wave attack, the preservation of the Mississippi Sound habitat that is vital to both local fisheries and economies, but also a large source of national oyster production, and the continued use of the barrier islands as a recreational resource. Table 6.2-10 shows the estimated NED benefits for each of the barrier island measures and table 6.2-11 shows the EQ benefits by measure. Benefits were quantified where possible and are based on expert elicitation from six interviews conducted with project delivery team members and knowledgeable federal and state agency contacts.

Table 6.2-10.
NED Benefits by Measures

Measures	Future 3 Avoidance of Increased Surge Damage (Annual $)	Future 4 Avoidance of Increased Surge Damage (Annual $)	Future 5 Avoidance of Increased Surge Damage (Annual $)	Future 6 Avoidance of Increased Surge Damage (Annual $)	Avoidance of Recreation Loss (Annual $)
	NED Benefits				
(No Action)	$0	$0	$0	$0	$0
Measure A	$17,699,600	$17,699,600	$17,699,600	$17,699,600	$466,341
Measure B	$10,831,480	$10,844,920	$12,646,145	$12,661,160	$116,585
Measure C	$9,748,332	$9,760,428	$11,381,531	$11,395,044	$116,585
Measure D	$9,206,758	$8,296,364	$9,674,301	$9,685,787	$116,585
Measure E	$9,206,758	$8,296,364	$9,674,301	$9,685,787	$116,585
Measure F	$7,365,406	$6,637,091	$7,739,441	$7,748,630	$116,585
Measure G	$7,229,600	$7,498,400	$8,082,900	$8,383,200	$233,171
Measure H	$17,699,600	$17,699,600	$17,699,600	$17,699,600	$466,341

1/ Estimates are based on expert or informed opinion and judgment to estimate the extent of the losses avoided in each category.

Table 6.2-11.
EQ Benefits by Measures

Measures	Avoidance Fisheries Landings Lost (Annual Pounds)	Avoidance Fisheries Landings Lost (Annual $)
(No Action)	0	$0
Measure A	183,558,261	$43,618,143
Measure B	36711652	$8,723,629
Measure C	27533739	$6,542,721
Measure D	18355826	$4,361,814
Measure E	18355826	$4,361,814
Measure F	9177913	$2,180,907
Measure G	91779131	$21,809,072
Measure H	183,558,261	$43,618,143

1/ Estimates are based on expert or informed opinion and judgment to estimate the extent of the losses avoided in each category.

6.2.4 Summary of Costs

Table 6.2-12 summarizes the rough order magnitude (ROM) costs for potential barrier island measures. IDC was calculated based on a five-year (60 month) construction duration and the FY08 discount rate of 4-7/8-percent. Average annual costs are based on the 4-7/8-percent discount rate and a 100-year period of analysis. There are no estimated direct costs for annual operation and maintenance; however, a maintenance plan does exist and is detailed in the barrier island appendix.

Table 6.2-12.
Total Average Annual Costs by Measure

Measures	Total Implementation Cost ($)[1]	IDC ($)	Total First Cost ($)	Average Annual First Cost ($)	Average Annual O&M Cost ($)	Total Average Annual Costs ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A	$942,200,000	$119,317,000	$1,061,517,000	$53,431,000	$0	$53,431,000
Measure B	$1,013,800,000	$128,383,000	$1,142,183,000	$57,491,000	$0	$57,491,000
Measure C	$147,400,000	$18,667,000	$166,067,000	$8,359,000	$0	$8,359,000
Measure D	$14,200,000	$1,798,000	$15,998,000	$805,000	$0	$805,000
Measure E	$39,200,000	$4,965,000	$44,165,000	$2,223,000	$0	$2,223,000
Measure F	$264,500,000	$33,495,000	$297,995,000	$14,999,000	$0	$14,999,000
Measure G	$181,400,000	$22,972,000	$204,372,000	$10,287,000	$0	$10,287,000
Measure H	$328,800,000	$41,639,000	$370,439,000	$18,646,000	$0	$18,646,000

1/ Numbers are rounded to the nearest thousand and are based on ROM costs at an FY-08 price level. The cost estimating appendix shows these in more detail, as well as MCACES costs for the tentatively-recommended plan.

6.2.5 Regional Economic Development (EIFS Model)

The purpose of this analysis is to determine the economic impact of the proposed project measures on business (sale volumes), income, employment, and population of the local area. Each of the measures would affect the local areas of Jackson County, Harrison County and Hancock County Mississippi. The expenditures for the measures are estimated to be $942,200,000 for Measure A, Restore Island Footprint measure, $1,013,800,000 for Measure B, Replenish Littoral Zone (river sand) measure, $147,700,000 for Measure C, Replenish Littoral Zone (offshore sand) measure, $14,200,000 for Measure D, 2-foot Dune with beach sand measure, $39,200,000 for Measure E, 6-foot Dune with plantings measure, $264,500,000 for the Measure F measure and $181,400,000 for Measure G, Restore Ship Island measure. Tables 6.2-10 and 6.2-11 summarize the EIFS model inputs and outputs for the Barrier Island Measures.

Table 6.2-13.
EIFS Model Inputs for Barrier Island Measures

	Measure A	Measure B	Measure C	Measure D	Measure E	Measure F	Measure G	Measure H
Region of Influence (ROI)	Three Counties	Three Counties	Three Counties	Three Counties	Three Counties	Three Counties	Three Counties	Three Counties
Change in Local Expenditures	$942,200,000	$1,013,800,000	$147,400,000	$14,200,000	$39,200,000	$264,500,000	$181,400,000	$328,800,000

Based of the given inputs the outputs are as followed:

Table 6.2-14.
EIFS Model Outputs for Barrier Island Measures

	Measure A	Measure B	Measure C	Measure D	Measure E	Measure F	Measure G	Measure H
Direct Sales Volume	$942,200,000	$1,013,800,000	$147,400,000	$14,200,000	$39,200,000	$264,500,000	$181,400,000	$328,800,000
Induced Sales Volume	$1,347,346,000	$1,449,734,000	$210,782,000	$20,306,000	$56,056,000	$378,235,000	$259,402,000	$470,184,000
Total Sales Volume	$2,289,546,000	$2,463,534,000	$358,182,000	$34,506,000	$95,256,000	$642,735,000	$440,802,000	$798,984,000
Direct Income	$197,936,200	$212,977,800	$30,965,600	$2,983,118	$8,235,085	$55,565,820	$38,108,280	$69,073,880
Induced Income	$283,048,700	$304,558,200	$44,280,810	$4,265,858	$11,776,170	$79,459,120	$54,494,840	$98,775,650
Total Income	$480,984,900	$517,536,000	$75,246,410	$7,248,976	$20,011,255	$135,024,940	$92,603,120	$167,849,530
Direct Employment	5,802	6,243	908	87	241	1,629	1,117	2,025
Induced Employment	8,297	8,928	1,298	125	345	2,329	1,597	2,895
Total Employment	14,099	15,171	2,206	212	586	3,958	2,714	4,920
Local Population	0	0	0	0	0	0	0	0

6.2.6 Summary of Costs and Benefits

Table 6.2-15 summarizes the costs and benefits for the various Barrier Island measures.

Table 6.2-15.
Summary Benefits and Costs by Measures

	Measure A	Measure B	Measure C	Measure D	Measure E	Measure F	Measure G	Measure H
National Economic Development Benefits								
Future 3 Damages Avoided (Annual $)	$17,699,600	$10,831,480	$9,748,332	$9,206,758	$9,206,758	$7,365,406	$7,229,600	$17,699,600
Future 4 Damages Avoided (Annual $)	$17,699,600	$10,844,920	$9,760,428	$8,296,364	$8,296,364	$6,637,091	$7,498,400	$17,699,600
Future 5 Damages Avoided (Annual $)	$17,699,600	$12,646,145	$11,381,531	$9,674,301	$9,674,301	$7,739,441	$8,082,900	$17,699,600
Future 6 Damages Avoided (Annual $)	$17,699,600	$12,661,160	$11,395,044	$9,685,787	$9,685,787	$7,748,630	$8,383,200	$17,699,600
Recreation Losses Avoided (Annual $)	$466,341	$116,585	$116,585	$116,585	$116,585	$116,585	$233,171	$466,341
Environmental Quality Benefits								
Fishery Losses Avoided ($)	$43,618,143	$8,723,629	$6,542,721	$4,361,814	$4,361,814	$2,180,907	$21,809,072	$43,618,143

Table 6.2-15.
Summary Benefits and Costs by Measures (continued)

	Measure A	Measure B	Measure C	Measure D	Measure E	Measure F	Measure G	Measure H
Regional Economic Development Benefits								
Change in Sales Volume	$2,289,546,000	$2,463,534,000	$358,182,000	$34,506,000	$95,256,000	$642,735,000	$440,802,000	$798,984,000
Change in Income	$480,984,900	$517,536,000	$75,246,410	$7,248,976	$20,011,255	$135,024,940	$92,603,120	$167,849,530
Change in Employment	14,099	15,171	2,206	212	586	3,958	2,714	4,920
Average Annual Costs including IDC								
Average Annual Cost	$53,431,000	$57,491,000	$8,359,000	$805,000	$2,223,000	$14,999,000	$10,287,000	$18,646,000

6.3 Evaluation of Beach and Dune Construction Measures

6.3.1 Planning Unit One

6.3.1.1 Background

The beaches of Hancock County are approximately 9 miles in length, and host one of the Gulf Coast's largest populations of Least Tern, a Federally-listed endangered species, plus a significant number of Piping Plover. The beaches possessed a vegetated dune system (pre-Katrina) that was maintained by local interests and supported a significant ecosystem, in addition to passive recreation usage outside the dune system. This dune system provided not only ecosystem benefits, but some measure of hurricane or storm damage reduction due to its ability to absorb some of the surge and wave energy during those types of events. During Hurricane Katrina, this dune system was almost entirely destroyed by surge and wave action. Almost all ecosystem functions and values were eliminated during this single event. Much of the sand removed is believed to be close off shore in the near shore zone. The MsCIP Interim Chiefs Report recommended that a beach and dune placement project be constructed in planning unit one. The interim project consists of the following: (1) replacing approximately 43,800 cubic yards of lost sand dune material, (2) placing 37,000 linear feet of stabilizing sand fence, and (3) planting 19.3 acres of dune vegetation. Figures 6.3-1 and 6.3-2 show the project location and extent for planning unit one.

6.3.1.1.1 Opportunities

The following opportunities were identified for this area:

- Hurricane storm damage reduction or remediation
- Preservation of Fish & Wildlife and restoration of their habitats
- Prevention or remediation of erosion
- Other related water resource purposes, such as ecosystem restoration or barrier island restoration

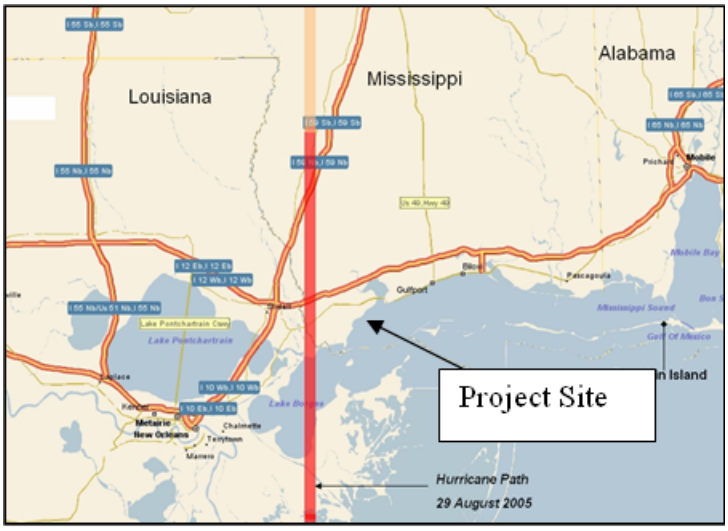


Figure 6.3-1. Project Sites for LOD2 in Planning Unit One

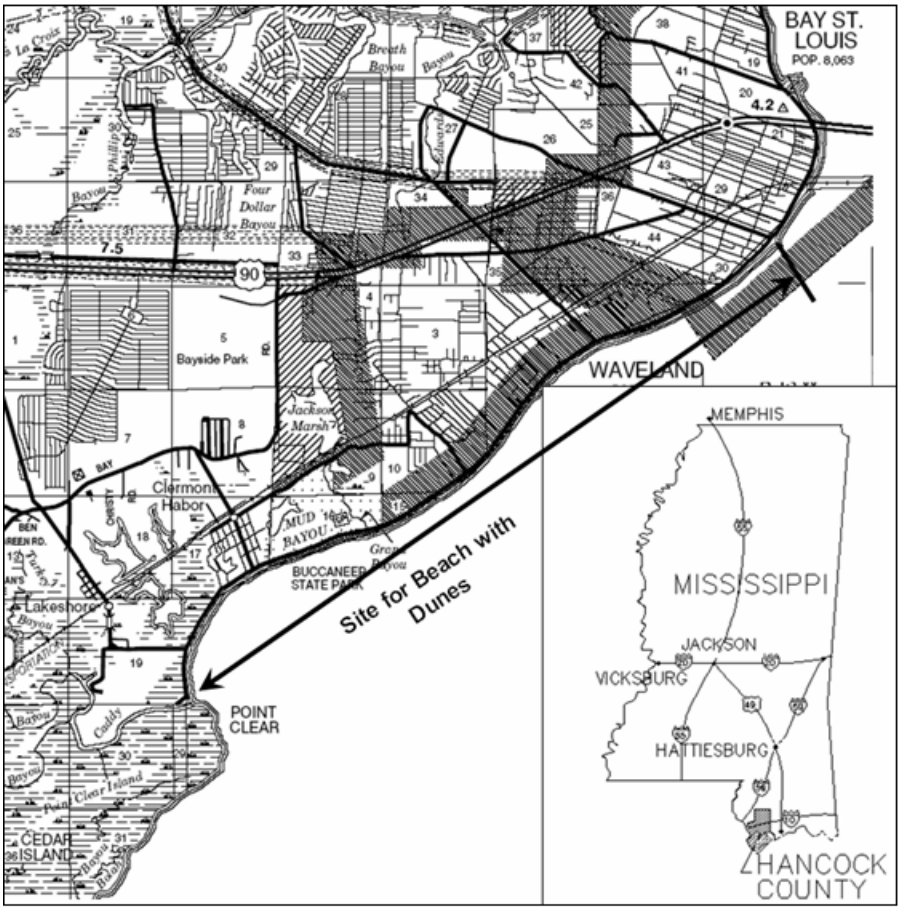


Figure 6.3-2. Project Limits for Line of Defense 2 in Planning Unit One

6.3.1.2 General Assumptions

The following assumptions were used in this analysis.

- The FY 2008 discount rate of 4-7/8 percent was used in estimating average annual benefits and costs,
- Price levels are October, 2007 unless otherwise stated,
- A 50-year period of analysis was used to calculate average annual benefits and costs.

6.3.1.3 Measures

Eleven measures were evaluated for enhanced beach protection at the study site. All involve providing a dune and berm to the location. Some of the measures, Measures A through H described below, can not be constructed without the construction of the Seawall and Elevated roadway measure, which is evaluated in great detail later in this appendix. The measures for Line of Defense 2 in planning unit one are as follows:

- Measure A consists of a 10.0 feet NAVD88 dune elevation, 40.0 feet dune crest width, with a dune slope of 1:3, and a berm with an 80.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. This measure is dependent on the elevated roadway and seawall and could not be implemented as a stand alone measure.
- Measure B consists of an 8.0 feet NAVD88 dune elevation, 50.0 feet dune crest width, with a dune slope of 1:3, and a berm with an 80.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. This measure is dependent on the elevated roadway and seawall and could not be implemented as a stand alone measure.
- Measure C consists of a 10.0 feet NAVD88 dune elevation, 20.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 100.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. This measure is dependent on the elevated roadway and seawall and could not be implemented as a stand alone measure.
- Measure D consists of an 8.0 feet NAVD88 dune elevation, 30.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 100.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. This measure is dependent on the elevated roadway and seawall and could not be implemented as a stand alone measure.
- Measure E consists of a 10.0 feet NAVD88 dune elevation, 40.0 feet dune crest width, with a dune slope of 1:3, and a berm with an 80.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows starting at the seaward toe of the dune. This measure is dependent on the elevated roadway and seawall and could not be implemented as a stand alone measure.
- Measure F consists of an 8.0 feet NAVD88 dune elevation, 50.0 feet dune crest width, with a dune slope of 1:3, and a berm with an 80.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows starting at the seaward toe of the dune. This measure is dependent on the elevated roadway and seawall and could not be implemented as a stand alone measure.

- Measure G consists of a 10.0 feet NAVD88 dune elevation, 20.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 100.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows starting at the seaward toe of the dune. This measure is dependent on the elevated roadway and seawall and could not be implemented as a stand alone measure.

- Measure H consists of an 8.0 feet NAVD88 dune elevation, 30.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 100.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of starting at the seaward toe of the dune. This measure is dependent on the elevated roadway and seawall and could not be implemented as a stand alone measure. Figure 6.3-3 shows a typical cross section for Measures A though H.

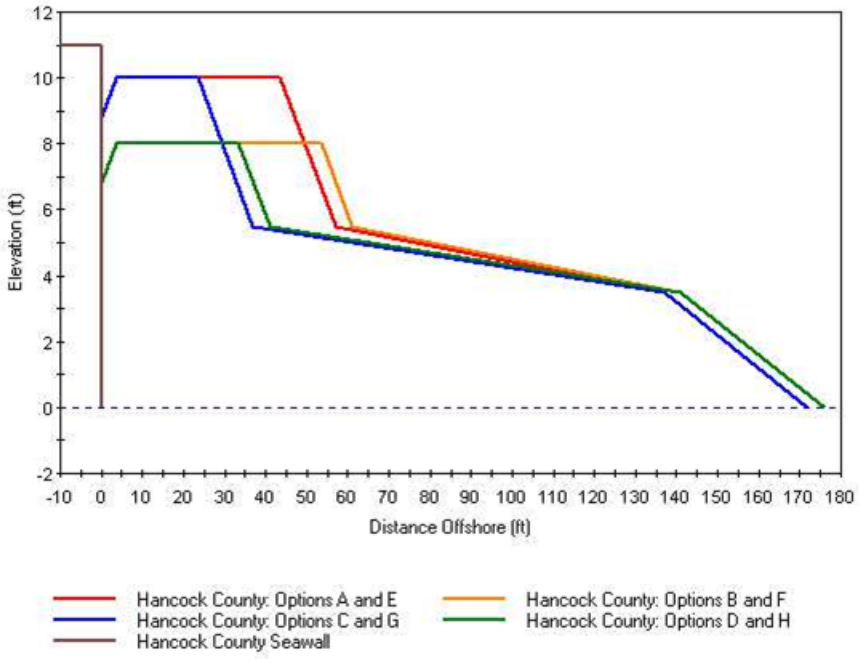


Figure 6.3-3. Typical Cross Section for Measures A through H

- Measures I and J are comparative with-project measures, for future evaluation, consisting of a design cross-section which includes a dune and berm constructed as a stand alone project which does not incorporate the Line of Defense 3 seawall. Measure I consists of a dune feature constructed approximately 50.0 feet seaward of the seawall at an elevation of 10.0 feet NAVD 88, with a crest width of 55.0 feet, and a dune slope of 1:3. The berm width would be extended to accommodate the placement of the dune feature. Sand fencing would be placed on the dunes to reduce sand transport due to the strong winds which frequently occur during storms. The cross section for Measure J is the same as Measure I; however the dune would be planted to provide for additional environmental habitat. For Measure J, sea oats would be planted on both the landward and seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of planted starting at the landward and seaward toes of the dune. The dunes will require initial and continued maintenance of vegetation and sand fencing. These measures are intended to be stand alone and are not dependent on the elevated roadway and seawall that is described in section 6.4.

- Measure K is also a measure for future evaluation which consists of an elevated berm section constructed primarily for the creation of environmental habitat. Measure K would be constructed as a stand alone measure which does not incorporate the Line of Defense 3 seawall. The elevated berm section would be constructed approximately 50.0 feet seaward of the existing seawall to an elevation 2.0 feet NAVD88 above the existing berm with a width of approximately 60.0 feet. The berm width would not be extended to accommodate the placement of the elevated berm feature. The new feature would be vegetated and sand fencing would be placed to create environmental habitat and to reduce sand transport due to the strong winds which frequently occur during storms. For Measure K, sea oats would be planted in a 30 by 30 inch grid pattern over the entire elevated berm area. The new feature will require initial and continued maintenance of vegetation and sand fencing. This measure is intended to be a stand alone and is not dependent on the elevated roadway and seawall that is described in section 6.4.

6.3.1.4 National Economic Development (NED)

This section describes the National Economic Development benefits for the various beach and dune placement measures in planning unit one that are attributable to hurricane and storm damage reduction. National economic development benefits are damages to structures and their contents that are reduced when a measure or alternative is implemented, or the difference between the with-project and without-project conditions.

There are two types of beach and dune placement measures for planning unit one; those that are dependent on the seawall and elevated roadway and those that can be implemented as stand alone measures. Those measures dependent on the seawall and elevated roadway, measures A through H, would be implemented to abut the seawall and elevated roadway and would be constructed to a maximum elevation of 1.0 foot lower than the seawall and elevated roadway, or to elevation 10.0 feet NAVD88, thus acting as a system. For these measures, equivalent annual damage reduction would be limited to structures that are physically located south of Beach Boulevard, since seawall and elevation of that roadway would be higher than the dune system itself. A visual description of this system can be seen above in figure 6.3-3. The remaining measures I, J, and K are stand alone, and would be implemented in lieu of the seawall and elevated roadway with dune system. The equivalent annual damage reduction attributable to the stand alone measures would impact structures located south of Beach Boulevard in planning unit one and some footprint of structures north of beach boulevard. Also, all beach and dune placement measures would provide some level of protection to the seawall and roadways that they abut, but those benefits are difficult to quantify and were not conducted in this analysis.

The Beach-FX program was selected to quantify the damage reduction benefits of all of the beach and dune placement measures. Beach-FX is a Monte Carlo based model that combines coastal processes economic conditions to evaluate damages from storm events and the level of damage reduction that would be attributable to a given measure. Chapter III of this appendix depicts the overall process of the Beach-FX evaluation. For this study, the exploration of the costal processes and economic inventorying was conducted. Further study would be required to combine the observed data and to evaluate the eleven alternatives previously mentioned. More detail on the further study can be found in the MsCIP Comprehensive Plan Main Report. Table 6.3-1 summarizes the costs by measure.

Summary of Costs

Table 6.3-1 summarizes the ROM costs at an FY-08 price level for the beach and dune placement measures for planning unit one.

Table 6.3-1.
Summary of Beach and Dune Costs by Measure for Planning Unit One

Measures	Implementation Cost ($)	IDC ($)	Total Implementation Cost ($)	Average Annual Implementation Cost ($)	Average Annual O&M ($)	Total Average Annual Costs ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A[1] (10FT by 40FT Dune no plantings)	$8,070,000	$178,700	$8,248,700	$443,139	$2,167,694	$2,610,833
Measure B[1] (8FT by 50FT Dune no plantings)	$6,100,000	$134,900	$6,234,900	$334,953	$1,638,530	$1,973,483
Measure C[1] (10FT by 20ft Dune no plantings)	$4,960,000	$109,600	$5,069,600	$272,350	$1,332,313	$1,604,663
Measure D[1] (8FT by 30FT Dune no plantings)	$4,030,000	$89,200	$4,119,200	$221,293	$1,082,504	$1,303,797
Measure E[1] (10FT by 40FT Dune with plantings)	$8,400,000	$185,900	$8,585,900	$461,254	$2,256,336	$2,717,590
Measure F[1] (8FT by 50FT Dune with plantings)	$6,440,000	$142,500	$6,582,500	$353,627	$1,729,857	$2,083,484
Measure G[1] (10FT by 20ft Dune with plantings)	$5,300,000	$117,300	$5,417,300	$291,030	$1,423,640	$1,714,670
Measure H[1] (8FT by 30FT Dune with plantings)	$4,360,000	$96,400	$4,456,400	$239,408	$1,171,146	$1,410,554
Measure I (10FT by 50FT Dune without plantings)	$19,100,000	$422,600	$19,522,600	$1,048,799	$5,130,478	$6,179,277
Measure J (10FT by 50FT Dune with plantings)	$19,450,000	$430,300	$19,880,300	$1,068,015	$5,224,492	$6,292,507
Measure K (2FT by 60FT Dune with plantings)	$4,640,000	$102,600	$4,742,600	$254,783	$0	$254,783

1/ Denotes measures that could not be implemented without the construction of the seawall, which is discussed in section 6.4.
2/ Cost include Construction Management, Supervision & Administration, and Contingencies. More detail on the costs can be found in the Cost Estimating Appendix.

6.3.1.6 National Ecosystem Restoration (NER)

The P&G defines the environmental quality account as, "displays of non-monetary effects on ecological, cultural, and aesthetic resources…" The EQ account is typically associated with ecosystem restoration projects, although it does address the following:

Cost Effective Analysis

The justification for the proposed section is evaluated on a cost effective and incremental cost basis in accordance with guidelines contained in ER 1105-2-100, *Planning – Planning Guidance Notebook*. The Corps' ecosystem restoration policy is described in more detail in ER 1165-2-501, *Water Resources Policies and Authorities – Civil Works Ecosystem Restoration Policy;* and EP 1165-2-501, *Water Resources Policies and Authorities – Ecosystem Restoration – Supporting Policy Information.* As cited in the *Planning Guidance Notebook,* Cost Effectiveness and Incremental Cost Analyses procedures are detailed in IWR Report 94-PS-2, Cost Effectiveness Analysis for Environmental Planning: Nine EASY steps; IWR Report 95-R-1, *Evaluation of Environmental Investments Procedures Manual Interim: Cost Effectiveness and Incremental Cost Analyses; and IWR Report 98-R-1, Making More Informed Decisions in Your Watershed When Dollars aren't Enough*. The analysis compares the cost effectiveness of the five measures based on their environmental outputs to determine the selected measure. Note: this section is intended to identify the cost effective environmental measures that can be constructed with the elevated roadway and seawall. Since measures I, J, and K are concept measures at the time of this report, and they were formulated based on reducing flood damages to be stand alone measures, they will automatically be carried forward for further consideration.

6.3.1.6.1 Cost Effective Analysis Assumptions

This analysis assumes a 50-year project life. Costs were amortized using the FY 2008 federal discount rate of 4.875-percent and are presented at October 2008 price levels. The outputs quantified in this cost effective analysis are defined as the quantification of expected improvements in target functions as related to project objectives (functional habitat index, FHI). FHI scores were based on an assessment protocol, which provide a basic level of stream health evaluation that is based on physical conditions within the assessment area. The assessment is used to record the scores for up to 15 assessment elements (i.e., channel condition, hydrologic alteration, riparian zone, bank stability, water appearance, nutrient enrichment, barriers to fish movement, instream fish cover, pools, insect/invertebrate habitat, canopy cover [warm water fishery], manure presence, salinity, riffle embeddedness, and macroinvertebrates observed). However, all assessment elements were not applicable to the assessment area and were not included.

The first step in cost-effective analysis is to display the environmental outputs (effects on habitat expressed in Functional Habitat Index, FHI) and the cost estimates of the management measure increments. Outputs and costs are displayed as average annual outputs and average annual costs. Both are acceptable so long as they are comparable. Average annual outputs and average annual costs were used for this analysis.

Table 6.3-2 displays the project measures and their associated average annual outputs and average annual costs. Project outputs for each measure are displayed in terms of functional habitat index (FHI) that can be supported for each measure considered.

Table 6.3-2.
Outputs and Costs by Measure

Measures	Annualized Implementation Cost ($)	Annual O&M ($)	Total Annual Cost ($)	Total Annual Output (FHI)
Measure AA (No Action)	$0	$0	$0	0
Measure A	$443,139	$2,167,694	$2,610,833	142
Measure B	$334,953	$1,638,530	$1,973,483	172
Measure C	$272,350	$1,332,313	$1,604,663	142
Measure D	$221,293	$1,082,504	$1,303,797	154
Measure E	$461,254	$2,256,336	$2,717,590	304
Measure F	$353,627	$1,729,857	$2,083,484	330
Measure G	$291,030	$1,423,640	$1,714,670	250
Measure H	$239,408	$1,171,146	$1,410,554	276

The second step in incremental analysis is to identify combinable management measures. This involves the analysis of the management measures to determine those that can be implemented together from those that cannot be implemented together. Each of the measures in this analysis is independent of the others. After the selection of one of the measures, the other measures are not needed; therefore the measures are not combinable.

The next step is to calculate outputs and costs of combinations. The combinations of the management measures are defined and analyzed incrementally. In this step, each combination of output (FHI) and cost ($) is calculated. However, since the measures cannot be combined, this step is not necessary in this case.

Eliminating economically inefficient solutions is the fourth step in incremental analysis. In order to do this, the list of solutions is reordered so that they are listed in ascending order of their outputs. Where two or more solutions produce the same output, the solutions are ranked in ascending order of their costs. The result is a ranking of measures AA, A, C, D, B, G, H, E, and F as displayed below in table 6.3-3. At each level of output the least cost measure is determined. Measure A was identified as an inefficient measure because it provides the same output as measure C for a greater cost. Measure A will not be carried forward in this analysis.

Table 6.3-3.
List of Efficient Measures

Measures	Total Annual Cost ($)	Total Annual Output (FHI)
Measure AA (No Action)	$0	0
Measure A	$2,610,833	142
Measure C	$1,604,663	142
Measure D	$1,303,797	154
Measure B	$1,973,483	172
Measure G	$1,714,670	250
Measure H	$1,410,554	276
Measure E	$2,717,590	304
Measure F	$2,083,484	330

The fifth step in incremental analysis is to eliminate economically ineffective solutions. The outputs and costs undergo a pair-wise comparison. The results of the comparison are analyzed to determine which solutions will produce less output at equal or greater cost than subsequently ranked solutions. Those solutions that will produce less output at equal or greater cost than subsequently ranked solutions are deleted. Measures C, B, G, and E were eliminated because they were found to be ineffective solutions. Measure C was eliminated because measure D produces more output for less cost than measure C, measures B and G were eliminated because measure H produces more output for less cost, and measure E was eliminated because measure F produces more output for less cost. Table 6.3-4 summarizes the results of step five.

Table 6.3-4.
List of Effective Measures

Measures	Total Annual Cost ($)	Total Annual Output (FHI)
Measure AA (No Action)	$0	0
Measure C	$1,604,663	142
Measure D	$1,303,797	154
Measure B	$1,973,483	172
Measure G	$1,714,670	250
Measure H	$1,410,554	276
Measure E	$2,717,590	304
Measure F	$2,083,484	330

Step six calculates the average cost of each of the cost effective solutions and eliminates those measures that yield less output at a higher cost than the measure with the lowest average cost per functional habitat index (FHI). Step seven repeats step six to further screen measures. Steps eight and nine perform an incremental cost analysis on the measures that were moved forward after going through steps six and seven.

Traditionally, these steps are part of the incremental analysis portion of the “Nine Easy Steps” and are performed on the remaining measures. However, since the Congressional Authority that was given to do the MsCIP Comprehensive study specifically directs the Corps of Engineers not to conduct Incremental Cost Analysis, this analysis will conclude at step six, with measures D, H and F moving forward for further consideration. Table 6.3-5 shows the environmentally cost effective measures for beach and dune placement for planning unit one that will be carried forward for further comparison.

Table 6.3-5.
List of Cost Effective Measures for Planning Unit One

Measures	Total Annual Cost ($)	Total Annual Output (FHI)
Measure AA (No Action)	$0	0
Measure D	$1,303,797	154
Measure H	$1,410,554	276
Measure F	$2,083,484	330
Measure I	$6,179,277	136
Measure J	$6,292,507	216
Measure K	$254,783	248

6.3.1.7 Regional Economic Development (RED)

The purpose of this section is to show the regional economic impact of the cost effective measures on business (sale volumes), income, employment, and population of the local area. Each of the measures would affect the local area of Hancock County, Mississippi. The expenditures for the measures are estimated to be $4,030,000 for the Measure D measure, $6,440,000 for the Measure F measure, $4,360,000 for the Measure H measure, $19,100,000 for the Measure I measure, $19,450,000 for the Measure J measure and $4,640,000 for the Measure K measure. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $20,150,000 for the measure D, $32,200,000 for the measure F, $21,800,000 for the measure H, $95,500,000 for the measure I, $97,520,000 for the Measure J measure and $0 for the Measure K measure (assuming a 50-year period of analysis and an interest rate of 4.875 percent). Tables 6.3-6 through 6.3-9 summarize the EIFS model inputs and outputs for the beach and dune placement measures at for Planning Unit One.

Table 6.3-6.
EIFS Model Implementation Inputs for LOD2

	Measure D	Measure F	Measure H	Measure I	Measure J	Measure K
Region of Influence (ROI)	Hancock County	Hancock County	Hancock County	Hancock County	Hancock County	Hancock County
Change in Local Expenditures	$4,030,000	$6,440,000	$4,360,000	$19,100,000	$19,450,000	$4,640,000

Based of the given inputs the outputs are as follows:

Table 6.3-7.
EIFS Model Implementation Outputs for LOD2

	Measure D	Measure F	Measure H	Measure I	Measure J	Measure K
Direct Sales Volume	$4,030,000	$6,440,000	$4,360,000	$19,100,000	$19,450,000	$4,640,000
Induced Sales Volume	$4,030,000	$6,440,000	$4,360,000	$19,100,000	$19,450,000	$4,640,000
Total Sales Volume	$8,060,000	$12,880,000	$8,720,000	$38,200,000	$38,900,000	$9,280,000
Direct Income	$971,774	$1,552,910	$1,051,349	$4,605,680	$4,690,077	$1,118,867
Induced Income	$971,774	$1,552,910	$1,051,349	$4,605,680	$4,690,077	$1,118,867
Total Income	$1,943,549	$3,105,820	$2,102,698	$9,211,359	$9,380,154	$2,237,733
Direct Employment	24	39	26	116	118	28
Induced Employment	24	39	26	116	118	28
Total Employment	49	78	53	231	235	56
Local Population	0	0	0	0	0	0

Table 6.3-8.
EIFS Model Operation and Maintenance Cost Inputs for LOD2

	Measure D	Measure F	Measure H	Measure I	Measure J	Measure K
Region of Influence (ROI)	Hancock County	Hancock County	Hancock County	Hancock County	Hancock County	Hancock County
Change in Local Expenditures	$20,150,000	$32,200,000	$21,800,000	$95,500,000	$97,250,000	$0

Based of the given inputs the outputs are as follows:

Table 6.3-9.
EIFS Model Operation and Maintenance Cost Outputs for LOD2

	Measure D	Measure F	Measure H	Measure I	Measure J	Measure K
Direct Sales Volume	$20,150,000	$32,200,000	$21,800,000	$95,500,000	$97,250,000	$0
Induced Sales Volume	$20,150,000	$32,200,000	$21,800,000	$95,500,000	$97,250,000	$0
Total Sales Volume	$40,300,000	$64,400,000	$43,600,000	$191,000,000	$194,500,000	$0
Direct Income	$4,858,871	$7,764,549	$5,256,744	$23,028,398	$23,450,385	$0
Induced Income	$4,858,871	$7,764,549	$5,256,744	$23,028,398	$23,450,385	$0
Total Income	$9,717,743	$15,529,098	$10,513,489	$46,056,796	$46,900,769	$0
Direct Employment	122	195	132	578	588	0
Induced Employment	122	195	132	578	588	0
Total Employment	244	390	264	1156	1177	0
Local Population	0	0	0	0	0	0

6.3.1.8 Summary of Cost Effective Measures and their Benefits

Table 6.3-10 shows the potential measures that are being carried forward for further consideration. Measures D, H, and F are beach and dune placement measures that depend on the construction of the seawall in order to be implemented. Measures I, J, and K are stand alone measures that do not depend on the seawall and elevated roadway for implementation.

Table 6.3-10.
List of Cost Effective Measures Carried Forward for Further Consideration
Planning Unit One

Measures	Total Annual Cost ($)	Environmental Output (FHI)	Change in Sales Volume	Change in Income	Change in Employment
Measure AA (No Action)	$0	0	$0	$0	0
Measure D	$1,303,797	154	$48,360,000	$11,661,292	293
Measure H	$1,410,554	276	$52,320,000	$12,616,186	317
Measure F	$2,083,484	330	$77,280,000	$18,634,917	468
Measure I	$6,179,277	136	$229,200,000	$55,268,156	1,387
Measure J	$6,292,507	216	$233,400,000	$56,280,923	1,412
Measure K	$254,783	248	$9,280,000	$2,237,733	56

6.3.1.9 Public Access and Parking

An analysis of public access and parking was conducted on the sections where beach and dune construction would take place. It was determined that planning unit one has sufficient access and parking to satisfy the requirements established in Engineering Regulation (ER) 1165-2-100. Planning unit one has access along the entire stretch of beach with 592 parking spaces that are available to everyone for no cost. Addendum C describes the result of the access and parking analysis in greater detail.

6.3.2 Panning Unit Two

6.3.2.1 Background

The beaches of Hancock County are approximately 9 miles in length, and host one of the Gulf Coast's largest populations of Least Tern, a Federally-listed endangered species, plus a significant number of Piping Plover. The beaches possessed a dune system (pre-Katrina) that was maintained by local interests, that was vegetated and supported a significant ecosystem, in addition to passive recreation usage outside the dune system. This dune system provided not only ecosystem benefits, but some measure of hurricane or storm damage reduction due to its ability to absorb some of the surge and wave energy during those types of events. During Hurricane Katrina, this dune system was almost entirely destroyed by surge and wave action. Almost all ecosystem functions and values were eliminated during this single event. Much of the sand removed is believed to be close off shore in the near shore zone. The MsCIP Interim Chief's Report recommended that a beach and dune placement project be constructed in Panning Unit 3. This interim project consists of restoring approximately 26 miles of dune systems that were destroyed by Hurricane Katrina. The proposed project area for planning unit two is shown in figures 6.3.2-1 through 6.3.2-3.

6.3.2.1.1 Opportunities

The following opportunities were identified for this area:

- Hurricane storm damage reduction or remediation
- Prevention or remediation of Saltwater Intrusion
- Preservation of Fish & Wildlife and restoration of their habitats
- Prevention or remediation of erosion
- Other related water resource purposes, such as ecosystem restoration or barrier island restoration



Figure 6.3.2-1. Project Sites for LOD2 in Panning Unit 2

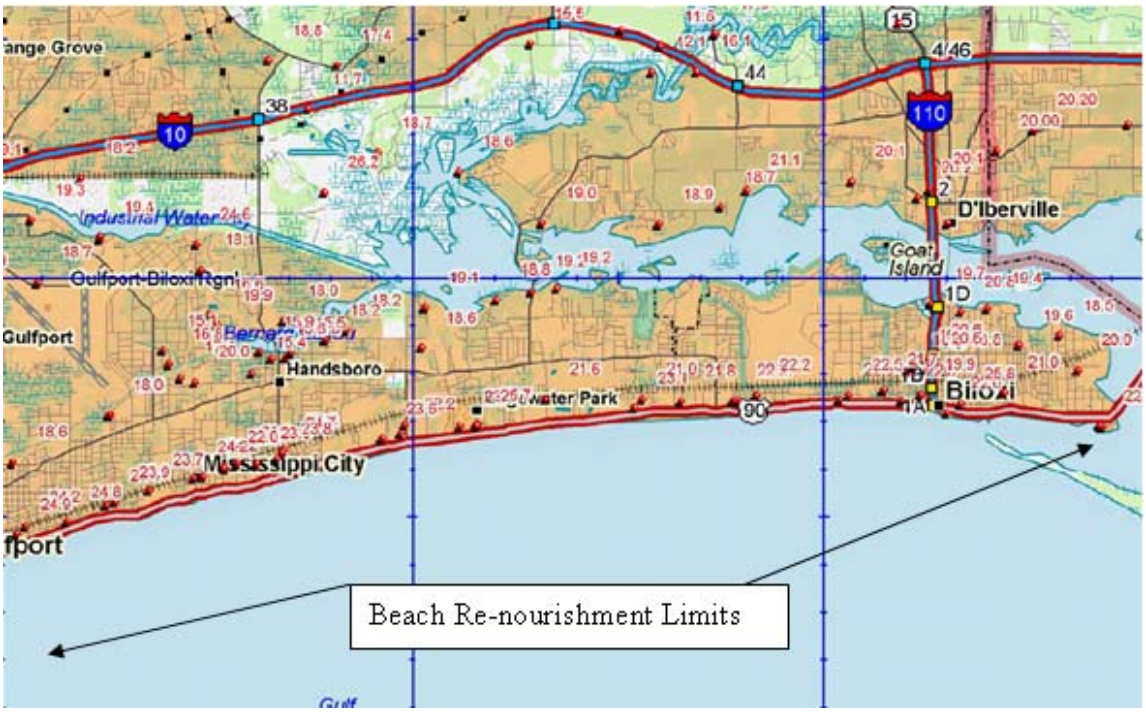


Figure 6.3.2-2. Eastern Project Limits for Line of Defense 2 in Panning Unit 2

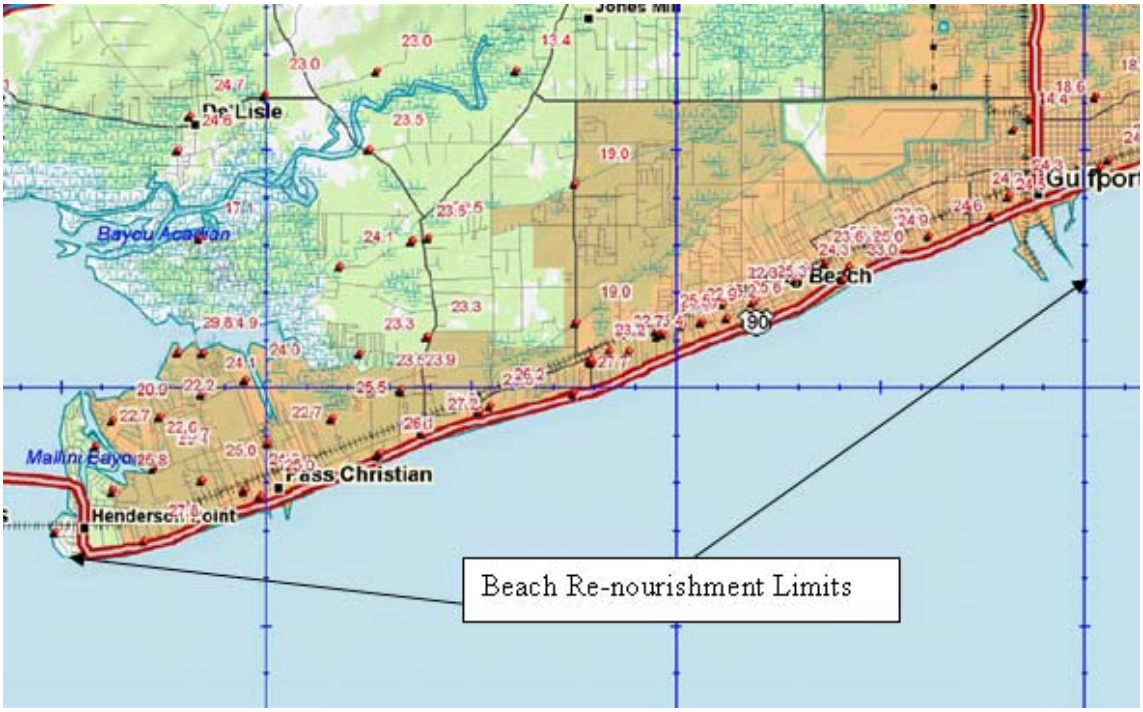


Figure 6.3.2-3. Western Project Limits for Line of Defense 2 in Panning Unit 2

6.3.2.2 General Assumptions

The following assumptions were used in this analysis.

- The FY 2008 discount rate of 4-7/8 percent was used in estimating average annual benefits and costs
- Price levels are October, 2007 unless otherwise stated.
- A 50-year period of analysis was used to calculate average annual benefits and costs.

6.3.2.3 Measures

Eleven plans were evaluated for enhanced beach protection at the study site. All involve providing a dune and berm to the location. Some of the alternatives, Measures A through H described below, can not be constructed without the construction of the Seawall and Elevated roadway measure, which is evaluated in great detail later in this appendix. The measures for Line of Defense 2 in Panning Unit 2 are as follows:

- Measure A consists of a 15.0 feet NAVD88 dune elevation, 35.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 160.0 feet width, an upper berm elevation of 7.2 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10.
- Measure B consists of a 13.0 feet NAVD88 dune elevation, 45.0 feet NAVD88 dune crest width, with a dune slope of 1:3, and a berm with a 160.0 feet width, an upper berm elevation of 7.2 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10.
- Measure C consists of a 15.0 feet NAVD88 dune elevation, 25.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 170.0 feet width, an upper berm elevation of 7.2 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10.
- Measure D consists of a 13.0 feet NAVD88 dune elevation, 15.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 160.0 feet width, an upper berm elevation of 7.2 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10.
- Measure E consists of a 15.0 feet NAVD88 dune elevation, 35.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 160.0 feet width, an upper berm elevation of 7.2 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.
- Measure F consists of a 13.0 feet NAVD88 dune elevation, 45.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 160.0 feet width, an upper berm elevation of 7.2 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.
- Measure G consists of a 15.0 feet NAVD88 dune elevation, 25.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 170.0 feet width, an upper berm elevation of 7.2 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.
- Measure H consists of a 13.0 feet NAVD88 dune elevation, 15.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 160.0 feet width, an upper berm elevation of 7.2 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern,

with a total of three rows of plants starting at the seaward toe of the dune. Figure 6.3.2-4 shows a typical cross section for Measures A though H.

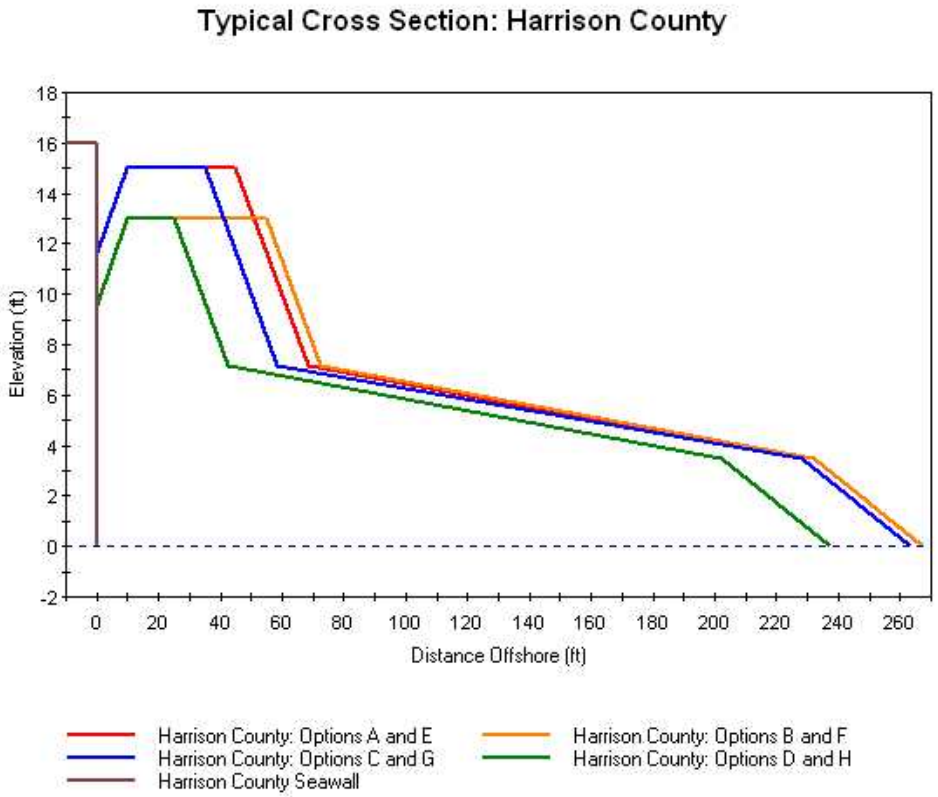


Figure 6.3.2-4. Typical Cross Section for Measures A through H

- Measures I and J are comparative with-project measures, for future evaluation, consisting of a design cross-section which includes a dune and berm constructed as a stand alone project which does not incorporate the Line of Defense 3 seawall. Measure I consists of a dune feature constructed approximately 50.0 feet seaward of the seawall at an elevation of 15.0 feet NAVD 88, with a crest width of 55.0 feet, and a dune slope of 1:3. The berm width would be extended to accommodate the placement of the dune feature. Sand fencing would be placed on the dunes to reduce sand transport due to the strong winds which frequently occur during storms. The cross section for Measure J is the same as Measure I; however the dune would be planted to provide for additional environmental habitat. For Measure J, sea oats would be planted on both the landward and seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the landward and seaward toes of the dune. The dunes will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Measures I and J is shown in Figure 6.3.2-5.

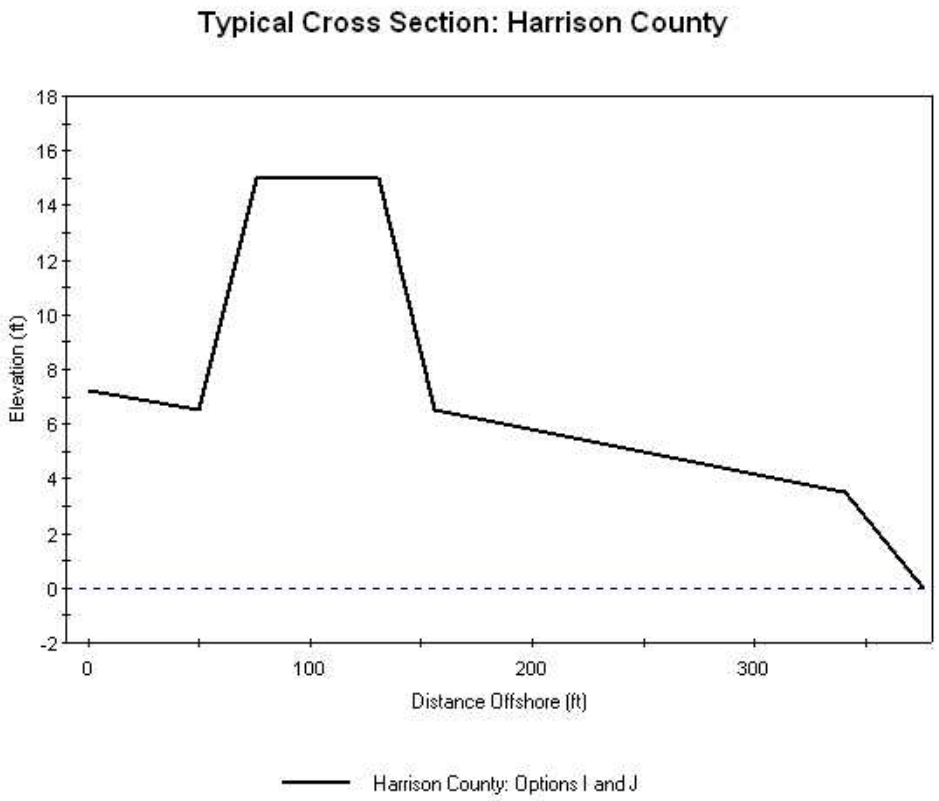


Figure 6.3.2-5. Typical Cross Section for Measures I and J

- Measure K is also a measure for future evaluation which consists of an elevated berm section constructed primarily for the creation of environmental habitat. Measure K would be constructed as a stand alone measure which does not incorporate the Line of Defense 3 seawall. The elevated berm section would be constructed approximately 50.0 feet seaward of the existing seawall to an elevation 2.0 feet above the existing berm with a width of approximately 60.0 feet. The berm width would not be extended to accommodate the placement of the elevated berm feature. The new feature would be vegetated and sand fencing would be placed to create environmental habitat and to reduce sand transport due to the strong winds which frequently occur during storms. For Measure K, sea oats would be planted in a 30 by 30 inch grid pattern over the entire elevated berm area. The new feature will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Measure K is shown in Figure 6.3.2-6.

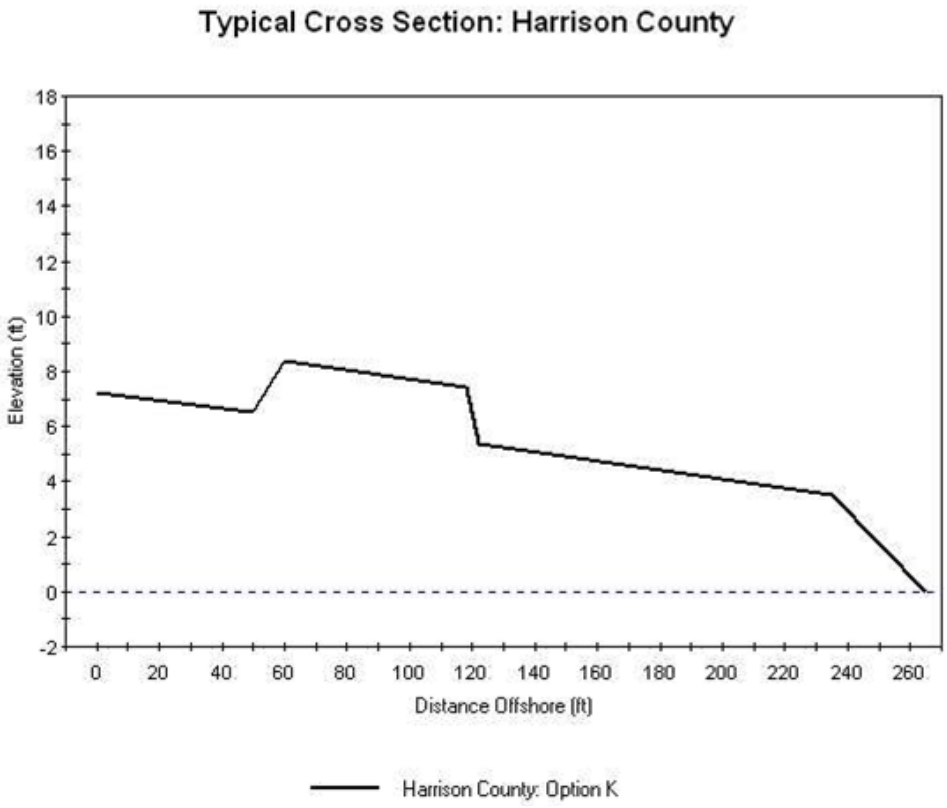


Figure 6.3.2-6. Typical Cross Section for Measure K

6.3.2.4 National Economic Development (NED)

This section describes the National Economic Development benefits for the various beach and dune placement measures in planning unit two that are attributable to hurricane and storm damage reduction. National economic development benefits are damages to structures and their contents that are reduced when a measure or alternative is implemented, or the difference between the with-project and without-project conditions.

There are two types of beach and dune placement measures for planning unit two; those that are dependent on the seawall and elevated roadway and those that can be implemented as stand alone measures. Those measures dependent on the seawall and elevated roadway, measures A through H, would be implemented to abut the seawall and elevated roadway and would be constructed to a maximum elevation of 1.0 foot lower than the seawall and elevated roadway, or to elevation 15.0 feet NAVD88, thus acting as a system. For these measures, equivalent annual damage reduction would be limited to structures that are physically located south of Beach Boulevard, since seawall and elevation of that roadway would be higher than the dune system itself. A visual description of this system can be seen above in figure 6.3-7. The remaining measures I, J, and K are stand alone, and would be implemented in lieu of the seawall and elevated roadway with dune system. The equivalent annual damage reduction attributable to the stand alone measures would impact structures located south of Beach Boulevard in planning unit two and some footprint of structures north of beach boulevard. Also, all beach and dune placement measures would provide some level of protection to the seawall and roadways that they abut, but those benefits are difficult to quantify and were not conducted in this analysis.

The Beach-FX program was selected to quantify the damage reduction benefits of all of the beach and dune placement measures. Beach-FX is a Monte Carlo based model that combines coastal processes economic conditions to evaluate damages from storm events and the level of damage reduction that would be attributable to a given measure. Chapter III of this appendix depicts the overall process of the Beach-FX evaluation. For this study, the exploration of the costal processes and economic inventorying was conducted. Further study would be required to combine the observed data and to evaluate the eleven alternatives previously mentioned. More detail on further study can be found in the MsCIP Comprehensive Plan Main Report. Table 6.3.2-1 summarizes the costs by measure for planning unit two.

6.3.2.6 National Ecosystem Restoration (NER)

The P&G defines the environmental quality account as, "displays of non-monetary effects on ecological, cultural, and aesthetic resources…" The EQ account is typically associated with ecosystem restoration projects, although it does address the following:

6.3.2.6.1 Cost Effective Analysis Assumptions

This analysis assumes a 50-year project life. Costs were amortized using the FY 2008 federal discount rate of 4.875-percent and are presented in October 2007 dollars. The outputs quantified in this cost effective analysis are defined as the quantification of expected improvements in target functions as related to project objectives (functional habitat index, FHI). FHI scores were based on an assessment protocol, which provide a basic level of stream health evaluation that is based on physical conditions within the assessment area. The assessment is used to record the scores for up to 15 assessment elements (i.e., channel condition, hydrologic alteration, riparian zone, bank stability, water appearance, nutrient enrichment, barriers to fish movement, instream fish cover, pools, insect/invertebrate habitat, canopy cover [warm water fishery], manure presence, salinity, riffle embeddedness, and macroinvertebrates observed). However, all assessment elements were not applicable to the assessment area and were not included.

The first step in cost-effective analysis is to display the environmental outputs (effects on habitat expressed in Functional Habitat Index, FHI) and the cost estimates of the management measure increments. Outputs and costs can be displayed as average annual outputs and average annual costs or total outputs and total costs. Both are acceptable so long as they are comparable. Average annual outputs and average annual costs were used for this analysis.

Table 6.3.2-2 displays the project alternatives and their associated average annual outputs and average annual costs. Project outputs for each alternative are displayed in terms of functional habitat index (FHI) that can be supported for each alternative considered.

Summary of Costs

Table 6.3.2-1 summarizes the ROM costs at an FY-08 price level for the beach and dune measures in planning unit two.

Table 6.3.2-1.
Summary of Beach and Dune Costs by Measure for Planning Unit Two

Measures	Implementation Cost (FY-08) ($)	IDC ($)	Total Implementation Cost ($)	Average Annual Implementation Cost ($)	Average Annual O&M ($)	Total Average Annual Costs ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A[1] (15FT by 35FT Dune without plantings)	$21,840,000	$752,800	$22,592,800	$1,213,737	$5,866,473	$7,080,210
Measure B[1] (13FT by 45FT Dune without plantings)	$18,600,000	$641,200	$19,241,200	$1,033,681	$4,996,172	$6,029,853
Measure C[1] (15FT by 25FT Dune without plantings)	$18,100,000	$624,100	$18,724,100	$1,005,901	$4,861,867	$5,867,768
Measure D[1] (13FT by 15FT Dune without plantings)	$10,400,000	$358,500	$10,758,500	$577,971	$2,793,559	$3,371,530
Measure E[1] (15FT by 35FT Dune with plantings)	$22,970,000	$791,800	$23,761,800	$1,276,538	$6,170,004	$7,446,542
Measure F[1] (13FT by 45FT Dune with plantings)	$19,760,000	$681,200	$20,441,200	$1,098,148	$5,307,761	$6,405,909
Measure G[1] (15FT by 25FT Dune with plantings)	$19,210,000	$662,100	$19,872,100	$1,067,575	$5,160,025	$6,227,600
Measure H[1] (13FT by 15FT Dune with plantings)	$11,520,000	$397,100	$11,917,100	$640,214	$3,094,403	$3,734,617
Measure I (Standalone 15FT Dune without plantings)	$40,290,000	$1,389,000	$41,679,000	$2,239,091	$10,822,354	$13,061,445
Measure J (Standalone 15FT Dune with plantings)	$41,460,000	$1,429,000	$42,889,000	$2,304,095	$11,136,629	$13,440,724
Measure K (Standalone 2FT Dune with plantings)	$9,680,000	$333,600	$10,013,600	$537,953	$0	$537,953

1/ Denotes measures that could not be implemented without the construction of the seawall, which is discussed in section 6.4.
2/ Cost include Construction Management, Supervision & Administration, and Contingencies. More detail on the costs can be found in the Cost Estimating Appendix.

Table 6.3.2-2.
Outputs and Costs by Measure

Measures	Annualized Implementation Cost ($)	Annual O&M ($)	Total Annual Cost ($)	Output (FHI)
Measure AA (No Action)	$0	$0	$0	0
Measure A	$1,213,737	$5,866,473	$7,080,210	142
Measure B	$1,033,681	$4,996,172	$6,029,853	172
Measure C	$1,005,901	$4,861,867	$5,867,768	154
Measure D	$577,971	$2,793,559	$3,371,530	130
Measure E	$1,276,538	$6,170,004	$7,446,542	304
Measure F	$1,098,148	$5,307,761	$6,405,909	330
Measure G	$1,067,575	$5,160,025	$6,227,600	276
Measure H	$640,214	$3,094,403	$3,734,617	250

The second step in cost effective analysis is to identify combinable management measures. This involves the analysis of the management measures to determine those that can be implemented together from those that cannot be implemented together. Each of the alternatives in this analysis is independent of the others. After the selection of one of the alternatives, the other alternatives are not needed; therefore the alternatives are not combinable.

The next step is to calculate outputs and costs of combinations. The combinations of the management measures are defined and analyzed incrementally. In this step, each combination of output (HU) and cost ($) is calculated. However, since the alternatives cannot be combined, this step is not necessary in this case.

Eliminating economically inefficient measures is the fourth step in cost effective analysis. In order to do this, the list of measures is reordered so that they are listed in ascending order of their outputs. Where two or more measures produce the same output, the measures are ranked in ascending order of their costs. The result is a ranking of measures AA, D, A, C, B, H, G, E, and F as displayed below in table 6.3.2-3. At each level of output the least cost measure is determined. No measures were identified as inefficient measures since all of the measures provide different levels of environmental lift; therefore all measures will be carried forward to the next step of this analysis.

Table 6.3.2-3.
List of Efficient Measures

Measures	Total Annual Cost ($)	Output (FHI)
Measure AA (No Action)	$0	0
Measure D	$3,371,530	130
Measure A	$7,080,210	142
Measure C	$5,867,768	154
Measure B	$6,029,853	172
Measure H	$3,734,617	250
Measure G	$6,227,600	276
Measure E	$7,446,542	304
Measure F	$6,405,909	330

The fifth step in cost effective analysis is to eliminate economically ineffective measures. The outputs and costs undergo a pair-wise comparison. The results of the comparison are analyzed to determine which measures will produce less output at equal or greater cost than subsequently ranked measures. Those measures that will produce less output at equal or greater cost than subsequently ranked measures are deleted. Measures A, C, and B were eliminated because they were found to be ineffective measures. Measure H produces more output for less cost than measures A, C, B. The results of this step are shown in table 6.3.2-4.

Table 6.3.2-4.
List of Effective Measures

Measures	Total Annual Cost ($)	Output (FHI)
Measure AA (No Action)	$0	0
Measure D	$3,371,530	130
Measure A	$7,080,210	142
Measure C	$5,867,768	154
Measure B	$6,029,853	172
Measure H	$3,734,617	250
Measure G	$6,227,600	276
Measure E	$7,446,542	304
Measure F	$6,405,909	330

Step six calculates the average cost of each of the cost effective measures and eliminates those measures that yield less output at a higher cost than the measure with the lowest average cost per functional habitat index (FHI). Step seven repeats step six to further screen alternatives. Steps eight and nine perform an incremental cost analysis on the measures that were moved forward after going through steps six and seven.

Traditionally, these steps are part of the cost effective analysis portion of the “Nine Easy Steps” and are performed on the remaining plans. However, since the Congressional Authority that was given to do the MsCIP Comprehensive study specifically directs the Corps of Engineers not to conduct Incremental Cost Analysis, this analysis will conclude at step five, with measures D, G, H and F moving forward for further consideration. Table 6.3.2-5 shows the environmentally cost effective plans for beach and dune placement for Panning Unit two that will be carried forward for further comparison.

Table 6.3.2-5.
List of Cost Effective Measures for Planning Unit Two

Measures	Total Annual Cost ($)	Output (FHI)
Measure AA (No Action)	$0	0
Measure D	$3,371,530	130
Measure H	$3,734,617	250
Measure G	$6,227,600	276
Measure F	$6,405,909	330
Measure I	$13,061,445	140
Measure J	$13,440,724	220
Measure K	$537,953	240

6.3.2.7 Regional Economic Development (RED)

The purpose of this section is to show the economic impact of the cost effective measures on business (sale volumes), income, employment, and population of the local area. Each of the measures would affect the local area of Harrison County, Mississippi. The expenditures for the measures are estimated to be $10,400,000 for the measure D, $19,760,000 for the measure F, $19,210,000 for measure G, $11,520,000 for the measure H, $40,290,000 for the measure I, $41,460,000 for the measure J, and $9,680,000 for the measure K. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $52,000,000 for the measure D, $98,800,000 for the measure F, $$96,050,000 for measure G, $57,600,000 for the measure H, $201,450,000 for the measure I, $207,300,000 for the measure J, and $0 for the measure K (assuming a 50-year period of analysis and an interest rate of 4.875 percent). Tables 6.3.2-6 through 6.3.2-9 summarize the EIFS model inputs and outputs for the beach and dune placement measures at Planning Unit Two.

Table 6.3.2-6.
EIFS Model Implementation Cost Inputs for LOD2

	Measure D	Measure F	Measure G	Measure H	Measure I	Measure J	Measure
Region of Influence (ROI)	Harrison County	Harrison County	Harrison County	Harrison County	Harrison County	Harrison County	Harrison County
Change in Local Expenditures	$10,400,000	$19,760,000	$19,210,000	$11,520,000	$40,290,000	$41,460,000	$9,680,000

Based of the given inputs the outputs are as follows:

Table 6.3.2-7.
EIFS Model Implementation Cost Outputs for LOD2

	Measure D	Measure F	Measure G	Measure H	Measure I	Measure J	Measure K
Direct Sales Volume	$10,400,000	$19,760,000	$19,210,000	$11,520,000	$40,290,000	$41,460,000	$9,680,000
Induced Sales Volume	$13,000,000	$24,700,000	$24,012,500	$14,400,000	$50,362,500	$51,825,000	$12,100,000
Total Sales Volume	$23,400,000	$44,460,000	$43,222,500	$25,920,000	$90,652,500	$93,285,000	$21,780,000
Direct Income	$2,201,423	$4,182,705	$4,066,283	$2,438,500	$8,528,399	$8,776,059	$2,049,017
Induced Income	$2,751,780	$5,228,381	$5,082,855	$3,048,125	$10,660,500	$10,970,076	$2,561,272
Total Income	$4,953,203	$9,411,086	$9,149,138	$5,486,625	$19,188,899	$19,746,135	$4,610,289
Direct Employment	66	125	122	73	256	263	61
Induced Employment	83	157	153	91	320	329	77
Total Employment	149	282	275	165	576	592	138
Local Population	0	0	0	0	0	0	0

Table 6.3.2-8.
EIFS Model Operation and Maintenance Cost Inputs for LOD2

	Measure D	Measure F	Measure G	Measure H	Measure I	Measure J	Measure K
Region of Influence (ROI)	Harrison County	Harrison County	Harrison County	Harrison County	Harrison County	Harrison County	Harrison County
Change in Local Expenditures	$52,000,000	$98,800,000	$96,050,000	$57,600,000	$201,450,000	$207,300,000	$0

Based of the given inputs the outputs are as follows:

Table 6.3.2-9.
EIFS Model Operation and Maintenance Cost Outputs for LOD2

	Measure D	Measure F	Measure G	Measure H	Measure I	Measure J	Measure K
Direct Sales Volume	$52,000,000	$98,800,000	$96,050,000	$57,600,000	$201,450,000	$207,300,000	$0
Induced Sales Volume	$65,000,000	$123,500,000	$120,062,500	$72,000,000	$251,812,500	$259,125,000	$0
Total Sales Volume	$117,000,000	$222,300,000	$216112,500	$129,600,000	$453,262,500	$466,425,000	$0
Direct Income	$11,007,117	$20,913,523	$20,331,415	$12,192,499	$42,641,995	$43,880,296	$0
Induced Income	$13,758,898	$26,141,907	$25,414,273	$15,240,626	$53,302,502	$54,850,378	$0
Total Income	$24,766,016	$47,055,430	45,745,688	$27,433,125	$95,944,497	$98,730,674	$0
Direct Employment	330	627	610	366	1,279	1,316	0
Induced Employment	413	784	763	457	1,600	1,646	0
Total Employment	743	1,412	1,373	823	2,879	2,962	0
Local Population	0	0		0	0	0	0

6.3.2.8 Summary of Cost Effective Measures

Table 6.3.2-10 shows the potential measures that are being carried forward for further consideration. Measures D, H, G, and F are beach and dune placement measures that depend on the construction of the seawall in order to be implemented. Measures I, J, and K are stand alone measures that do not depend on the seawall for implementation.

Table 6.3.2-10.
List of Measures Carried Forward for Further Evaluation in Planning Unit Two
Planning Unit Two

Measures	Total Annual Cost ($)	Total Annual Output (FHI)	Change in Sales Volume	Change in Income	Change in Employment
Measure AA (No Action)	$0	0	$0	$0	0
Measure D[1]	$3,371,530	130	$140,400,000	$29,719,219	892
Measure H[1]	$3,734,617	250	$155,520,000	$32,919,750	988
Measure G[1]	$6,227,600	276	$259,335,000	$54,894,826	1,647
Measure F[1]	$6,405,909	330	$266,760,000	$56,466,515	1,694
Measure I	$13,061,445	140	$543,915,000	$115,133,396	3,454
Measure J	$13,440,724	220	$559,710,000	$118,476,808	3,555
Measure K	$537,953	240	$21,780,000	$4,610,289	138

6.3.2.9 Public Access and Parking

A parking and access analysis was conducted on the sections where beach and dune constriction would take place for planning unit two. It was determined that planning unit two has sufficient access and parking to satisfy the requirements established in Engineering Regulation (ER) 1165-2-100. Planning unit two also has access along the entire twenty-six mile length of beach and has 2,788 free parking spaces. Addendum C describes the result of the access and parking analysis in greater detail.

6.3.3 Planning Unit Three

6.3.3.1 Background

The beaches of Jackson County are host one of the Gulf Coast's largest populations of Least Tern, a Federally-listed endangered species, plus a significant number of Piping Plover. During Hurricane Katrina, this dune system was almost entirely destroyed by surge and wave action. Almost all ecosystem functions and values were eliminated during this single event. Much of the sand removed is believed to be close off shore in the near shore zone. The MsCIP Interim Chiefs Report did not recommend a beach and dune placement project be constructed in planning unit three; therefore the without-project condition for this planning unit is the post storm condition. Maintenance occurs on the Jackson County beaches if it is determined that significant erosion occurs following a significant event; with the beaches restored to the pre-storm condition. There is no scheduled periodic maintenance of the beaches. The future without-project conditions assume continuation of the present maintenance activities to restore the berm only feature in Jackson. The berm elevation varies from approximately 5.0 feet NAVD88 at the seawall to 3.5 feet NAVD88 at the slope break to the Mississippi Sound. Figure 6.3.3-1 shows the project location for planning unit three.



Figure 6.3.3-1. Project Sites for Beach and Dune Placement in Planning Unit Three

6.3.3.1.1 Opportunities

The following opportunities were identified for this area:

- Hurricane storm damage reduction or remediation
- Preservation of Fish & Wildlife and restoration of their habitats
- Prevention or remediation of erosion
- Other related water resource purposes, such as ecosystem restoration or barrier island restoration

6.3.3.2 General Assumptions

The following assumptions were used in this analysis.

- The FY 2008 discount rate of 4-7/8 percent was used in estimating average annual benefits and costs
- Price levels are October, 2007 unless otherwise stated.
- A 50-year period of analysis was used to calculate average annual benefits and costs.

6.3.3.3 Measures

Two plans were evaluated for enhanced beach protection at the study site. All involve providing a dune and berm to the location. Some of the alternatives, Measures A through H described below, can not be constructed without the construction of the Seawall and Elevated roadway measure, which is evaluated in great detail later in this appendix. The measures for Line of Defense 2 in planning unit three are as follows:

- Measure A consists of a 10.0 feet NAVD88 dune elevation, 40.0 feet dune crest width, with a dune slope of 1:3, and a berm with an 80.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10.
- Measure B consists of an 8.0 feet NAVD88 dune elevation, 50.0 feet dune crest width, with a dune slope of 1:3, and a berm with an 80.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10.
- Measure C consists of a 10.0 feet NAVD88 dune elevation, 20.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 100.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10.
- Measure D consists of an 8.0 feet NAVD88 dune elevation, 30.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 100.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10.
- Measure E consists of a 10.0 feet NAVD88 dune elevation, 40.0 feet dune crest width, with a dune slope of 1:3, and a berm with an 80.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.
- Measure F consists of an 8.0 feet NAVD88 dune elevation, 50.0 feet dune crest width, with a dune slope of 1:3, and a berm with an 80.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.
- Measure G consists of a 10.0 feet NAVD88 dune elevation, 20.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 100.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.
- Measure H consists of an 8.0 feet NAVD88 dune elevation, 30.0 feet dune crest width, with a dune slope of 1:3, and a berm with a 100.0 feet width, an upper berm elevation of 5.5 feet NAVD88, and seaward berm elevation of 3.5 feet NAVD88, and a foreshore slope of 1:10. In addition, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern,

with a total of three rows of plants starting at the seaward toe of the dune. Figure 6.3.3-2 shows a typical cross section for Measures A though H.

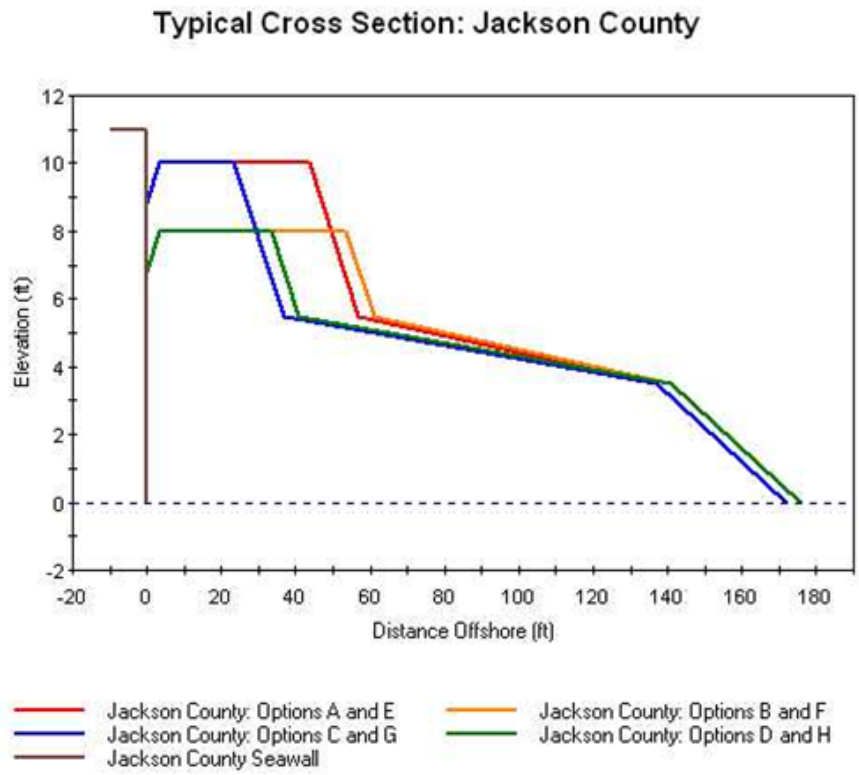


Figure 6.3.3-2. Typical Cross Section for Measures A through H

Measures I and J are comparative with-project measures, for future evaluation, consisting of a design cross-section which includes a dune and berm constructed as a stand alone project which does not incorporate the Line of Defense 3 seawall. Measure I consists of a dune feature constructed approximately 50.0 feet seaward of the seawall at an elevation of 10.0 feet NAVD 88, with a crest width of 55.0 feet, and a dune slope of 1:3. The berm width would be extended to accommodate the placement of the dune feature. Sand fencing would be placed on the dunes to reduce sand transport due to the strong winds which frequently occur during storms. The cross section for Measure J is the same as Measure I; however the dune would be planted to provide for additional environmental habitat. For Measure J, sea oats would be planted on both the landward and seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the landward and seaward toes of the dune. The dunes will require initial and continued maintenance of vegetation and sand fencing. Figure 6.3.3-3 shows the typical cross section for measures I and J.

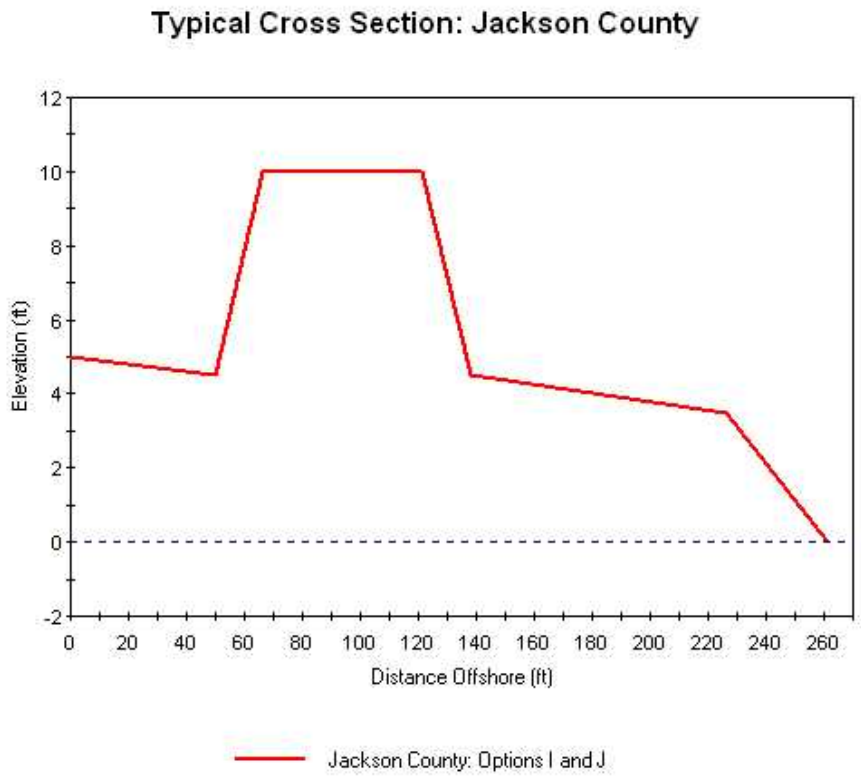


Figure 6.3.3-3. Typical cross section for Measures I and J

Measure K is also a measure for future evaluation which consists of an elevated berm section constructed primarily for the creation of environmental habitat. Measure K would be constructed as a stand alone measure which does not incorporate the Line of Defense 3 seawall. The elevated berm section would be constructed approximately 50.0 feet seaward of the existing seawall to an elevation 2.0 feet above the existing berm with a width of approximately 60.0 feet. The berm width would not be extended to accommodate the placement of the elevated berm feature. The new feature would be vegetated and sand fencing would be placed to create environmental habitat and to reduce sand transport due to the strong winds which frequently occur during storms. For Measure K, sea oats would be planted in a 30 by 30 inch grid pattern over the entire elevated berm area. The new feature will require initial and continued maintenance of vegetation and sand fencing. Figure 6.3.3-4 shows the typical cross section for measure K.

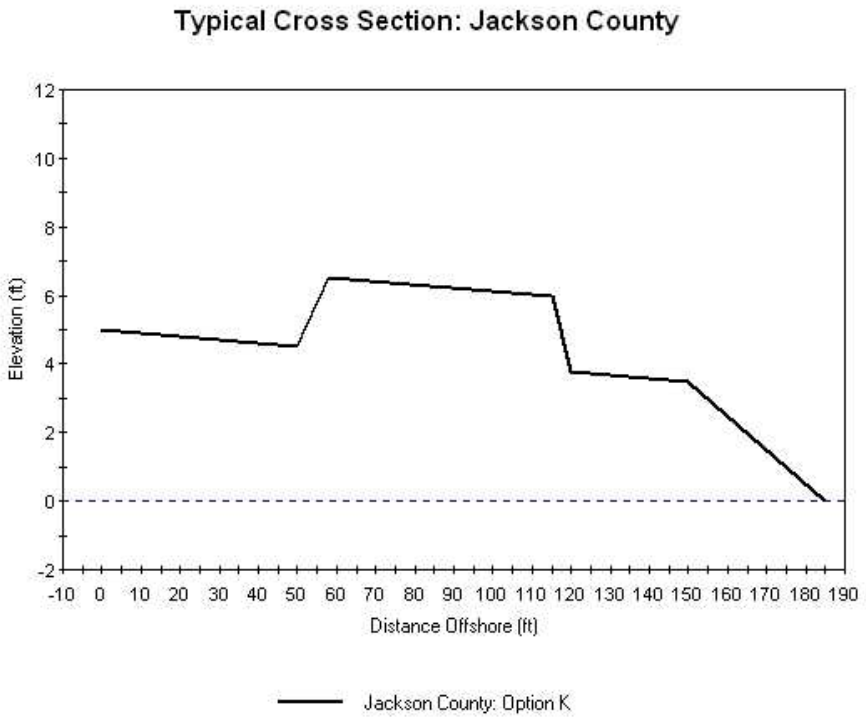


Figure 6.3.3-4. Typical cross section for measure K

6.3.3.4 National Economic Development (NED)

This section describes the National Economic Development benefits for the various beach and dune placement measures in planning unit three that are attributable to hurricane and storm damage reduction. National economic development benefits are damages to structures and their contents that are reduced when a measure or alternative is implemented, or the difference between the with-project and without-project conditions.

There are two types of beach and dune placement measures for planning unit three; those that are dependent on the seawall and elevated roadway and those that can be implemented as stand alone measures. Those measures dependent on the seawall and elevated roadway, measures A through H, would be implemented to abut the seawall and elevated roadway and would be constructed to a maximum elevation of 1.0 foot lower than the seawall and elevated roadway, or to elevation 10.0 feet NAVD88, thus acting as a system. For these measures, equivalent annual damage reduction would be limited to structures that are physically located south of Beach Boulevard, since seawall and elevation of that roadway would be higher than the dune system itself. A visual description of this system can be seen above in figure 6.3-11. The remaining measures I, J, and K are stand alone, and would be implemented in lieu of the seawall and elevated roadway with dune system. The equivalent annual damage reduction attributable to the stand alone measures would impact structures located south of Beach Boulevard in planning unit three and some footprint of structures north of Beach Boulevard. Also, all beach and dune placement measures would provide some level of protection to the seawall and roadways that they abut, but those benefits are difficult to quantify and were not conducted in this analysis.

The Beach-FX program was selected to quantify the damage reduction benefits of all of the beach and dune placement measures. Beach-FX is a Monte Carlo based model that combines coastal processes economic conditions to evaluate damages from storm events and the level of damage reduction that would be attributable to a given measure. Chapter III of this appendix depicts the overall process of the

Beach-FX evaluation. For this study, the exploration of the coastal processes and economic inventorying was conducted. Further study would be required to combine the observed data and to evaluate the eleven alternatives previously mentioned. More detail on the further study can be found in the MsCIP Comprehensive Plan Main Report. Table 6.3.3-1 summarizes the costs for the beach and dune construction measures for planning unit three. For this study, the exploration of the coastal processes and economic inventorying was conducted. Further study would be required to combine the observed data and to evaluate the eleven alternatives previously mentioned. More detail on the further study can be found in the MsCIP Comprehensive Plan Main Report. Table 6.3.3-1 summarizes the costs for the beach and dune construction measures for planning unit three.

6.3.3.5 Summary of Costs

Table 6.3.3-1 summarizes the ROM costs at an FY-08 price level for the beach and dune measures in planning unit three.

Table 6.3.3-1.
Summary of Beach and Dune Costs by Measure for Planning Unit Three

Measures	Implementation Cost ($)	IDC ($)	Total Implementation Cost ($)	Average Annual Implementation Cost ($)	Average Annual O&M ($)	Total Average Annual Costs ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A[1] (10FT by 40FT Dune without plantings)	$1,910,000	$42,200	$1,952,200	$104,877	$513,048	$617,924
Measure B[1] (8FT by 50FT Dune without plantings)	$1,450,000	$32,100	$1,482,100	$79,622	$389,487	$469,108
Measure C[1] (10FT by 20FT Dune without plantings)	$1,180,000	$26,400	$1,206,400	$64,811	$316,961	$381,772
Measure D[1] (8FT by 30FT Dune without plantings)	$960,000	$21,200	$981,200	$52,712	$257,867	$310,579
Measure E[1] (10FT by 40FT Dune with plantings)	$1,990,000	$44,000	$2,034,000	$109,271	$534,537	$643,808
Measure F[1] (8FT by 50FT Dune with plantings)	$1,530,000	$33,900	$1,563,900	$84,016	$410,975	$494,992
Measure G[1] (10FT by 20ft Dune with plantings)	$1,260,000	$27,900	$1,287,900	$69,189	$338,450	$407,639
Measure H[1] (8FT by 30FT Dune with plantings)	$1,040,000	$22,900	$1,062,900	$57,101	$279,356	$336,457
Measure I (10FT by 50FT Dune without plantings)	$4,490,000	$99,400	$4,589,400	$246,553	$1,206,065	$1,452,618
Measure J (10FT by 50FT Dune with plantings)	$4,570,000	$101,200	$4,671,200	$250,948	$1,227,554	$1,478,502
Measure K (2FT by 60FT Dune with plantings)	$1,110,000	$24,600	$1,134,600	$60,953	$0	$60,953

1/ Denotes measures that could not be implemented without the construction of the seawall, which is discussed in section 6.4.
2/ Cost include Construction Management, Supervision & Administration, and Contingencies. More detail on the costs can be found in the Cost Estimating Appendix.

6.3.3.6 National Ecosystem Restoration (NER)

The P&G defines the environmental quality account as, “displays of non-monetary effects on ecological, cultural, and aesthetic resources…” The EQ account is typically associated with ecosystem restoration projects, although it does address the following:

6.3.3.6.1 Cost Effective Analysis Assumptions

This analysis assumes a 50-year project life. Costs were amortized using the FY 2008 federal discount rate of 4.875-percent and are presented in October 2007 dollars. The outputs quantified in this cost effective analysis are defined as the quantification of expected improvements in target functions as related to project objectives (functional habitat index, FHI). FHI scores were based on an assessment protocol, which provide a basic level of stream health evaluation that is based on physical conditions within the assessment area. The assessment is used to record the scores for up to 15 assessment elements (i.e., channel condition, hydrologic alteration, riparian zone, bank stability, water appearance, nutrient enrichment, barriers to fish movement, instream fish cover, pools, insect/invertebrate habitat, canopy cover [warm water fishery], manure presence, salinity, riffle embeddedness, and macroinvertebrates observed). However, all assessment elements were not applicable to the assessment area and were not included.

The first step in cost-effective analysis is to display the environmental outputs (effects on habitat expressed in Functional Habitat Index, FHI) and the cost estimates of the management measure increments. Outputs and costs can be displayed as average annual outputs and average annual costs or total outputs and total costs. Both are acceptable so long as they are comparable. Average annual outputs and average annual costs were used for this analysis.

Table 6.3.3-2 displays the project alternatives and their associated average annual outputs and average annual costs. Project outputs for each alternative are displayed in terms of functional habitat index (FHI) that can be supported for each alternative considered.

Table 6.3.3-2.
Outputs and Costs by Increments by Measure

Measures	Annualized Implementation Cost ($)	Annual O&M ($)	Total Annual Cost ($)	Total Annual Output (FHI)
Measure AA (No Action)	$0	$0	$0	0
Measure A	$104,877	$513,048	$617,924	142
Measure B	$79,622	$389,487	$469,108	172
Measure C	$64,811	$316,961	$381,772	142
Measure D	$52,712	$257,867	$310,579	154
Measure E	$109,271	$534,537	$643,808	304
Measure F	$84,016	$410,975	$494,992	330
Measure G	$69,189	$338,450	$407,639	250
Measure H	$57,101	$279,356	$336,457	276

The second step in cost effective analysis is to identify combinable management measures. This involves the analysis of the management measures to determine those that can be implemented together from those that cannot be implemented together. Each of the alternatives in this analysis is independent of the others. After the selection of one of the alternatives, the other alternatives are not needed; therefore the alternatives are not combinable.

The next step is to calculate outputs and costs of combinations. The combinations of the management measures are defined and analyzed incrementally. In this step, each combination of output (FHI) and cost ($) is calculated. However, since the alternatives cannot be combined, this step is not necessary in this case.

Eliminating economically inefficient solutions is the fourth step in cost effective analysis. In order to do this, the list of solutions is reordered so that they are listed in ascending order of their outputs. Where two or more solutions produce the same output, the solutions are ranked in ascending order of their costs. The result is a ranking of measures AA, A, C, D, B, G, H, E, and F as displayed below in table 6.3.3-3. At each level of output the least cost measure is determined. Measure A was identified as an inefficient measure and will not be carried forward in this analysis.

Table 6.3.3-3.
List of Economically Efficient Measures for Planning Unit Three

Measures	Total Annual Cost ($)	Total Annual Output (FHI)
Measure AA (No Action)	$0	0
Measure A	$617,924	142
Measure C	$381,772	142
Measure D	$310,579	154
Measure B	$469,108	172
Measure G	$407,639	250
Measure H	$336,457	276
Measure E	$643,808	304
Measure F	$494,992	330

The fifth step in cost effective analysis is to eliminate economically ineffective solutions. The outputs and costs undergo a pair-wise comparison. The results of the comparison are analyzed to determine which solutions will produce less output at equal or greater cost than subsequently ranked solutions. Those solutions that will produce less output at equal or greater cost than subsequently ranked solutions are deleted. Measures C, B, G, and E were eliminated because they were found to be ineffective solutions. These measures were eliminated from further consideration because measure D produces more output for less cost than measure C, measure H produces more output for less cost than measures B and G, and measure F produces more output at less cost than measure E. The results of this step are summarized in table 6.3.3-4.

Step six calculates the average cost of each of the cost effective solutions and eliminates those measures that yield less output at a higher cost than the measure with the lowest average cost per functional habitat index (FHI). Step seven repeats step six to further screen alternatives. Steps eight and nine perform an incremental cost analysis on the measures that were moved forward after going through steps six and seven.

Table 6.3.3-4.
List of Economically Effective Measures for Planning Unit Three

Measures	Total Annual Cost ($)	Total Annual Output (FHI)
Measure AA (No Action)	$0	0
Measure C	$381,772	142
Measure D	$310,579	154
Measure B	$469,108	172
Measure G	$407,639	250
Measure H	$336,457	276
Measure E	$643,808	304
Measure F	$494,992	330

Traditionally, these steps are part of the cost effective analysis portion of the "Nine Easy Steps" and are performed on the remaining plans. However, since the Congressional Authority that was given to do the MsCIP Comprehensive study specifically directs the Corps of Engineers not to conduct Incremental Cost Analysis, this analysis will conclude at step six, with measures H and F moving forward for further consideration. Table 6.3.3-5 shows the environmentally cost effective plans for beach and dune placement for planning unit three that will be carried forward for further comparison.

Table 6.3.3-5.
List of Cost Effective Measures for Planning Unit Three

Measures	Total Annual Cost ($)	Total Annual Output (FHI)
Measure AA (No Action)	$0	0
Measure D	$310,579	154
Measure H	$336,45	276
Measure F	$494,992	330
Measure I	$1,452,618	136
Measure J	$1,478,502	216
Measure K	$60,953	248

6.3.3.7 Regional Economic Development (RED)

The purpose of this section is to show the economic impact of the cost effective project measures on business (sale volumes), income, employment, and population of the local area. Each of the measures would affect the local area of Jackson County, Mississippi. The expenditures for the measures are estimated to be $960,000 for the measure D, $1,530,000 for the measure F, $1,040,000 for the measure H, $4,490,000 for the measure I, $4,570,000 for the measure J, and $1,110,000 for the measure K. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $4,800,000 for the measure D, $7,650,000 for the measure F, $5,200,000 for the measure H, $22,450,000 for the measure I, $22,850,000 for the Measure J measure, and $0 for the Measure K measure (assuming a 50-year period of analysis and an interest rate of 4.875 percent). Tables 6.3.3-6 through 6.3.3-9 show the EIFS model inputs and outputs for the measures ate planning unit three.

Table 6.3.3-6.
EIFS Model Implementation Inputs for LOD2

	Measure D	Measure F	Measure H	Measure I	Measure J	Measure K
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$960,000	$1,530,000	$1,040,000	$4,490,000	$4,570,000	$1,110,000

Based of the given inputs the outputs are as follows:

Table 6.3.3-7.
EIFS Model Implementation Outputs for LOD2

	Measure D	Measure F	Measure H	Measure I	Measure J	Measure K
Direct Sales Volume	$960,000	$1,530,000	$1,040,000	$4,490,000	$4,570,000	$1,110,000
Induced Sales Volume	$1,075,200	$1,713,600	$1,164,800	$5,028,800	$5,118,400	$1,243,200
Total Sales Volume	$2,035,200	$3,243,600	$2,204,800	$9,518,800	$9,688,400	$2,353,200
Direct Income	$187,225	$298,389	$202,827	$875,665	$891,267	$216,478
Induced Income	$209,691	$334,196	$227,166	$980,744	$998,219	$242,456
Total Income	$396,916	$632,585	$429,992	$1,856,409	$1,889,486	$458,934
Direct Employment	5	9	6	25	26	6
Induced Employment	6	10	7	28	29	7
Total Employment	12	18	12	54	55	13
Local Population	0	0	0	0	0	0

Table 6.3.3-8.
EIFS Model Operation and Maintenance Cost Inputs for LOD2

	Measure D	Measure F	Measure H	Measure I	Measure J	Measure K
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$4,800,000	$7,650,000	$5,200,000	$22,450,000	$22,850,000	$0

Based of the given inputs the outputs are as follows:

Table 6.3.3-9.
EIFS Model Operation and Maintenance Cost Outputs for LOD2

	Measure D	Measure F	Measure H	Measure I	Measure J	Measure K
Direct Sales Volume	$4,800,000	$7,650,000	$5,200,000	$22,450,000	$22,850,000	$0
Induced Sales Volume	$5,376,000	$8,568,000	$5,824,000	$25,144,000	$25,592,000	$0
Total Sales Volume	$10,176,000	$16,218,000	$11,024,000	$47,594,000	$48,442,000	$0
Direct Income	$936,123	$1,491,946	$1,014,133	$4,378,324	$4,456,334	$0
Induced Income	$1,048,457	$1,670,979	$1,135,829	$4,903,722	$4,991,094	$0
Total Income	$1,984,580	$3,162,924	$2,149,962	$9,282,046	$9,447,428	$0
Direct Employment	27	43	29	127	129	0
Induced Employment	30	49	33	142	145	0
Total Employment	58	92	62	269	274	0
Local Population	0	0	0	0	0	0

6.3.3.8 Summary of Cost Effective Measures and their Benefits for Planning Unit Three

Table 6.3.3-10 shows the potential measures that are being carried forward for further consideration. Measures D, H, and F are beach and dune placement measures that depend on the construction of the seawall in order to be implemented. Measures I, J, and K are stand alone measures that do not depend on the seawall for implementation.

Table 6.3.3-10.
List of Measures Carried Forward for Further Evaluation in Planning Unit Three

Measures	Total Annual Cost ($)	Total Annual Output (FHI)	Change in Sales Volume	Change in Income	Change in Employment
Measure AA (No Action)			$0	$0	0
Measure D[1]	$310,579	154	$12,211,200	$2,381,496	69
Measure F[1]	$494,992	330	$19,461,600	$3,795,509	110
Measure H[1]	$336,45	276	$13,228,800	$2,579,954	75
Measure I	$1,452,618	136	$57,112,800	$11,138,455	323
Measure J	$1,478,502	216	$58,130,400	$11,336,913	329
Measure K	$60,953	248	$2,353,200	$458,934	13

6.3.3.9 Public Access and Parking

A public access and parking analysis was conducted on the sections where beach and dune constriction would take place. It was determined that each of the three planning units has sufficient access and parking to satisfy the requirements established in Engineering Regulation (ER) 1165-2-100. Planning unit three has three access points for the Ocean Springs beach area that are all within the required half mile distance and have 300 free parking spaces all within a quarter mile of one of the access points. Addendum C describes the result of the access and parking analysis in greater detail.

6.4 Seawall and Elevated Roadway Area Measures

6.4.1 General

The Seawall and Elevated Roadway area is located in all three planning units just north of the roadways that run parallel to the beach. These areas are denoted by the coastal zone area. In planning unit one, the seawall area includes planning sub-units two, three and four, in planning unit two, planning sub-units eight, ten, thirteen, fifteen, eighteen, and twenty, and in planning unit three the planning sub-units are twenty-one and twenty-two. These areas are all highly populated and include several east/west evacuation routes.

6.4.2 Historic (Pre-Hurricane Katrina) Conditions

The pre-Hurricane Katrina conditions for planning sub-units three and four in planning unit one represented a mostly residential community. The areas in planning unit one included 27,310 tax parcels, of which 15,464 contained an asset with some economic value and 11,846 were vacant land. Of the 15,464 parcels that contain assets, 12,061 were residential one-story, 337 were residential two-story, 237 were mobile homes, 2,419 were commercial, and 410 were municipal. The areas in planning unit two included 34,028 tax parcels, of which 20,028 contained an asset with

some economic value and 14,000 were vacant land. Of the 20,028 parcels that contain assets, 18,628 were residential one-story, 658 were residential two-story, 318 were mobile homes, 256 were commercial, and 168 were municipal. The areas in planning unit three included 17,360 tax parcels, of which 12,705 contained an asset with some economic value and 4,655 were vacant land. Of the 12,705 parcels that contain assets, 11,380 were residential one-story, 315 were residential two-story, 85 were mobile homes, 793 were commercial, and 132 were municipal. Table 6.4-1 summarizes the assets by planning unit for the seawall and elevated roadway area.

Table 6.4-1.
Pre-Hurricane Katrina Economic Asset Characteristics for the Impacted Seawall and Roadway Areas

	Planning Unit One	Planning Unit Two	Planning Unit Three	
Asset Categories	**Assets by Category**	**Assets by Category**	**Assets by Category**	**Total**
Residential	12,398	19,286	11,695	43,379
Mobile Homes	237	318	85	640
Commercial	2,419	256	793	3,468
Municipal	410	168	132	710
Vacant Land	11,846	14,000	4,655	30,501
Total	**27,310**	**34,028**	**17,360**	**78,698**

Figure 6.4-1 denotes the various zones and shows the coastal zone in beige. Figure 6.4-2 shows the planning sub-units of the area by planning unit.

6.4.2.1 Existing (Post-Hurricane Katrina) Conditions

Hurricane Katrina made its Mississippi landfall just west of planning sub-units three and four. It is estimated that the storm destroyed 21,228 structures at least fifty-percent or more in these areas. Of those, 7.903 were destroyed in planning unit one, 12,789 in planning unit two, and 536 were destroyed in planning unit three. Table 6.4-2 displays the destroyed structures by category and by planning unit for these areas.

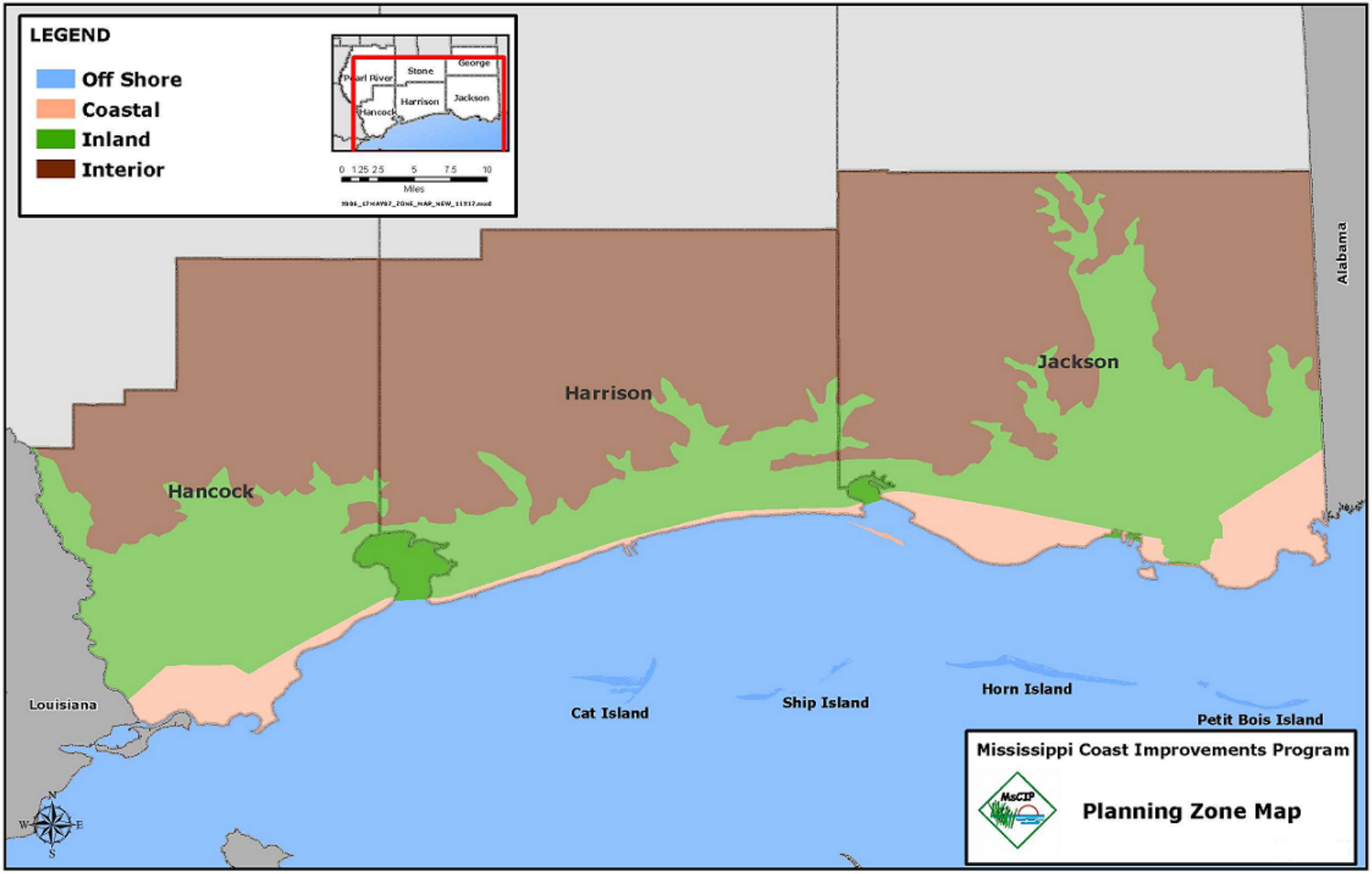


Figure 6.4-1. Planning Zones – Impacted area is the coastal zone

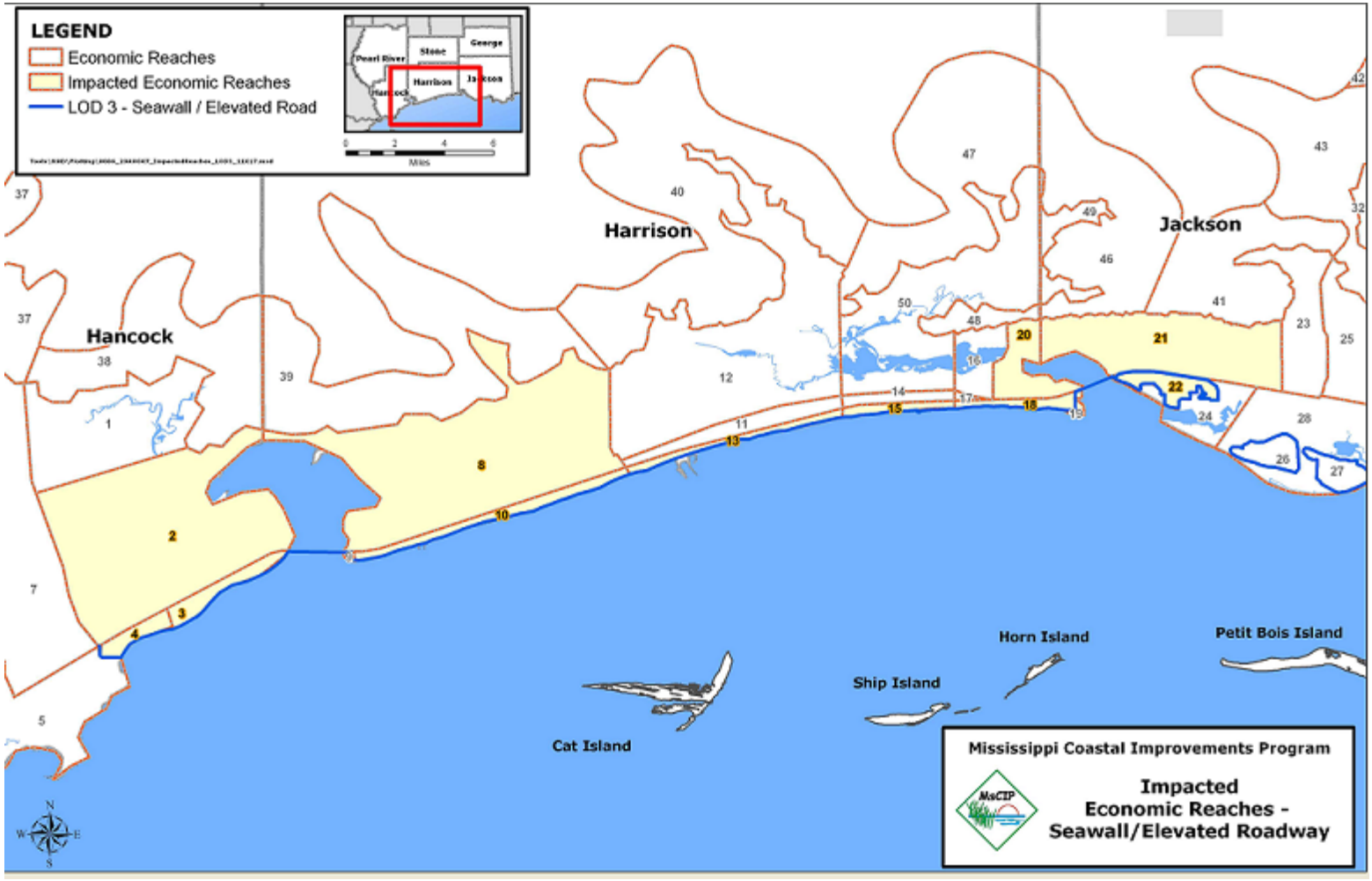


Figure 6.4-2. Planning sub-units in Coastal Area for Planning Unit One, Two, and Three

Table 6.4-2.
Destroyed Structures by Category and Planning Unit

	Planning Unit One	Planning Unit Two	Planning Unit Three	
Asset Categories	**Assets by Category**	**Assets by Category**	**Assets by Category**	**Total**
Residential	6,741	11,106	474	18,321
Mobile Homes	27	111	10	148
Commercial	1,054	1,492	44	2,590
Municipal	81	80	8	169
Total	**7,903**	**12,789**	**536**	**21,228**

6.4.3 Opportunities

The following opportunities were identified for this area:

- Hurricane storm damage reduction or remediation.

6.4.4 Assumptions

The following assumptions were used in this analysis.

- The FY 2008 discount rate of 4-7/8-percent was used in estimating average annual benefits and costs.
- Price levels are October, 2007 unless otherwise stated.
- A 100-year period of analysis (2012 to 2111) was used to calculate average annual benefits and costs.
- Full redevelopment of the area will take place by the base year 2012.

6.4.5 Measures

Initially, a comprehensive list of measures was identified for flood damage reduction purposes for planning unit one. This list was screened and vetted for engineering and environmental feasibility and for policy compliance. The MsCIP Comprehensive Main Report and the Engineering and Environmental Appendices contain a detailed description of the measures that were initially screened.

Several potential measures were carried forward for this area for the purpose of flood damage reduction. These measures include both structural features and nonstructural actions. The measures evaluated for economic benefits include:

- Measure A - LOD-3, Seawall and Elevated Roadway

This measure will elevate an existing 2-lane roadway up to an elevation of 11.0-feet NAVD88 in planning unit one, to an elevation of 16.0-feet NAVD88 in planning unit two, and up to an elevation of 11.0-feet NAVD88 in planning unit three. This will include raising an associated seawall, landward slope protection, interior drainage, and pumping stations as required. This measure also requires the installation of surge barriers across St. Louis Bay and Biloxi Bay to elevation 20.0-feet NAVD88. See the Engineering Appendix for more detail on this measure.

- Measure B – Nonstructural One

This measure includes the acquisition and flood proofing (elevate in place) of structures to an ABFE level of protection. See the Nonstructural Appendix for more detail on this measure.

- Measure C – Nonstructural Two

This measure includes the acquisition and flood proofing (elevate in place) of structures to approximately elevation 20.0-feet NAVD88. See the Nonstructural Appendix for more detail on this measure.

- Measure D – Nonstructural Three

This measure includes the acquisition and flood proofing (elevate in place) of structures to approximately elevation 30.0-feet NAVD88. See the Nonstructural Appendix for more detail on this measure. See the Nonstructural Appendix for more detail on this measure.

6.4.6 National Economic Development (NED)

The purpose of this section is to document investigations conducted to identify the National Economic Development (NED) benefits of each of the potential measures previously listed. For this analysis, NED benefits are the reduced inundation damages of assets and their contents when one of the potential measures is in place. Typically, NED benefits are annualized over the period of the analysis (average annual benefits) and then compared to annualized costs over the period of analysis (average annual costs). This comparison is commonly known as the benefit-to-cost ratio (BCR). For purposes of this analysis, no benefit-to-cost ratios will be calculated as per the legislative Congressional language authorizing this study. The Coastal Mississippi Comprehensive Plan Report was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states: "…***that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project plan features based upon maximizing net national economic development benefits…"*** More detail on the authorizing language can be found in the MsCIP Comprehensive Plan Main Report.

6.4.6.1 Future Without-Project Conditions

Equivalent annual flood damages for several future without-project scenarios were evaluated using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. Each of the alternatives were evaluated and compared to the without project conditions for three of the six future without project scenarios. Future without-project scenarios one, two, three, four, five and six were used to evaluate the flood damage reduction benefits for this area. These future scenarios were chosen because the redevelopment projected for this area could take the form it was before Hurricane Katrina or it could be redeveloped back as condominiums and condos.

Future scenario one is the full redevelopment of structures within the study area by the year 2012 with no relative sea level rise over the 100-year period of analysis. Structures will be rebuilt to what they were pre-Hurricane Katrina; residential back to residential, commercial back to commercial, etc. This future scenario, as previously noted in section 5.3, is for sensitivity purposes only and will not be evaluated against all of the potential measures for the Inland Barrier area.

Future scenario two is the full redevelopment of structures within the study area by the year 2012 with no relative sea level rise over the 100-year period of analysis. Structures will be rebuilt to what they were pre-Hurricane Katrina; residential back to residential, commercial back to commercial, etc, with the exception of the water front areas for planning units one and two. In these planning units,

the scenario will address what if commercial and casino redevelopment would occur along the water front and Back Bay areas. This future scenario, as previously noted in section 5.3, is for sensitivity purposes only and will not be evaluated against all of the potential measures for the Inland Barrier area.

Future scenario three has the same redevelopment as future scenario one with a maximum relative sea level rise of 2.0-feet depending on location. Equivalent annual damages that could occur under this scenario are $426,040,000 (rounded to the nearest thousand).

Future scenario four has the same redevelopment as future scenario two with a maximum relative sea level rise of 2.0-feet depending on location. Equivalent annual damages that could occur under this scenario are $434,040,000 (rounded to the nearest thousand).

Future scenario five has the same redevelopment as future scenario one with a maximum relative sea level rise of 3.4-feet depending on location. Equivalent annual damages that could occur under this scenario are $475,200,000 (rounded to the nearest thousand). These damages are an 11.54-percent increase over the 2.0-feet relative sea level rise accounted for in future scenario two.

Future scenario six has the same redevelopment as future scenario two with a maximum relative sea level rise of 3.4-feet depending on location. Equivalent annual damages that could occur under this scenario are $483,700,000 (rounded to the nearest thousand). These damages are an 11.44-percent increase over future scenario four with a maximum of 2.0-feet relative sea level rise.

6.4.6.2 Equivalent annual damages Reduced and Residual Damages

Equivalent annual damages reduced are calculated as the difference between the damages under the future without-project scenarios and the damages incurred with the measure in place. The HECFDA model was run for each measure to determine the damages reduced as compared to the without-project scenario.

In order to provide the HEC-FDA model with accurate information about the economic characteristics of each measure, separate inventories were created for each measure. The inventories are the same as the without-project inventory except that footprints of seawall and elevated roadway and the acquisitions were deleted from the inventory and flood proofed (structure to be raised in place) structures were given a specific first floor elevation. The structure inventories for each of the HEC-FDA with-measure runs are as follows:

- Measure A – Seawall and Elevated Roadway

This measure includes the without-project inventory less 1,543 parcels that were deleted out of the inventory. Of those, 411 parcels were estimated to be impacted in planning unit one, 1,004 in planning unit two, and 128 in planning unit three. These parcels represent the footprint of the seawall and elevated roadway across the three planning units and some portion of the total would have to be purchase for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure B – ABFE Nonstructural

This measure includes the acquisition of 24,411 parcels some with structures and some vacant land, and the flood proofing (elevate structure in place) of 8,053 structures to an elevation ranging from 14.9-feet NAVD88 to 22.4-feet NAVD88 depending on the planning sub-unit the structures is assigned. This plan was formulated by the nonstructural flood proofing committee and details can be found in the Nonstructural Appendix. This elevation was determined to be approximately the ABFE

level of protection is defined as still water elevation, plus wave run-up plus and estimate for waves (depth divided by two), and is the minimum implementation elevation that a nonstructural measure do to the requirements of the National Flood Insurance Program (NFIP).

The equivalent annual damage reduction by measure for the Seawall and Elevated Roadway is shown in table 6.4-3.

Table 6.4-3.
Equivalent Annual Damage Reduction by Future Scenario

Measures	Equivalent Annual Damage Reduction Future 3 ($)	Equivalent Annual Damage Reduction Future 4 ($)	Equivalent Annual Damage Reduction Future 5 ($)	Equivalent Annual Damage Reduction Future 6 ($)
(No Action)	$0	$0	$0	$0
Measure A Seawall/Elevated Roadway	$52,030,000	$54,260,000	$58,090,000	$59,920,000
Measure B ABFE Nonstructural	$200,860,000	$206,490,000	$220,160,000	$226,120,000

Equivalent annual damages reduced are rounded to the nearest thousand dollars.

6.4.6.3 Residual Damages

Residual damages are the equivalent annual damages that still remain even when a project is in place. Residual damages are calculated as the future without-project equivalent annual damages minus the damages reduced of the various measures. The purpose of residual damages is to calculate and communicate the portions of damages that will not be reduced by the implementation of a plan or "what damages are left on the table". Residual damage by measure is shown in table 6.4-4.

Table 6.4-4.
Residual Damages by Measure and by Future Scenario

Measures	Residual Damages Future 3 ($)	Residual Damages Future 4 ($)	Residual Damages Future 5 ($)	Residual Damages Future 6 ($)
(No Action)	$0	$0	$0	$0
Measure A Seawall/Elevated Roadway	$374,010,000	$379,780,000	$417,110,000	$423,780,000
Measure B ABFE Nonstructural	$225,180,000	$227,550,000	$255,040,000	$257,580,000

Equivalent annual damages reduced are rounded to the nearest thousand dollars.

6.4.7 Environmental Quality (EQ)

6.4.7.1 Impacts of Seawall Elevated Roadway Measure

The Engineering Research and Development Center Wetlands and Coastal Ecology Branch were asked to conduct an assessment of potential impacts to wetlands as a result of constructing various levees and seawalls along the Mississippi Gulf Coastal Plain. This report summarizes the results of the assessment. The analysis of impacts included two components:

1) A calculation of total acreage of all wetlands (by type and planning reach) that is directly under the levee footprints.

2) A modified Hydrogeomorphic (HGM) wetland rapid assessment of impacted Estuarine/Tidal Fringe wetlands, based on the Mississippi and Alabama Gulf Coast HGM guidebook (Shafer et al., 2007), with impacts reported as loss of functional units. Tables 6.4-5 and 6.4-6 show the impacts of the Jackson, Hancock, and Harrison Counties Seawall footprints respectively.

Table 6.4-5.
Wetland Acres Impacted by Jackson County Seawall

Reach ID	Estuarine and Marine Deepwater	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Total
22	0.0	0.7	0.2	0.5	1.4
24	0.6	0.6	0.0	0.0	1.3
Total	**0.6**	**1.4**	**0.2**	**0.5**	**2.7**

Table 6.4-6.
Wetland Acres Impacted by Hancock and Harrison Seawall

Reach ID	Estuarine and Marine Deepwater	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Total
2	0.0	0.0	0.6	3.8	4.4
3	0.0	0.1	0.0	0.0	0.1
4	0.6	0.7	0.8	0.0	2.1
5	0.0	0.4	0.0	5.3	5.6
7	0.0	0.0	0.0	1.9	1.9
10	0.0	4.7	0.0	0.0	4.7
13	0.0	6.4	0.0	0.0	6.4
18	0.0	0.1	0.1	0.0	0.3
Total	**0.6**	**12.4**	**1.5**	**10.9**	**25.4**

Nonstructural measures would have no construction activities other than demolition and disposal of building materials in an approved land fill occurs as a result of this measure. More detail on the impacts of the structural and nonstructural measures for the coast wide area can be found in the Environmental Appendix.

6.4.8 Summary of Costs

Table 6.4-7 summarizes the ROM costs at an FY-08 price level by measure for the seawall and elevated roadway impact area.

Table 6.4-7.
Summary of Costs by Measure for Seawall and Elevated Roadway Area

Measures	Implement Cost (FY-08) ($)	Average Annual Implementation Cost ($)	Average Annual O&M ($)	IDC ($)	Total Average Annual Costs ($)
(No Action)	$0	$0	$0	$0	$0
Measure A Seawall and Elevated Roadway	$5,002,500,000	$245,979,051	$60,148,000	N/A	$306,127,051
Measure C ABFE Nonstructural	$8,580,261,000	$421,902,000	$110,000	N/A	$422,012,000

6.4.9 Regional Economic Development (RED)

The purpose of this section is to describe the economic impact of the proposed measure on business (sale volumes), income, employment, and population of the local area. Each of the measures would affect the local area of Hancock, Jackson, and Harrison Counties, Mississippi. The expenditures for the measures are estimated to be $5,002,500,000 for the seawall and elevated roadway measure, $8,580,261,333 for the ABFE nonstructural measure. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $1,223,235,756 for the seawall and elevated roadway measure, $2,237,081 for the ABFE nonstructural measure based on a 100-year period of analysis and an FY 08 discount rate of 4.875-percent. The EIFS model inputs and outputs for the seawall and elevated roadway area are summarized in tables 6.4-8 through 6.4-11.

Table 6.4-8.
EIFS Model Implementation Costs Inputs for the Seawall and Elevated Area

	Seawall & Elevated Roadway	ABFE Nonstructural
Region of Influence (ROI)	Hancock, Harrison & Jackson Counties	Hancock, Harrison & Jackson Counties
Change in Local Expenditures	$5,002,500,000	$8,580,261,333

Based of the given implementation cost inputs the outputs are as follows:

Table 6.4-9.
EIFS Model Implementation Costs Outputs for the Seawall and Elevated Area

	Seawall & Elevated Roadway	ABFE Nonstructural
Direct Sales Volume	$5,002,500,000	$8,580,261,333
Induced Sales Volume	$5,755,350,000	$9,336,803,805
Total Sales Volume	$10,757,850,000	$17,917,065,137
Direct Income	$1,115,405,211	$1,965,390,069
Induced Income	$1,274,630,230	$2,124,627,724
Total Income	$2,390,035,440	$4,090,017,793
Direct Employment	31,133	52,577
Induced Employment	35,915	57,351
Total Employment	67,048	109,928
Local Population	0	0

Table 6.4-10.
EIFS Model O&M Costs Inputs for the Seawall and Elevated Area

	Seawall & Elevated Roadway	ABFE Nonstructural
Region of Influence (ROI)	Hancock, Harrison & Jackson Counties	Hancock, Harrison & Jackson Counties
Change in Local Expenditures	$1,223,235,756	$2,237,081

Based of the given O&M cost inputs the outputs are as follows:

Table 6.4-11.
EIFS Model O&M Costs Outputs for the Seawall and Elevated Area

	Seawall & Elevated Roadway	ABFE Nonstructural
Direct Sales Volume	$1,223,235,756	$2,237,081
Induced Sales Volume	$1,393,527,224	$2,590,946
Total Sales Volume	$2,616,762,980	$4,828,027
Direct Income	$274,711,471	$484,736
Induced Income	$310,746,337	$558,828
Total Income	$585,457,808	$1,043,565
Direct Employment	7,602	14
Induced Employment	8,684	16
Total Employment	16,286	30
Local Population	0	0

6.5 Evaluation of Pearlington Area Measures

6.5.1 General

The Pearlington area, shown in figure 6.5-1, is located in the western area of planning unit one along the Pearl River. The area is denoted as planning sub-unit six and is depicted in the figure below. The pre-Hurricane Katrina conditions for this area represented a mostly residential community. As shown in Table 6.5-1, it was estimated from the field inventorying process that planning sub-unit six included 1,155 tax parcels, of which 1,152 contained a structure with some economic value and 3 ere vacant land. Of those 1,152 parcels that contain structures, 1,043 were residential one-story, 5 ere residential two-story, 17 were mobile homes, 64 were commercial, and 23 were municipal.

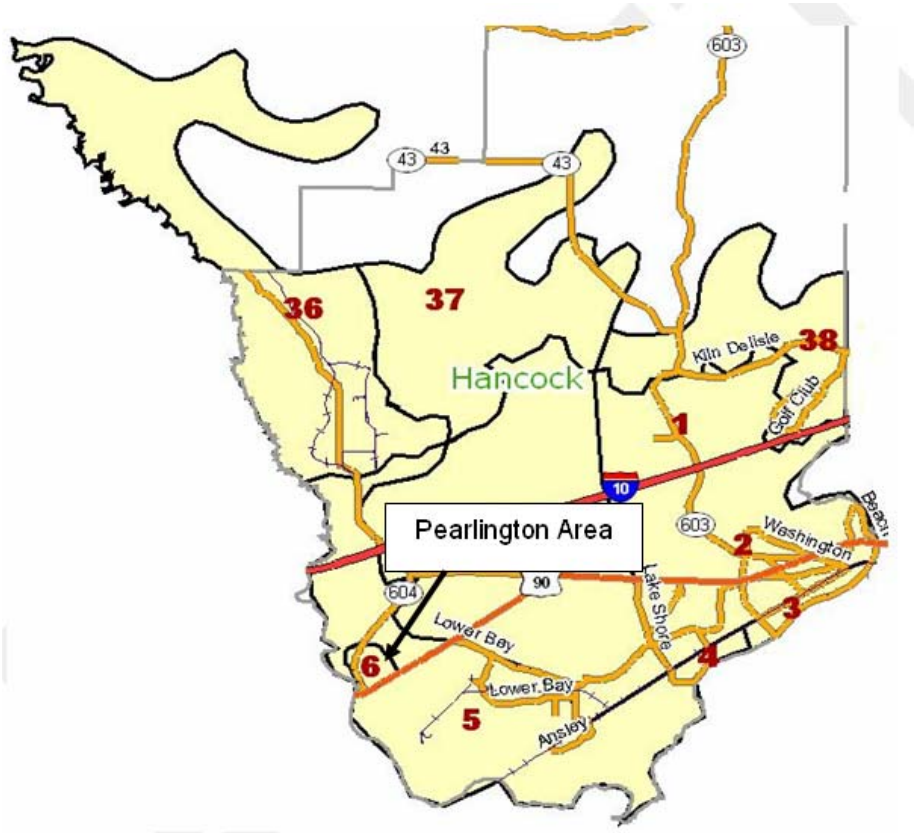


Figure 6.5-1. Pearlington Area – Planning Sub-unit Six

Table 6.5-1.
Pre-Hurricane Katrina Estimate of Structures
for the Pearlington Area Planning Sub-unit Six

Asset Categories	Assets by Category
Residential	1,048
Mobile Homes	17
Commercial	64
Municipal	23
Vacant Land	3
Total Tax Parcels	**1,155**

6.5.2 Opportunities

The following opportunities were identified for this area:

- Hurricane storm damage reduction or remediation.

6.5.3 Assumptions

The following assumptions were used in this analysis:

- The FY 2008 discount rate of 4-7/8 percent was used in estimating average annual benefits and costs.
- Price levels are October, 2007 unless otherwise stated.
- A 100-year period of analysis (2012 to 2111) was used to calculate average annual benefits and costs.

6.5.4 Measures

Initially, a comprehensive list of measures was identified for flood damage reduction purposes for planning unit one. This list was screened and vetted for engineering and environmental feasibility and for policy compliance. The MsCIP Comprehensive Main Report and the Engineering and Environmental Appendices contain a detailed description of the measures that were initially screened.

Several potential measures were carried forward for this area for the purpose of flood damage reduction. These measures include both structural features and nonstructural actions. The measures evaluated for economic benefits include:

Measure A - Pearlington Ring Levee
This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 20.0-feet NAVD88.

Measure B - Pearlington Ring Levee
This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 30.0-feet NAVD88.

Measure C – Pearlington Nonstructural One
This measure includes the acquisition and flood proofing (elevate-in-place) of structures to the FEMA advisory base flood elevation (ABFE).

Measure D – Pearlington Nonstructural Two
This measure includes the acquisition and flood proofing of structures to approximately elevation 20.0-feet NAVD88.

Measure E – Pearlington Nonstructural Three
This measure includes the acquisition and flood proofing of structures to approximately elevation 30.0-feet NAVD88.

Figure 6.5-2 shows the measures for the Pearlington Area (planning sub-unit six); the red line represents the approximate footprint of the ring levees, the dark green within the ring levee footprint represents potential ABFE buyout areas and the light green area within the ring levee footprint represents potential flood proof (elevate-in-place) areas.

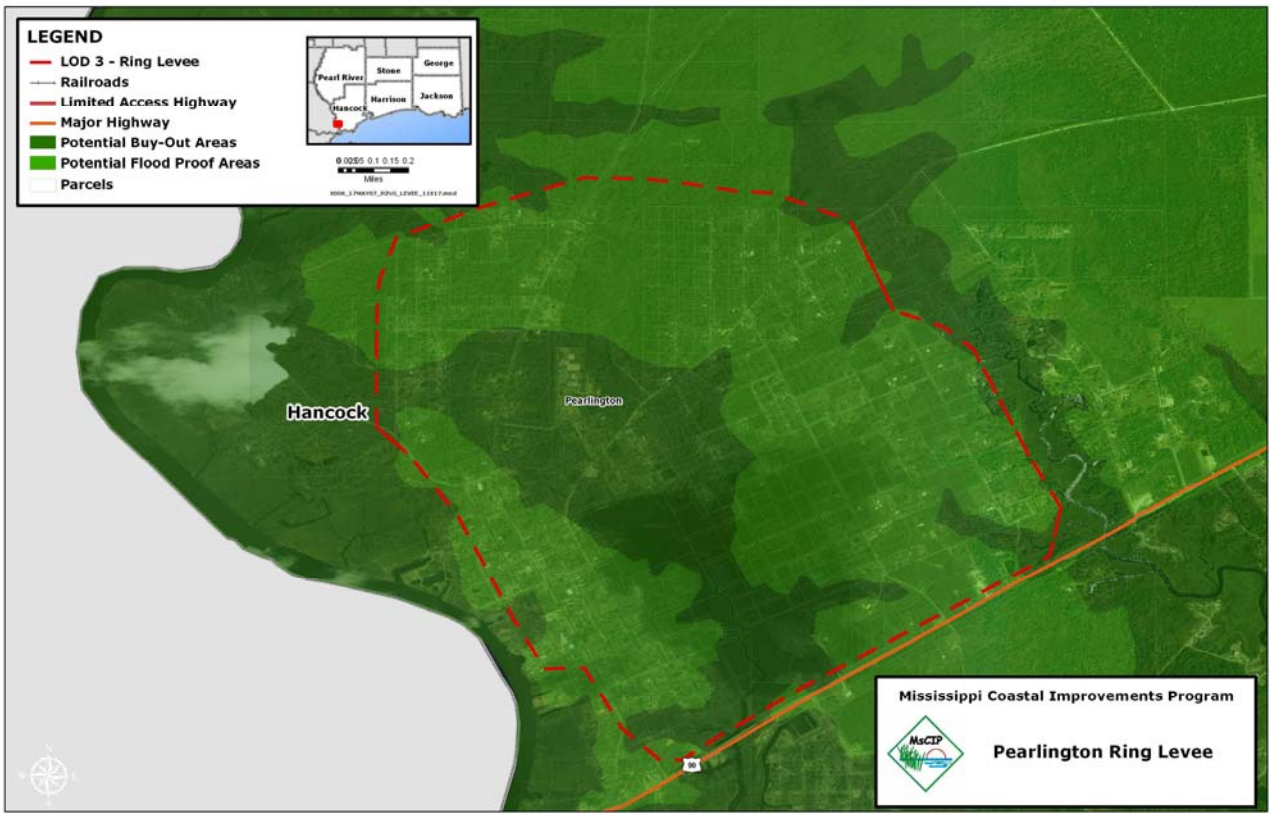


Figure 6.5-2. Display of Potential Measures for the Pearlington Area (Planning Sub-Unit Six)

6.5.5 National Economic Development (NED)

The purpose of this section is to document investigations conducted to identify the National Economic Development (NED) benefits of each of the potential measures previously listed. For this analysis, NED benefits are the reduced inundation damages of assets and their contents when one of the potential measures is in place. Typically, NED benefits are annualized over the period of the analysis (average annual benefits) and then compared to annualized costs over the period of analysis (average annual costs). This comparison is commonly known as the benefit-to-cost ratio (BCR). For purposes of this analysis, no benefit-to-cost ratios will be calculated as per the legislative Congressional language authorizing this study. The Coastal Mississippi Comprehensive Plan Report was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states: "…***that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project plan features based upon maximizing net national economic development benefits…"*** More detail on the authorizing language can be found in the MsCIP Comprehensive Plan Main Report.

6.5.5.1 Existing Conditions Post-Hurricane Katrina)

The effects of Hurricane Katrina storm surge were devastating to the Pearlington Area. Peak water elevation in the area ranged from 16-to-19-feet NAVD88. It is estimated that between 95 and 99-percent of the structures in the area sustained significant inundation damage (fifty-percent or more). Destroyed residences and commercial structures have displaced the majority of the residences within the area. Expected redevelopment of the area is described in the following section.

6.5.5.2 Future Without-Project Conditions

Equivalent annual flood damages for several future without-project scenarios were evaluated using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. Each of the measures were evaluated and compared to future without-project scenarios three, and five, as previously discussed in section 5.3. These future scenarios were chosen because the redevelopment projected for this area is anticipated to return to the pre-Katrina development. Futures scenarios two, four, and six were not used for evaluation purposes since this area is not accommodative for commercial and condominium redevelopment under those mixed redevelopment scenarios (see section 5.3 for more detail).

Future scenario one is the full redevelopment of structures within the study area by the year 2012 with no relative sea level rise over the 100-year period of analysis. Table 6.5-2 shows structures by category and by elevation. The number of structures per elevation is added to the previous number of structures per elevation in each category. For example, in the residential category there is one structure with an elevation of 1-foot or lower, there are ten structures with an elevation of 2-feet or less, etc. This future scenario, as previously noted in section 5.3, is for sensitivity purposes only and will not be evaluated against all of the potential measures for the Pearlington area.

Table 6.5-2.
Cumulative Structures by Category and by Estimated First Floor Elevation Future Scenarios One, Three, and Five Applicable for Base Year and Most Likely Future Years

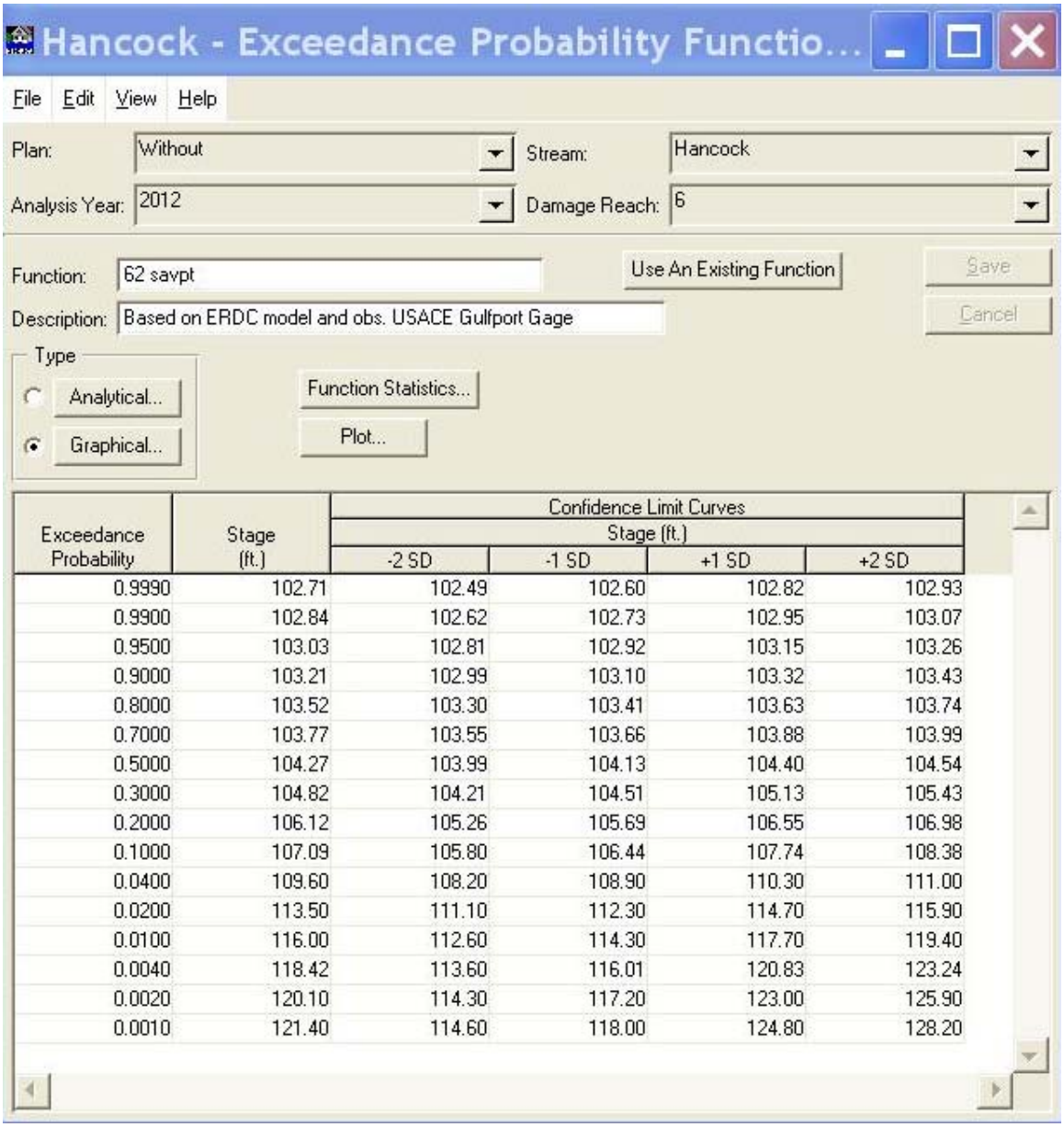
Estimated First Floor Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
1-foot	1	0	0	0	1
2-foot	10	0	0	0	10
3-foot	22	0	0	0	22
4-foot	35	0	0	0	35
5-foot	51	0	0	0	51
6-foot	75	0	0	0	75
7-foot	125	0	0	0	125
8-foot	214	0	0	0	214
9-foot	351	0	0	0	351
10-foot	425	0	0	0	425
11-foot	452	0	0	0	452
12-foot	459	0	0	0	459
13-foot	460	0	0	0	460
14-foot	460	0	0	0	460
15-foot	460	0	0	0	460
16-foot	460	0	0	0	460
17-foot	460	0	0	0	460
18-foot	460	0	0	0	460
19-foot	460	0	0	0	460
20-foot	1,048	17	64	23	1,152
Total	**1,048**	**17**	**64**	**23**	**1,152**

Estimated first floor elevations can be compared to the exceedance probability functions or both future scenarios three and five.

Future scenario three is the full redevelopment of assets within the study area by the year 2012. Under this scenario, assets will be rebuilt as they were pre-Hurricane Katrina. For example, if the asset was a residential structure pre-Hurricane Katrina it will be rebuilt as a residential structure;

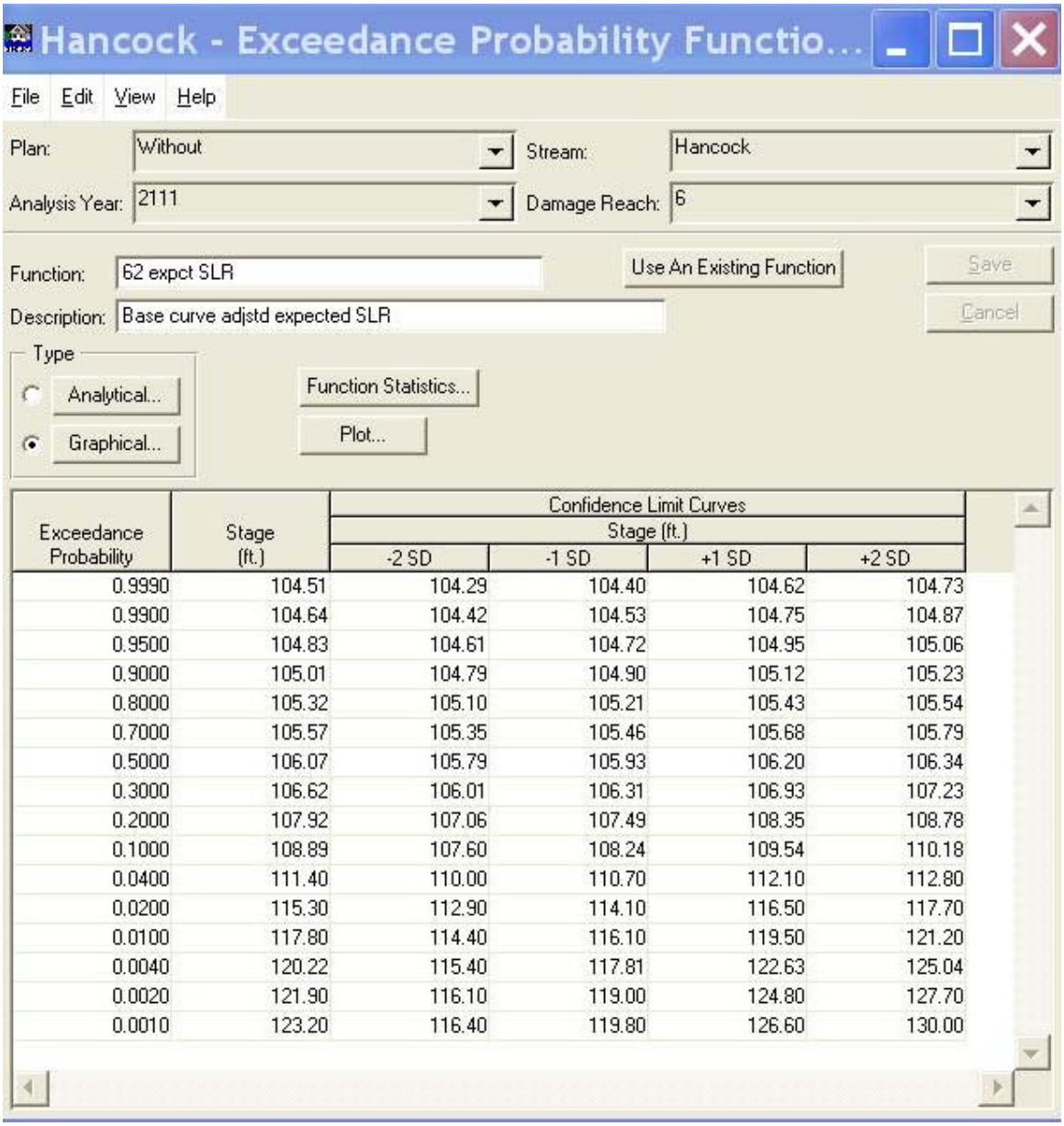
commercial structures will be built back to commercial structures; etc. Basically, future scenario three is the same structure inventory as future scenario one with the addition of an expected relative sea level rise over the 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $12,885,000 (rounded to the nearest thousand). The total number of structures in this scenario are the same as in scenario one and can be seen above in table 6.5-2. Figures 6.5-3 and 6.5-4 depict the base year and most likely future year exceedance probability functions for the Pearlington area (planning sub-unit six). The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most likely future year exceedance probability function depicted in figure 6.5-4 includes an adjustment for expected relative sea level rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet. For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.

Future scenario five is the same as future scenario one with the addition of a high relative sea level rise 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $14,205,000 (rounded to the nearest thousand). These damages represent approximately a ten-percent (10.24%) increase over the expected relative sea level rise accounted for in future scenario three. The total number of structures in this scenario is the same as in scenarios one and three and can be seen above in table 6.5.2. Figures 6.5-5 and 6.5-6 depict the base year and most likely future year exceedance probability functions for the Pearlington area (planning sub-unit six). The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most likely future year exceedance probability function depicted in figure 6.5-5 includes an adjustment for expected relative sea level rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet. For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.



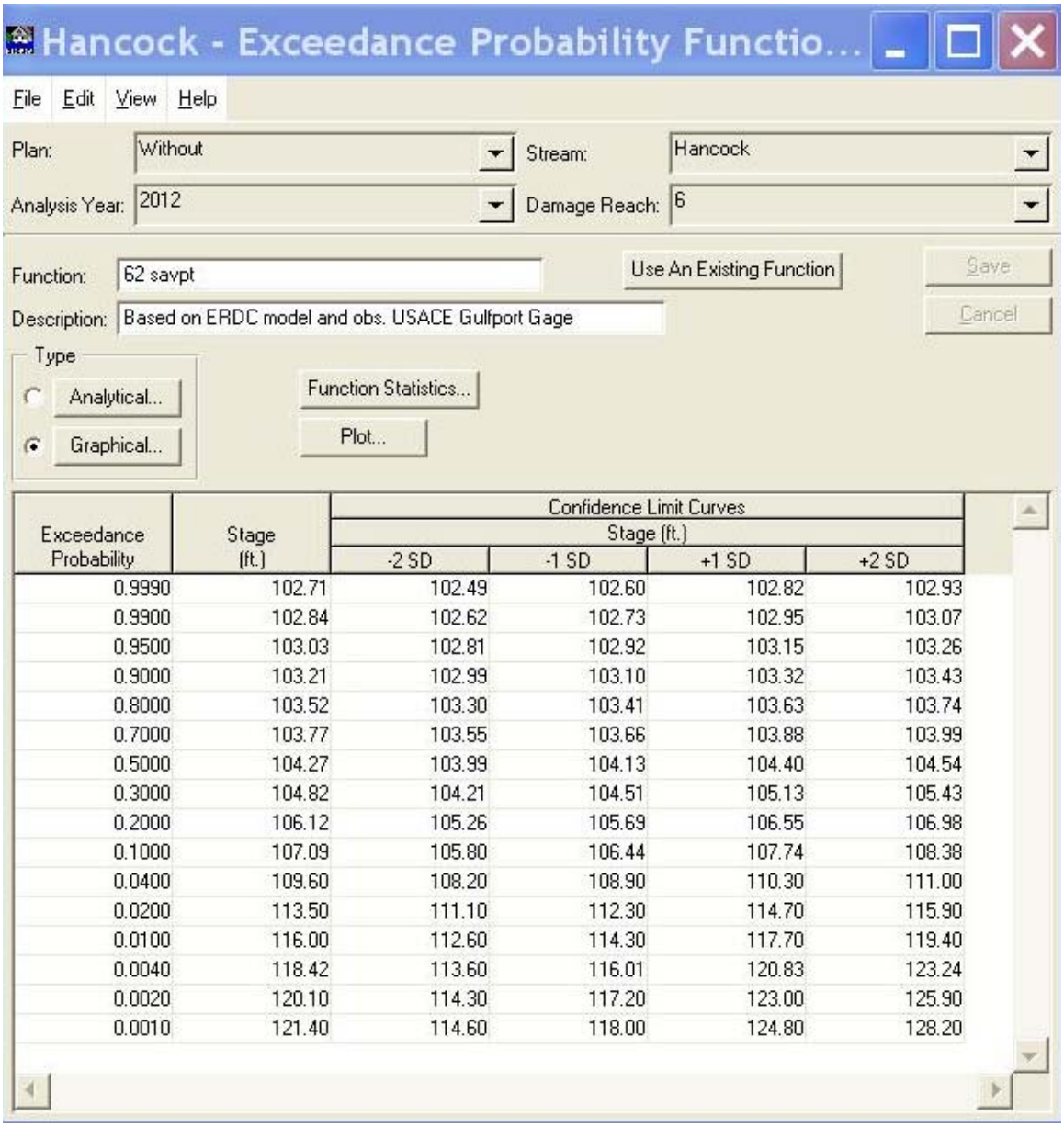
Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	102.71	102.49	102.60	102.82	102.93
0.9900	102.84	102.62	102.73	102.95	103.07
0.9500	103.03	102.81	102.92	103.15	103.26
0.9000	103.21	102.99	103.10	103.32	103.43
0.8000	103.52	103.30	103.41	103.63	103.74
0.7000	103.77	103.55	103.66	103.88	103.99
0.5000	104.27	103.99	104.13	104.40	104.54
0.3000	104.82	104.21	104.51	105.13	105.43
0.2000	106.12	105.26	105.69	106.55	106.98
0.1000	107.09	105.80	106.44	107.74	108.38
0.0400	109.60	108.20	108.90	110.30	111.00
0.0200	113.50	111.10	112.30	114.70	115.90
0.0100	116.00	112.60	114.30	117.70	119.40
0.0040	118.42	113.60	116.01	120.83	123.24
0.0020	120.10	114.30	117.20	123.00	125.90
0.0010	121.40	114.60	118.00	124.80	128.20

Figure 6.5-3 Future Scenario 3 Base Year (2012) Exceedance Probability Function for the Pearlington Area



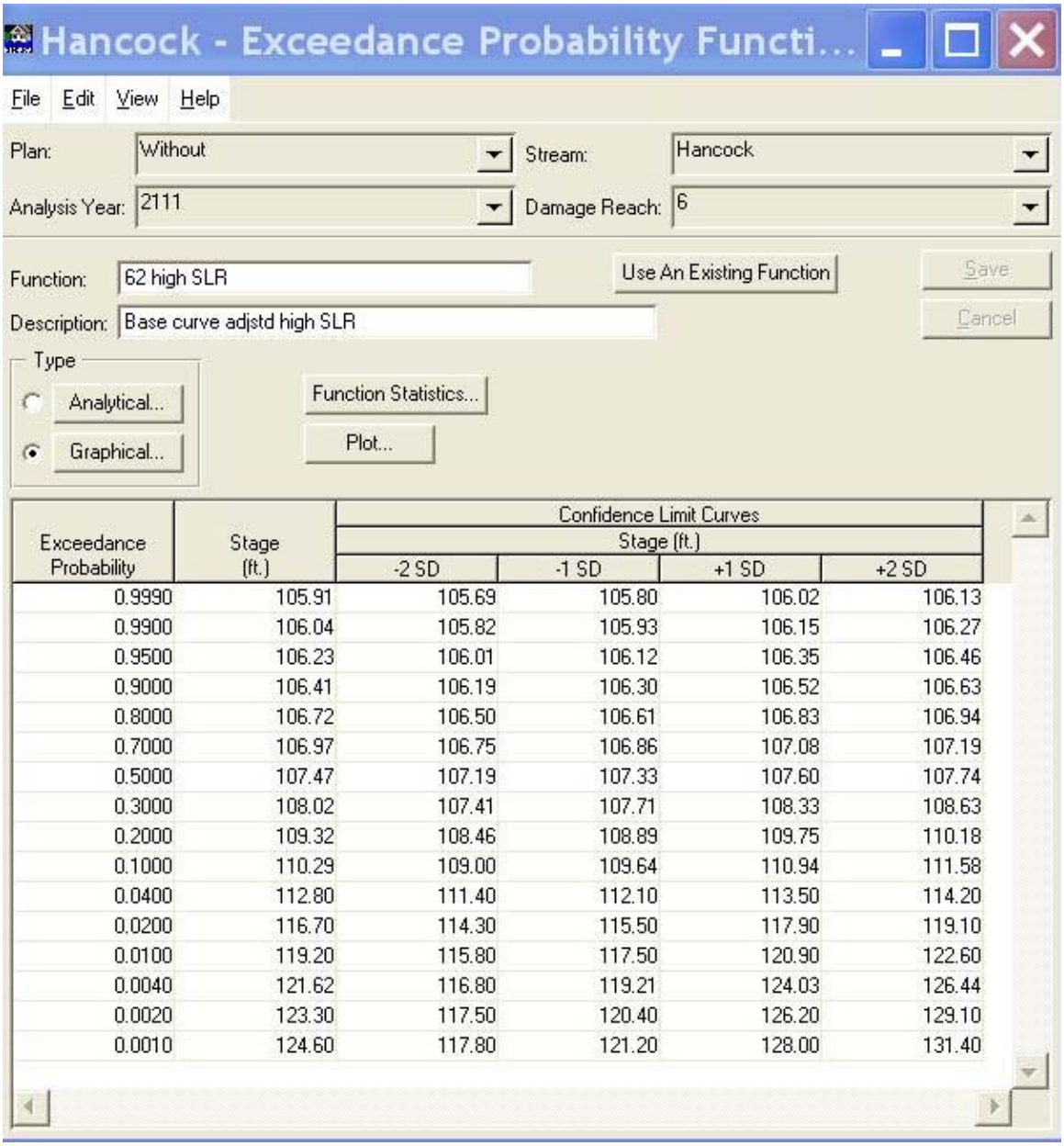
Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	104.51	104.29	104.40	104.62	104.73
0.9900	104.64	104.42	104.53	104.75	104.87
0.9500	104.83	104.61	104.72	104.95	105.06
0.9000	105.01	104.79	104.90	105.12	105.23
0.8000	105.32	105.10	105.21	105.43	105.54
0.7000	105.57	105.35	105.46	105.68	105.79
0.5000	106.07	105.79	105.93	106.20	106.34
0.3000	106.62	106.01	106.31	106.93	107.23
0.2000	107.92	107.06	107.49	108.35	108.78
0.1000	108.89	107.60	108.24	109.54	110.18
0.0400	111.40	110.00	110.70	112.10	112.80
0.0200	115.30	112.90	114.10	116.50	117.70
0.0100	117.80	114.40	116.10	119.50	121.20
0.0040	120.22	115.40	117.81	122.63	125.04
0.0020	121.90	116.10	119.00	124.80	127.70
0.0010	123.20	116.40	119.80	126.60	130.00

Figure 6.5-4 Future Scenario 3 Most Likely Future Year (2012) Exceedance Probability Function for the Pearlington Area – Includes an adjustment for relative sea level rise



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	102.71	102.49	102.60	102.82	102.93
0.9900	102.84	102.62	102.73	102.95	103.07
0.9500	103.03	102.81	102.92	103.15	103.26
0.9000	103.21	102.99	103.10	103.32	103.43
0.8000	103.52	103.30	103.41	103.63	103.74
0.7000	103.77	103.55	103.66	103.88	103.99
0.5000	104.27	103.99	104.13	104.40	104.54
0.3000	104.82	104.21	104.51	105.13	105.43
0.2000	106.12	105.26	105.69	106.55	106.98
0.1000	107.09	105.80	106.44	107.74	108.38
0.0400	109.60	108.20	108.90	110.30	111.00
0.0200	113.50	111.10	112.30	114.70	115.90
0.0100	116.00	112.60	114.30	117.70	119.40
0.0040	118.42	113.60	116.01	120.83	123.24
0.0020	120.10	114.30	117.20	123.00	125.90
0.0010	121.40	114.60	118.00	124.80	128.20

Figure 6.5-5 Future Scenario 5 Base Year (2012) Exceedance Probability Function for the Pearlington Area



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	105.91	105.69	105.80	106.02	106.13
0.9900	106.04	105.82	105.93	106.15	106.27
0.9500	106.23	106.01	106.12	106.35	106.46
0.9000	106.41	106.19	106.30	106.52	106.63
0.8000	106.72	106.50	106.61	106.83	106.94
0.7000	106.97	106.75	106.86	107.08	107.19
0.5000	107.47	107.19	107.33	107.60	107.74
0.3000	108.02	107.41	107.71	108.33	108.63
0.2000	109.32	108.46	108.89	109.75	110.18
0.1000	110.29	109.00	109.64	110.94	111.58
0.0400	112.80	111.40	112.10	113.50	114.20
0.0200	116.70	114.30	115.50	117.90	119.10
0.0100	119.20	115.80	117.50	120.90	122.60
0.0040	121.62	116.80	119.21	124.03	126.44
0.0020	123.30	117.50	120.40	126.20	129.10
0.0010	124.60	117.80	121.20	128.00	131.40

Figure 6.5-6 Future Scenario 5 Most Likely Future Year (2012) Exceedance Probability Function for the Pearlington Area – Includes an adjustment for relative sea level rise

6.5.5.3 Equivalent annual damages Reduced and Equivalent Annual Residual Damages

Equivalent annual damages reduced are calculated as the difference between the damages under the future without-project scenarios three and five and the damages incurred with the measure in place. The HEC-FDA model was run for each measure to determine the damages reduced as compared to the without-project scenario. In order to provide the HEC-FDA model with accurate information about the economic characteristics of each measure, separate inventories were created for each measure. The inventories are the same as the without project inventory except that footprints of levees and acquisitions were deleted from the inventory and flood proofed structures

(structures to be raised in place) were given a higher elevation. The structure inventories for each of the HEC-FDA measure runs are as follows:

- Measure A – Pearlington Ring Levee at elevation 20.0-feet NAVD88

This measure includes the without-project inventory less 138 parcels that were deleted out of the inventory. These parcels represent the footprint of the 20.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure B – Pearlington Ring Levee at elevation 30.0-feet NAVD88

This measure includes the without-project inventory less 138 parcels that were deleted out of the inventory. These parcels represent the footprint of the 30.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its construction. At this level of analysis, it is assumed that all of the parcels identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure C – Pearlington ABFE Nonstructural One

This measure includes the acquisition of 539 parcels that include a structure and the flood proofing (raise structure in place) of 588 structures to elevation of 19.35-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was determined to be approximately the ABFE level of protection and is defined as still water elevation, plus wave run-up, plus an estimate for waves (depth divided by two), and is the minimum implementation elevation that a nonstructural measure do to the requirements of the National Flood Insurance Program (NFIP).

- Measure D – Pearlington Nonstructural Two to elevation 20.0-feet NAVD88

This measure includes the acquisition of 950 parcels that include a structure and the flood proofing (raise structure in place) of 177 structures to an elevation of 20.0-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levee at elevation 20.0-feet NAVD88.

- Measure E – Pearlington Nonstructural Three to elevation 30.0-feet NAVD88

This measure includes the acquisition of 1,127 parcels that include a structure. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levee at elevation 30.0-feet NAVD88.

Residual damage is the equivalent annual damages that still remain even when a project is in place. Residual damage is calculated as the future without-project equivalent annual damages minus the damages reduced of the various measures. The purpose of residual damage is to calculate and communicate the portions of damages that will not be reduced by the implementation of a plan or "what damages are left on the table." Table 6.5-3 summarizes the without project damages, damages reduced, and the residual damage by measure and by future scenario.

Table 6.5-3.
Summary of Damages by Potential Measure and Applicable Future Scenario

Measures	Equivalent Annual Damages Future 3 ($)	Equivalent Annual Damage Reduction Future 3 ($)	Residual Damage Future 3 ($)	Equivalent annual damages Future 5 ($)	Equivalent Annual Damage Reduction Future 5 ($)	Residual Damage Future 5 ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A 20Ft Ring Levee	$12,885,000	$11,894,000	$991,000	$14,205,000	$13,088,000	$1,117,000
Measure B 30FT Ring Levee	$12,885,000	$12,267,000	$618,000	$14,205,000	$13,228,000	$977,000
Measure C ABFE Nonstructural	$12,885,000	$12,260,000	$625,000	$14,205,000	$13,520,000	$685,000
Measure D 20FT Nonstructural	$12,885,000	$ 12,813,000	$ 72,000	$14,205,000	$ 14,123,000	$ 82,000
Measure E 30FT Nonstructural	$12,885,000	$12,885,000	$0	$14,205,000	$14,205,000	$0

Damages are rounded to the nearest thousand dollars.

6.5.6 Environmental Quality (EQ)

6.5.6.1 Impacts of Ring Levee Measures

The Engineering Research and Development Center Wetlands and Coastal Ecology Branch were asked to conduct an assessment of potential impacts to wetlands as a result of constructing various levees and seawalls along the Mississippi Gulf Coastal Plain. This report summarizes the results of the assessment. The analysis of impacts included two components:

1. A calculation of total acreage of all wetlands (by type and planning reach) that is directly under the levee footprints.

2. A modified Hydrogeomorphic (HGM) wetland rapid assessment of impacted Estuarine/Tidal Fringe wetlands, based on the Mississippi and Alabama Gulf Coast HGM guidebook (Shafer et al., 2007), with impacts reported as loss of functional units. Tables 6.5-4 and 6.5-5 show the impacts of the Pearlington ring levees at elevations 20.0-feet NAVD88, and 30.0-feet NAVD88 respectively.

Table 6.5-4.
Wetland acres impacted by elevation 20' Pearlington ring levee

Reach ID	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Freshwater Pond	Total
5	1.1	0.6	0.1	1.9
6	2.7	0.7	0.0	3.4
Total	**3.8**	**1.3**	**0.1**	**5.3**

Table 6.5-5.
Wetland acres impacted by elevation 30' Pearlington ring levee

Reach ID	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Freshwater Pond	Total
5	2.2	1.2	0.2	3.6
6	3.3	1.0	0.0	4.3
Total	**5.5**	**2.2**	**0.2**	**7.9**

Nonstructural measures would have no construction activities other than demolition and disposal of building materials in an approved land fill occurs as a result of this measure. More detail on the impacts of the structural and nonstructural measures for the Pearlington area can be found in the Environmental Appendix.

6.5.7 Summary of Costs

Table 6.5-6 summarizes the ROM costs at an FY-08 price level by measure for the Pearlington Area (planning sub-unit six).

Table 6.5-6.
Summary of Costs by Measure for the Pearlington Area

Measures	Implement Cost (FY-08) ($)	Capital Recovery Factor	Average Annual Implementation Cost ($)	Average Annual O&M ($)	IDC ($)	Total Average Annual Costs ($)
(No Action)	$0	0.049171225	$0	$0	$0	$0
Measure A 20FT Ring Levee	$104,800,000	0.049171225	$5,153,000	$1,320,000	N/A	$6,473,000
Measure B 30FT Ring Levee	$120,200,000	0.049171225	$5,910,000	$1,526,000	N/A	$7,436,000
Measure C ABFE Nonstructural	$274,808,000	0.049171225	$13,513,000	$10,000	N/A	$13,523,000
Measure D 20FT Nonstructural	$152,102,000	0.049171225	$7,479,000	$10,000	N/A	$7,489,000
Measure E 30FT Nonstructural	$152,102,000	0.049171225	$7,479,000	$10,000	N/A	$7,489,000

The implementation costs include 1/ supervision and administration (30 account), 2/ planning, engineering & design (31 account) and 3/ appropriate contingencies. See the Cost Appendix for more detail on the implementation cost breakdowns. Numbers are rounded to the nearest thousand.

6.5.8 Regional Economic Development (RED)

The purpose of this section is to describe the economic impact of the proposed measures on business (sale volumes), income, employment, and population of the local area. Each of the measures would affect the local area of Hancock County, Mississippi. The expenditures for the measures are estimated to be $104,800,000 for the 20.0-feet NAVD88 ring levee measure, $120,200,000for the 30.0-feet NAVD88 ring levee measure, $274,808,000 for the ABFE nonstructural measure, $152,102,000 for the 20.0-feet NAVD88 nonstructural measure, and $152,102,000 for the 30.0-feet NAVD88 nonstructural measure. Moreover, the total Operation and

Maintenance (O&M) expenditures, which are based on the total present worth of O&M costs over the period of analysis, are estimated to be $26,845,000 for the 20.0-feet NAVD88 ring levee measure, $31,034,000 for the 30.0-feet NAVD88 ring levee measure, $203,000 for the ABFE nonstructural measure, $203,000 for the 20.0-feet NAVD88 nonstructural measure, and $203,000 for the 30.0-feet NAVD88 nonstructural measure respectively (assuming a 100- year period of analysis and an interest rate of 4.875-percent). The following tables summarize the inputs and outputs of the EIFS model by measure.

Table 6.5-7.
EIFS Model Construction Costs Inputs for the Pearlington Area

	20-Foot Ring Levee	30-Foot Ring Levee	ABFE Nonstructural	20-Foot Nonstructural	30-Foot Nonstructural
Region of Influence (ROI)	Hancock County	Hancock County	Hancock County	Hancock County	Hancock County
Change in Local Expenditures	$104,800,000	$120,200,000	$387,900,000	$152,102,000	$152,102,000

Based of the given inputs the outputs are as follows:

Table 6.5-8.
EIFS Model Construction Costs Outputs for the Pearlington Area

	20-Foot Ring Levee	30-Foot Ring Levee	ABFE Nonstructural	20-Foot Nonstructural	30-Foot Nonstructural
Direct Sales Volume	$104,800,000	$120,200,000	$387,900,000	$152,102,000	$152,102,000
Induced Sales Volume	$104,800,000	$120,200,000	$387,900,000	$152,102,000	$152,102,000
Total Sales Volume	$209,600,000	$240,400,000	$775,800,000	$304,204,000	$304,204,000
Direct Income	$25,270,954	$28,984,434	$93,536,290	$36,677,125	$36,677,125
Induced Income	$25,270,954	$28,948,434	$93,536,290	$36,677,125	$36,677,125
Total Income	$50,541,909	$57,968,868	$187,072,580	$73,354,250	$73,354,250
Direct Employment	634	727	2,347	920	920
Induced Employment	634	727	2,347	920	920
Total Employment	1,268	1,454	4,694	1,840	1,840
Local Population	0	0	0	0	0

Table 6.5-9.
EIFS Model O&M Costs Inputs for the Pearlington Area

	20-Foot Ring Levee	30-Foot Ring Levee	ABFE Nonstructural	20-Foot Nonstructural	30-Foot Nonstructural
Region of Influence (ROI)	Hancock County	Hancock County	Hancock County	Hancock County	Hancock County
Change in Local Expenditures	$26,845,000	$31,034,000	$203,000	$203,000	$203,000

Based of the given inputs the outputs are as follows:

Table 6.5-10.
EIFS Model O&M Costs Outputs for the Pearlington Area

	20-Foot Ring Levee	30-Foot Ring Levee	ABFE Nonstructural	20-Foot Nonstructural	30-Foot Nonstructural
Direct Sales Volume	$26,845,000	$31,034,000	$203,000	$203,000	$203,000
Induced Sales Volume	$26,845,000	$31,034,000	$203,000	$203,000	$203,000
Total Sales Volume	$53,690,000	$62,068,000	$406,000	$406,000	$406,000
Direct Income	$6,473,271	$7,483,385	$48,950	$48,950	$48,950
Induced Income	$6,473,271	$7,483,385	$48,950	$48,950	$48,950
Total Income	$12,946,541	$14,966,771	$97,900	$97,900	$97,900
Direct Employment	162	188	1	1	1
Induced Employment	162	188	1	1	1
Total Employment	324	376	2	2	2
Local Population	0	0	0	0	0

6.6 Admiral Island Ecosystem Restoration Measures

This section describes the evaluation of ecosystem restoration measures at the Admiral Island area that is located within planning sub-unit two, which is part of planning unit one. The total area includes approximately 400 acres of state owned land. This area was selected for ecosystem restoration using the Decision Support System, a GIS based model created by the Corps' Engineer Research and Development Center (ERDC). For more details on the selection process for ecosystem restoration sites see the economic appendix. Figure 6.6-1 shows the location of the Admiral Island area.

6.6.1 Formulation of Alternatives

6.6.1.1 Assumption

In order for the Admiral Island site to undergo ecosystem restoration, it is assumed that there will be mandatory buy-outs of properties and removal of all existing structures within the footprint of the site. These buy-outs will be part of the flood damage reduction alternative and not this ecosystem restoration alternative.

6.6.1.2 Objectives

The following ecosystem restoration objectives were developed:

- Restore the natural hydrology
- Provide storm surge protection
- Restore native tidal wetland plant communities
- Provide fish and tidal wildlife habitat
- Prevent saltwater intrusion

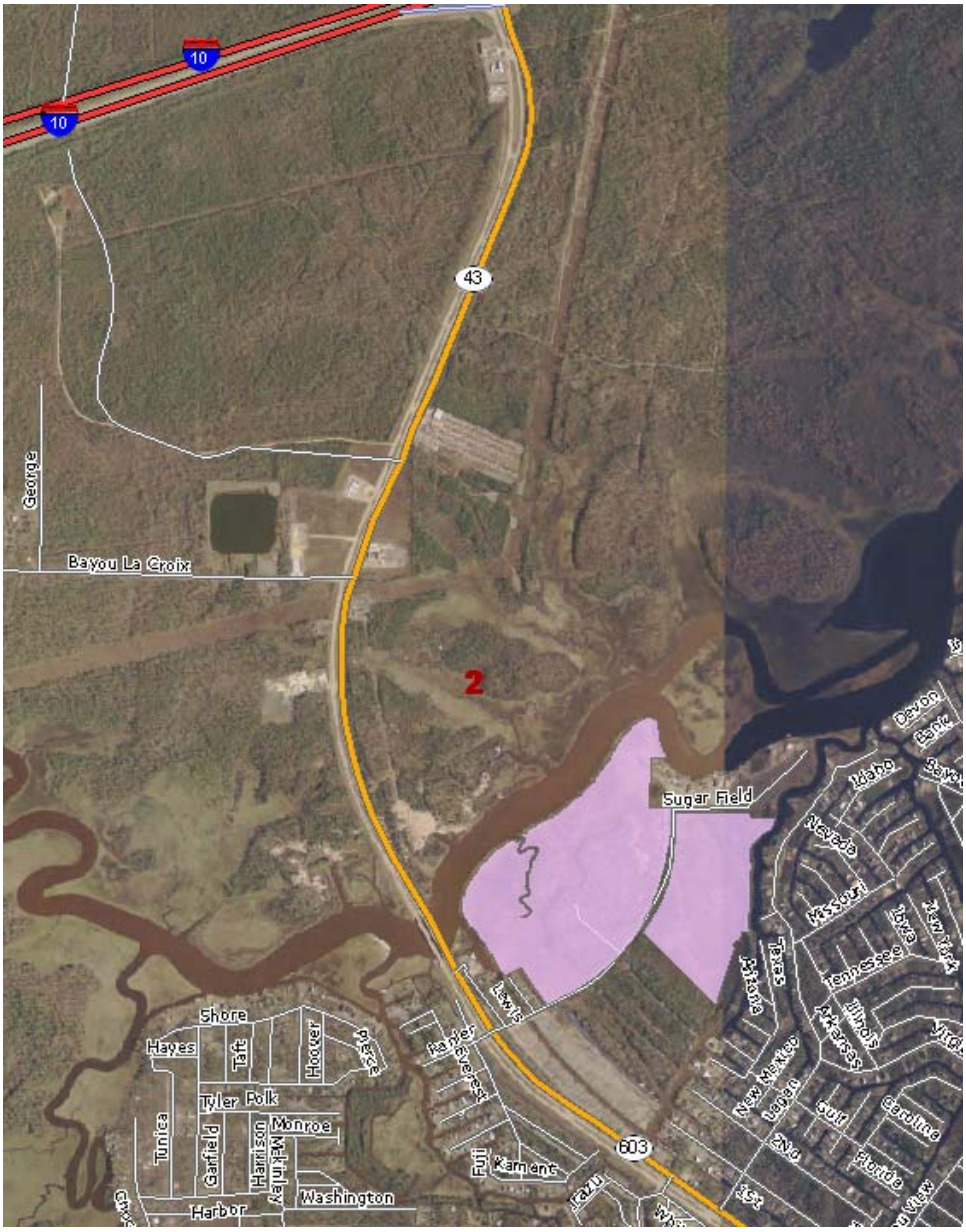


Figure 6.6-1. Location of the Admiral Island Restoration Area

6.6.1.3 Ecosystem Restoration Management Measures

Proposed restoration management measures are listed in Table 6.6-1. Narrative descriptions of each management measure follow this table.

Table 6.6-1.
Ecosystem Restoration Management Measures

Management Measure	Description
No Action	No Action
1	Excavate Old Fill Material
2	Remove Exotic Species
3	Fill Existing Artificial Ditches
4 *a* *b* *C*	Plant Native Vegetation - 0.5 meter spacing - 1.0 meter spacing - 2.0 meter spacing

6.6.1.4 Excavate Old Fill Material (1)

This management measure must be included in all alternatives for the restoration to be successful. It includes 90-95 percent removal of existing exotic species in the excavated areas. This measure positively affects the hydrologic regime.

6.6.1.5 Remove Exotic Species from Non-Excavated Areas and Maintenance of Exotics in All Areas over the Project Life (2)

This management measure must be included in all alternatives for the restoration to be successful. It includes 100 percent removal of exotic species from non-excavated areas over the life of the project. The exotic species include Chinese Tallow, Phragmites, and Cogon Grass. This measure positively affects the percentage of the area covered by exotic species.

6.6.1.6 Fill Existing Artificial Ditches and Channels (3)

This management measure does not need to be included in all alternatives for the restoration to be successful. It includes 100 percent removal of existing artificial ditches and channels. This measure provides additional positive affects to the hydrologic regime.

6.6.1.7 Plant Native Vegetation (4)

The types of native vegetation that will be planted include Spartina alterniflora (Smooth Cordgrass) at the seaward edge of marsh; Juncus roemerianus (Black Needle Rush) at a just slightly higher elevation; and Spartina patens (Saltmeadow Cordgrass) at the next slightly higher elevation.

This management measure must be included in all alternatives for the restoration to be successful. There are three different planting density options: (a) 0.5 meter spacing, (b) 1.0 meter spacing, and (c) 2.0 meters spacing. Planting emergent tidal marsh at varying densities will result in obtaining desired environmental output at varying years and costs. It is estimated that 2 re-planting efforts would be required for the two least dense plantings: 2.0 meters and 1.0 meter spacing. It is estimated that the 0.5 meter spacing will achieve full benefits in about 5 years while the 1.0 meter spacing and 2.0 meter spacing will achieve full benefits in about 7 and 10 years, respectively.

This measure affects the percent cover by woody plant species, wildlife habitat diversity, vegetation height, wetland indicator status and the mean percent cover emergent plant species.

6.6.1.8 Ecosystem Restoration Alternatives

These four management measures were combined to create six alternatives. Each alternative includes the mandatory management measures of excavating old fill material, removing exotic plant species from non-excavated areas, and planting native vegetation. Since there are three different planting densities, three alternatives are created with this combination of management measures. When the management measure of filling existing artificial ditches is added to this combination, this creates another three alternatives.

All alternatives will restore 123 acres. Alternative 1 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas, planting native vegetation at a density of 0.5 meters, and filling existing artificial ditches. Alternative 2 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas, planting native vegetation at a density of 1.0 meter, and filling existing artificial ditches. Alternative 3 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas, planting native vegetation at a density of 2.0 meter, and filling existing artificial ditches. Alternative 4 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas and planting native vegetation at a density of 0.5 meters. Alternative 5 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas and planting native vegetation at a density of 1.0 meter. Alternative 6 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas and planting native vegetation at a density of 2.0 meters. Figure 6.6-2 shows the location of the Admiral Island restoration site. Table 6.6-2 displays a description of each ecosystem restoration alternative.



Figure 6.6-2 Admiral Island restoration site

Table 6.6-2.
Ecosystem Restoration Alternatives

Alternative	Management Measure	Description
0	No Action	No Action
1	1 + 2 +3+ 4a	Excavate Fill Remove Exotics Plant at Density 0.5m Fill Ditches
2	1 + 2 + 3+4b	Excavate Fill Remove Exotics Plant at Density 1.0m Fill Ditches
3	1 + 2 + 3+4c	Excavate Fill Remove Exotics Plant at Density 2.0m Fill Ditches
4	1 + 2 + 4a	Excavate Fill Remove Exotics Plant at Density 0.5m
5	1 + 2 + 4b	Excavate Fill Remove Exotics Plant at Density 1.0m
6	1 + 2 + 4c	Excavate Fill Remove Exotics Plant at Density 2.0m

6.6.1.9 Benefits

Benefits are measured in terms of Average Annual Functional Units (AAFU). The Hydrogeomorphic (HGM) approach was used to assess wetland function. A HGM assessment was performed in 2000 using the Regional Guidebook for Applying the HGM Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains. Results from this assessment were used to establish baseline (current) conditions and, ultimately, to measure the functional unit benefits resulting from different restoration alternatives. Table 6.6-3 displays the AAFU net benefits for each alternative. The AAFU net benefit was calculated as the difference between the total functional units for the ecosystem restoration alternative and the total functional units for the no action alternative.

Table 6.6-3.
Summary of Benefits

Alternative	Alternative Description	Net AAFU Net Benefits
No Action	No Action	0
Alternative 1	Excavate Fill Remove Exotics Plant at Density 0.5m Fill Ditches	61
Alternative 2	Excavate Fill Remove Exotics Plant at Density 1.0m Fill Ditches	60
Alternative 3	Excavate Fill Remove Exotics Plant at Density 2.0m Fill Ditches	59
Alternative 4	Excavate Fill Remove Exotics Plant at Density 0.5m	51
Alternative 5	Excavate Fill Remove Exotics Plant at Density 1.0m	50.5
Alternative 6	Excavate Fill Remove Exotics Plant at Density 2.0m	49

6.6.1.10 Costs

The rough order magnitude (ROM) first costs of construction, which do not include interest during construction, include excavating 916,483 cubic yards of old fill material for $10,998,000 and planting native vegetation at densities of 0.5m, 1m and 2.0m spacing for $3,571,000, $1,786,000 and $893,000, respectively. The cost of filling ditches with 7,000 cubic yards of material is estimated at approximately $35,000. Herbicide application by hand to 62 acres of land not excavated is estimated at approximately $893,000. Mobilization and demobilization are estimated at approximately $2,400,000, and miscellaneous site items are estimated at approximately $1,000,000. A contingency of 25 percent and lands and damages costs of $25,000 were added to the construction cost. This cost was increased by an 8 percent planning, Engineering and Design (PED) cost and a 6 percent Construction Management cost.

For each alternative, these first costs of construction are presented in Table 6.6-4 in OCTOBER 2007 dollars along with the Interest During Construction (IDC), investment cost (first cost plus the IDC), Average Annual Investment Cost (AAIC), Average Annual Operations and Maintenance (AAO&M) cost and, ultimately, the Average Annual Costs (AAC).

Table 6.6-4.
Summary of Costs by Measure for Admiral Island Area

Alternative	Alternative Description	Implement-ation Cost (FY-08)	IDC	Investment Cost	AAIC	AAO&M	AAC
0	No Action	$0	$0	$0	$0	$0	$0
1	Excavate Fill Remove Exotics Plant at Density 0.5m Fill Ditches	$26,340,000	$580,000	$26,920,000	$1,447,000	$2,000	$1,449,000
2	Excavate Fill Remove Exotics Plant at Density 1.0m Fill Ditches	$23,790,000	$530,000	$24,320,000	$1,306,000	$58,000	$1,364,000
3	Excavate Fill Remove Exotics Plant at Density 2.0m Fill Ditches	$22,490,000	$500,000	$22,990,000	$1,235,000	$58,000	$1,293,000
4	Excavate Fill Remove Exotics Plant at Density 0.5m	$26,280,000	$580,000	$26,860,000	$1,443,000	$2,000	$1,445,000
5	Excavate Fill Remove Exotics Plant at Density 1.0m	$23,720,000	$530,000	$24,250,000	$1,302,000	$58,000	$1,360,000
6	Excavate Fill Remove Exotics Plant at Density 2.0m	$22,440,000	$500,000	$22,900,000	$1,232,000	$58,000	$1,290,000

Note: Numbers are rounded to the nearest thousand.

First costs of construction are used along with the duration of 12 months of construction and a discount rate of 4.875 percent to calculate IDC. The sum of the first costs of construction and IDC cost equal the investment cost. This cost is amortized at the Fiscal Year (OCTOBER) 2007 Federal discount rate of 4.875 percent over a 50-year economic period of analysis to calculate the AAIC. AAO&M costs for monitoring in years 2 through 6 and re-planting in years 3 and 5 were present valued and amortized at an interest rate of 4.875 percent over a 50-year economic period of analysis. The sum of the AAIC and AAO&M cost equal the AAC.

6.6.2 Comparison of Alternatives

Table 6.6-5 displays all alternatives with their respective AAC and AAFU in increasing order of AAFU.

To determine if an alternative is cost effective, economically inefficient alternatives must first be identified and eliminated. An economically inefficient alternative is an alternative that cost more for the same level of benefit. No alternatives are eliminated for the reason of economic inefficiency because each alternative produces a different level of benefit.

Table 6.6-5.
All Alternatives: AAC and AAFU for Admiral Island

Alternative	AAC	AAFU
No Action	$0	0
6	$1,290,000	49
5	$1,360,000	50.5
4	$1,445,000	51
3	$1,293,000	59
2	$1,364,000	60
1	$1,449,000	61

Note: The AAC values are rounded to the nearest thousand.

Lastly, economically ineffective alternatives are identified and eliminated to determine which alternatives are cost effective. An economically ineffective alternative is an alternative that will produce less benefit at an equal or greater cost than a subsequent alternative. The AAFU benefits are place in ascending order and a pair-wise comparison of the benefits and costs is conducted to eliminate economically ineffective alternatives.

As shown in Table 6.6-6, the two shaded alternatives, 5 and 6, were eliminated because they produced less benefit at greater cost than a subsequent alternative. For example, Alternative 4 produces 51 AAFU at an AAC of $1,445,000 while Alternative 3 produces 59 AAFU at an AAC $1,293,000. Alternative 4 produces less AAFU at a greater cost than Alternative 3. Therefore, Alternative 4 is eliminated. As shown in Table 6.6-7 and plotted in Figure 6.6-3, the cost effective alternatives are Alternative 6, Alternative 3, Alternative 2, and Alternative 1.

Table 6.6-6.
Elimination of Economically Ineffective Alternatives

Alternative	Alternative Description	AAC	AAFUs	Cost Effective?
No Action	No Action	$0	0	Yes
6	Excavate Fill Remove Exotics Plant at Density 2.0m	$1,290,000	49	Yes
5	Excavate Fill Remove Exotics Plant at Density 1.0m	$1,360,000	50.5	No
4	Excavate Fill Remove Exotics Plant at Density 0.5m	$1,445,000	51	No
3	Excavate Fill Remove Exotics Plant at Density 2.0m Fill Ditches	$1,293,000	59	Yes
2	Excavate Fill Remove Exotics Plant at Density 1.0m Fill Ditches	$1,364,000	60	Yes
1	Excavate Fill Remove Exotics Plant at Density 0.5m Fill Ditches	$1,449,000	61	Yes

Note: The AAC values are rounded to the nearest thousand.

Table 6.6-7.
Cost Effective Alternatives

Alternative	Alternative Description	AAC	AAFUs	Cost Effective?
No Action	No Action	$0	0	Yes
6	Excavate Fill Remove Exotics Plant at Density 2.0m	$1,290,000	49	Yes
3	Excavate Fill Remove Exotics Plant at Density 2.0m Fill Ditches	$1,293,000	59	Yes
2	Excavate Fill Remove Exotics Plant at Density 1.0m Fill Ditches	$1,364,000	60	Yes
1	Excavate Fill Remove Exotics Plant at Density 0.5m Fill Ditches	$1,449,000	61	Yes

Note: The AAC values are rounded to the nearest thousand.

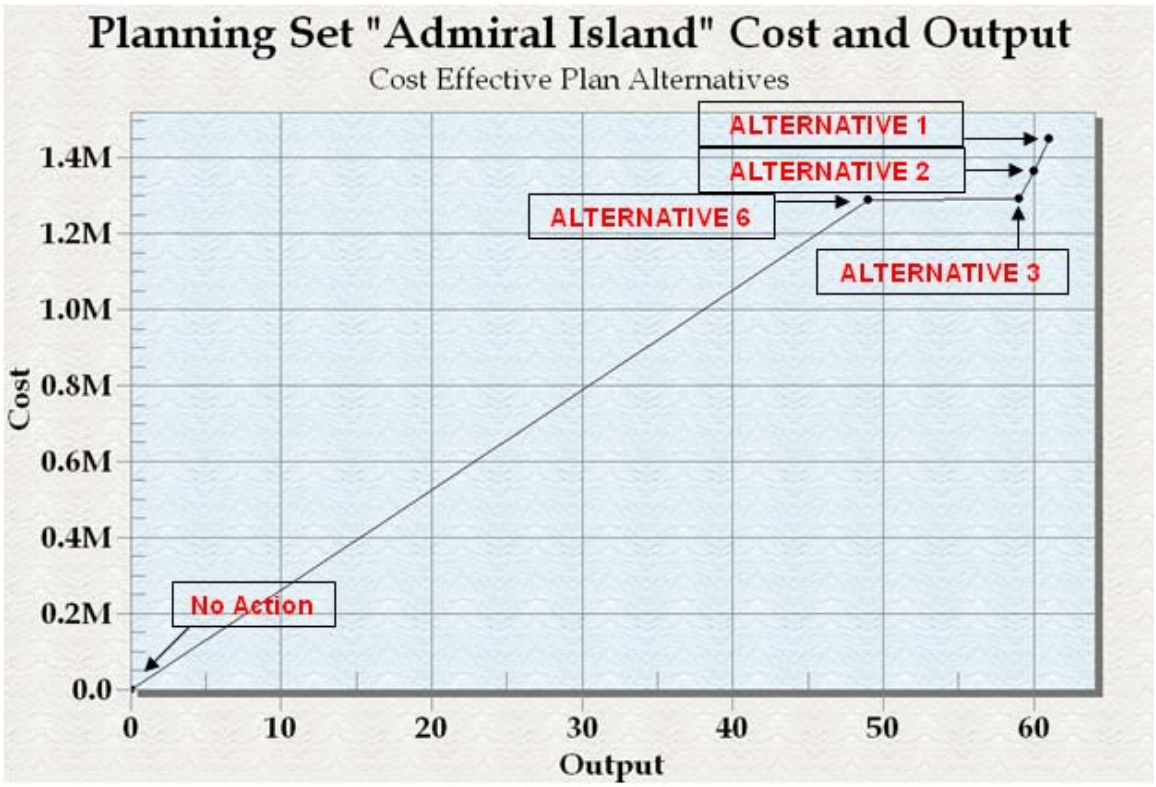


Figure 6.6-3 Display of Cost Effective Alternatives for the Admiral Island Area

6.6.3 Regional Economic Development (RED) Benefits

6.6.3.1 Socioeconomic Impacts using the Economic Impact Forecast System

The purpose of this analysis is to determine the economic impact of the proposed project alternatives on business (sales volumes), income, employment, and population of the local area. Each of the alternatives would affect the local area of Hancock County, Mississippi. The expenditures for the alternatives are estimated to be $26,300,000for Alternative 1, $23,800,000 for the Alternative 2, $22,500,000for Alternative 3, and $22,400,000 for Alternative 6. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $43,000for Alternative 1, $1,075,000 for Alternative 2, $1,075,000 for Alternative 3, and $1,075,000 for Alternative 6, (assuming a 50 year period of analysis and an interest rate of 4.875 percent). Tables 6.6-8 through 6.6-11 summarize the EIFS model inputs and outputs for the cost effective measures at Admiral Island.

Table 6.6-8.
EIFS Model Implementation Inputs for Admiral Island Ecosystem

	No Action	Alternative 1	Alternative 2	Alternative 3	Alternative 6
Region of Influence (ROI)	Hancock County	Hancock County	Hancock County	Hancock County	Hancock County
Change in Local Expenditures	$0	$26,300,000	$23,800,000	$22,500,000	$22,400,000

Based of the given inputs the outputs are as follows:

Table 6.6-9.
EIFS Model Implementation Outputs for Admiral Island Ecosystem

	No Action	Alternative 1	Alternative 2	Alternative 3	Alternative 6
Direct Sales Volume	$0	$26,300,000	$23,800,000	$22,500,000	$22,400,000
Induced Sales Volume	$0	$26,300,000	$23,800,000	$22,500,000	$22,400,000
Total Sales Volume	$0	$52,600,000	$47,600,000	$45,000,000	$44,800,000
Direct Income	$0	$6,341,852	$5,739,014	$5,425,539	$5,401,425
Induced Income	$0	$6,341,852	$5,739,014	$5,425,539	$5,401,425
Total Income	$0	$12,683,704	$11,478,029	$10,851,078	$10,802,851
Direct Employment	0	159	144	136	136
Induced Employment	0	159	144	136	136
Total Employment	0	318	288	272	271
Local Population	0	0	0	0	0

Table 6.6-10.
EIFS Model O&M Inputs for Admiral Island Ecosystem

	No Action	Alternative 1	Alternative 2	Alternative 3	Alternative 6
Region of Influence (ROI)	Hancock County	Hancock County	Hancock County	Hancock County	Hancock County
Change in Local Expenditures	$0	$43,000	$1,075,000	$1,075,000	$1,075,000

Based of the given inputs the outputs are as followed:

Table 6.6-11.
EIFS Model O&M Outputs for Admiral Island Ecosystem

	No Action	Alternative 1	Alternative 2	Alternative 3	Alternative 6
Direct Sales Volume	$0	$43,000	$1,075,000	$1,075,000	$1,075,000
Induced Sales Volume	$0	$43,000	$1,075,000	$1,075,000	$1,075,000
Total Sales Volume	$0	$86,000	$2,150,000	$2,150,000	$2,150,000
Direct Income	$0	$10,369	$259,220	$259,220	$259,220
Induced Income	$0	$10,369	$259,220	$259,220	$259,220
Total Income	$0	$20,738	$518,440	$518,440	$518,440
Direct Employment	0	0	7	7	7
Induced Employment	0	0	7	7	7
Total Employment	0	0	14	14	14
Local Population	0	0	0	0	0

6.7 Evaluation of Turkey Creek Ecosystem Restoration Measures

This section describes the evaluation of ecosystem restoration measures at the Turkey Creek area that is located within planning sub-unit 12, which is part of planning unit two. The total area includes 879 acres. There are no structures within the area, and the acquisition of the parcels would have to occur before the implementation of any of the alternatives. This area was selected for ecosystem restoration using the Decision Support System, a GIS based model created by the Corps' Engineer Research and Development Center (ERDC). For more details on the selection process for ecosystem restoration sites see the Economic Appendix. Figure 6.7-1 shows the location of the Turkey Creek area.

6.7.1 Formulation of Alternatives

6.7.1.1 Assumption

In order for the Turkey Creek site to undergo ecosystem restoration, it is assumed that there will be mandatory buy-outs of required properties in the site footprint. The costs of these buy-outs are accounted for in the flood damage reduction alternative and not in this ecosystem restoration alternative. However, there are non-building structures that require removal and disposal. These costs result from and are included in this ecosystem restoration alternative.

6.7.1.2 Objectives

The following objectives were developed for this ecosystem restoration study:

- Restore native vegetation
- Restore natural hydrology
- Restore fish and wildlife habitat
- Provide storm water storage protection

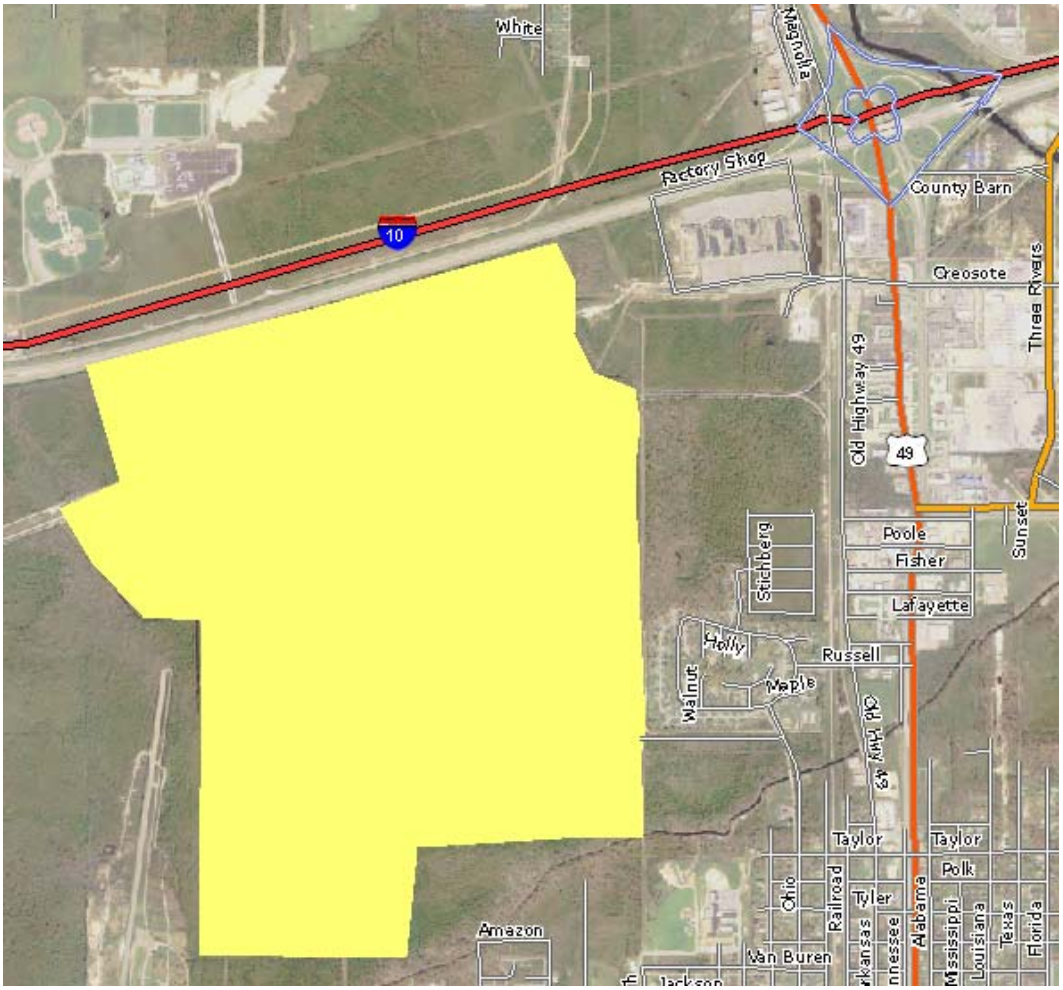


Figure 6.7-1. Location of Turkey Creek Restoration area in Planning Unit Two

6.7.1.3 Ecosystem Restoration Management Measures

Proposed restoration management measures are listed in table 6.7-1. Narrative descriptions of each management measure follow this table.

Table 6.7-1.
Ecosystem Restoration Management Measures

Management Measure	Description
No Action	No Action
1	Fill Ditches
2 a b	Maintain Vegetation By Burning By Mowing
3	Excavate and Remove Existing Roadbeds and Any Additional Fill

6.7.1.3.1 Fill Ditches (1)

This management measure must be included in all alternatives for the restoration to be successful. This measure affects the outflow of water. It measures the removal of water by ditches or drains.

6.7.1.3.2 Maintain Vegetation (2)

This management measure must be included in all alternatives for the restoration to be successful. There are two methods that will be analyzed for maintaining vegetation: (a) burning and (b) mowing. Fire benefits this ecosystem in many different ways. It creates a bare seedbed for pine seedlings and other fire dependent plants, reduces fuel loads and recycles nutrients. Periodic burning promotes early successional plants that are important to many species of wildlife indigenous to this ecosystem. Many of the plant species found in this ecosystem are fire dependent; for example, the federally endangered American Chaff seed flowers almost exclusively after a fire. It has been reduced to a fraction of its original range due to fire suppression and habitat destruction. Fire suppression is mainly due to liability issues and fear of litigation.

Mowing is a mechanical alternative that many land managers use to maintain early successional habitats. Although it is successful to some extent, it fails to provide all the necessary components that come from prescribed fire. This method also has a negative effect. Mowing requires the use of heavy equipment in sensitive areas. Tractors can create ruts in saturated soils, creating hydrologic problems and micro site conditions. Mowing can also introduce non-native species through the use of contaminated equipment. Another disadvantage of mowing is that the duff or litter layer remains on the ground, preventing seeds from reaching the bare ground needed for germination. This thick litter layer can also provide heavy fuel loads increasing the risk of wildfires during dry periods. Although mowing provides some level of habitat management in pine savannahs, it is not a substitute for prescribed fire. Mowing can maintain succession, but may inhibit other functions of the system.

6.7.1.3.3 Excavate and Remove Existing Roadbeds and Any Additional Fill (3)

This management measure must be included in all alternatives for the restoration to be successful. This measure affects the surface water storage.

6.7.1.4 Ecosystem Restoration Alternatives

These management measures were combined to create six alternatives. Each alternative requires filling ditches, maintaining vegetation growth by burning and mowing the project area in the initial year of construction as well as maintaining it by either burning every three years or mowing every year over the life of the project, and excavating and removing existing roadbeds and any additional fill. The difference between each alternative includes the number of acres restored and the method of maintaining vegetation over the life of the project.

Alternatives 1 and 2 consist of restoring the project areas north and south of the railroad: 897 acres. Alternative 1 maintains vegetation by burning once every three years. Alternative 2 maintains vegetation by mowing every year. Alternatives 3 and 4 consist of restoring only the project area south of the railroad: 689 acres. Alternative 3 maintains vegetation by burning once every three years. Alternative 4 maintains vegetation by mowing every year. Alternatives 5 and 6 consist of restoring only the project area north of the railroad: 190 acres. Alternative 5 maintains vegetation by burning once every three years. Alternative 6 maintains vegetation by mowing every year. Figure 6.7-2 shows the Turkey Creek restoration site. Table 6.7-2 displays a description of each ecosystem restoration alternative.

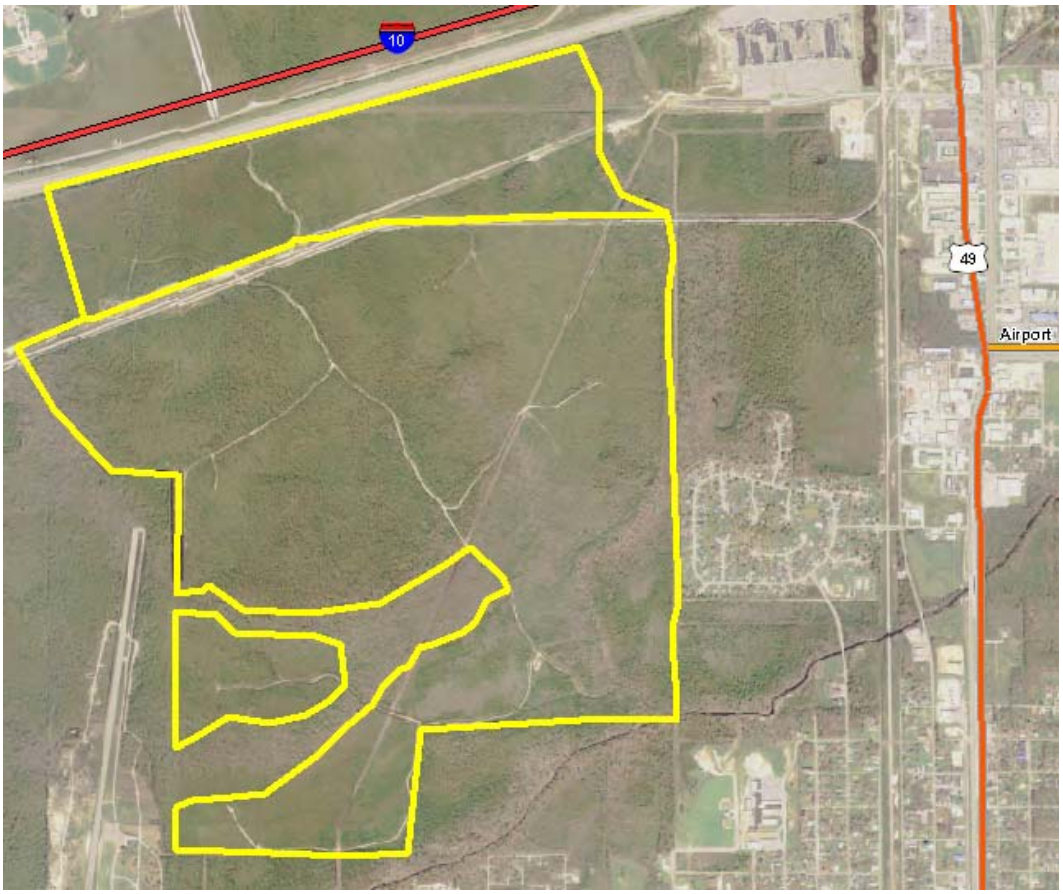


Figure 6.7-2. Turkey Creek Restoration Site

Table 6.7-2.
Ecosystem Restoration Alternatives

Alternative	Management Measures	Alternative Description
0	No Action	No Action
1	1 + 2a +3	879 Acre Restoration Maintain by Burning
2	1 + 2b + 3	879 Acre Restoration Maintain by Mowing
3	1 + 2a +3	689 Acre Restoration Maintain by Burning
4	1 + 2b + 3	689 Acre Restoration Maintain by Mowing
5	1 + 2a +3	190 Acre Restoration Maintain by Burning
6	1 + 2b + 3	190 Acre Restoration Maintain by Mowing

6.7.1.5 Benefits

In order to restore this area to a Wet Pine Savannah habitat, the higher areas will be designated as Wet Pine Savannah. These areas have depression areas within them which will enable water to flow down to the depression areas; thus, holding water. The Wet Pine Savannah habitat will be restored with Wet Pine Flatwoods, such as Pinus elliotti, Morella cerifera, Ilex glabra, Spartina patens and Panicum virgatum.

Many species of wildlife are indigenous to the Wet Pine Savannah habitat. Understory plant communities may contain wiregrass, sedges, orchids, American Chaff seed and rough-leaved loosestrife. Insectivorous plants that may be found include pitcher plants, bladderworts, venus flytrap, and sundews. Rare, threatened or endangered birds that may occur in these areas include Henslowe's sparrow, Bachman's sparrow, red-cockaded woodpecker, and Mississippi Sandhill Crane. This ecosystem may also benefit the Mississippi Gopher frog and in drier areas along ridges, the black pine snake and the gopher tortoise.

Benefits are measured in terms of Average Annual Functional Units (AAFU). The Hydrogeomorphic (HGM) approach was used to assess wetland function. A HGM assessment was performed in 2000 using the Regional Guidebook for Applying the HGM Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains. Results from this assessment were used to establish baseline (current) conditions and, ultimately, to measure the functional unit benefits resulting from different restoration alternatives. Table 6.7-3 shows the total functional units under each alternative and the AAFU net benefit. It is assumed that functional units will remain the same under existing conditions and the no action alternative. The AAFU net benefit was calculated as the difference between the total functional units for the ecosystem restoration alternative and the total functional units for the no action alternative.

Table 6.7-3.
Summary of Benefits

Alternative	Alternative Description	Total Functional Units	AAFU Net Benefit
Existing Condition (alternatives 1-2)	Existing Condition	1,222	-
Existing Condition (alternatives 3-4)	Existing Condition	1,012	-
Existing Condition (alternatives 5-6)	Existing Condition	210	-
No Action (alternatives 1-2)	No Action	1,222	0
No Action (alternatives 3-4)	No Action	1,012	0
No Action (alternatives 5-6)	No Action	210	0
Alternative 1	879 Acre Restoration Maintain by Burning	3,268	2,046
Alternative 2	879 Acre Restoration Maintain by Mowing	2,574	1,352
Alternative 3	689 Acre Restoration Maintain by Burning	2,577	1,565
Alternative 4	689 Acre Restoration Maintain by Mowing	2,037	815
Alternative 5	190 Acre Restoration Maintain by Burning	691	481
Alternative 6	190 Acre Restoration Maintain by Mowing	537	327

6.7.1.6 Costs

A rough order magnitude (ROM) cost estimate was developed for the 879, 190, and 689 acres of restoration. It included the cost of filling ditches with 130,200, 28,100, and 102,100 cubic yards of material for $1,562,420, $337,480, and $1,224,900, respectively; burning 879, 190, and 689 acres of vegetation for $131,850, 28,480, and 103,370, respectively; mowing 879, 190, and 689 acres for $74,720, 16,140, and 58,580, respectively; removing and disposing of structures, roads and utilities for $2,601,040, $560,530, and $2,040,510, respectively; mobilizing and demobilizing for $20,000; and miscellaneous site items for $45,000. These construction costs equaled $4,435,000, $1,008,000, and $3,492,000, respectively. A contingency cost of 25% and lands and damages costs of $1,126,000, $375,000, and 777,000 were added to the construction cost. Then, Planning, Engineering and Design (PED) costs of 8% and a Construction Management cost of 6% were added for a total first cost of construction. The first cost of 879 acres of restoration is estimated at $7,600,000. The first cost of 190 acres of restoration is estimated at $1,900,000. The first cost of 689 acres of restoration is estimated at $5,900,000.

The first cost plus Interest During Construction (IDC) equals the investment cost. IDC cost of 879, 190, and 689 acres of restoration is estimated at $168,900, $41,400, and $130,200, respectively. Investment cost of 897, 190, and 689 acres of restoration is estimated at $7,800,000, $1,910,000, and $6,020,000, respectively. O&M cost of burning every three years 879, 190, and 689 acres is estimated at $3,040,000, $2,384,000, and $656,000, respectively. O&M cost of mowing every year 879, 190, and 689 acres is estimated at $5,243,000, $4,116,000, and $1,127,000, respectively. Average Annual Investment Cost (AAIC) plus Average Annual Operations and Maintenance (AAO&M) cost equals Average Annual Costs (AAC).

- For Plan 1, AAIC of $419,000 plus AAO&M of $60,000.equals an AAC of $479,000.
- For Plan 2, AAIC of $419,000 plus AAO&M of $107,000.equals an AAC of $526,000.
- For Plan 3, AAIC of $101,000 plus AAO&M of $13,000.equals an AAC of $114,000.
- For Plan 4, AAIC of $101,000 plus AAO&M of $23,000.equals an AAC of $124,000.
- For Plan 5, AAIC of $323,000 plus AAO&M of $47,000.equals an AAC of $370,000.
- For Plan 6, AAIC of $323,000 plus AAO&M of $84,000.equals an AAC of $407,000.

For each alternative, the first costs of construction, IDC, investment cost, O&M cost, AAIC, AAO&M cost and AAC are presented in table 6.7-4 at October 2007 price levels.

First cost of construction is used along with the duration of 12 months of construction and a discount rate of 4.875 percent to calculate Interest During Construction (IDC). The sum of the first cost of construction and IDC cost equals the investment cost. This cost is amortized at the FY 2007 federal discount rate of 4.875 percent over a 50-year economic period of analysis to calculate the Average Annual Investment Cost (AAIC). Average Annual O&M (AAO&M) costs for burning once every three years or mowing every year were present valued and amortized at an interest rate of 4.875 percent over a 50-year economic period of analysis. The sum of the AAIC and AAO&M cost equals the Average Annual Costs (AAC).

Table 6.7-4.
Summary of Costs by Measure for Turkey Creek

Alternative	Alternative Description	Implementation Cost (FY-08)	IDC	Investment Cost	AAIC	AAO&M	AAC
0	No Action	$0	$0	$0	$0	$0	$0
1	879 Acre Restoration Maintain by Burning	$7,636,000	$169,000	$7,804,000	$419,000	$60,000	$479,000
2	879 Acre Restoration Maintain by Mowing	$7,636,000	$169,000	$7,804,000	$419,000	$107,000	$526,000
3	689 Acre Restoration Maintain by Burning	$5,887,000	$130,000	$6,017,000	$323,000	$47,000	$370,000
4	689 Acre Restoration Maintain by Mowing	$5,887,000	$130,000	$6,017,000	$323,000	$84,000	$407,000
5	190 Acre Restoration Maintain by Burning	$1,871,000	$41,000	$1,913,000	$101,000	$13,000	$114,000
6	190 Acre Restoration Maintain by Mowing	$1,871,000	$41,000	$1,913,000	$101,000	$23,000	$124,000

Note: Numbers are rounded to the nearest thousand dollars.

6.7.2 Comparison of Alternatives

Table 6.7-5 displays all alternatives with their respective AAC and AAFU.

Table 6.7-5.
All Alternatives: AAC and AAFU

Alternative	AAC	AAFU
No Action	$0	0
1	$479,000	2,046
2	$526,000	1,352
3	$370,000	1,565
4	$407,000	815
5	$114,000	481
6	$124,000	327

Note: The AAC values are rounded to the nearest thousand dollars.

In order to determine the cost effectiveness of each alternative, the list of alternatives is reordered so that they are listed in increasing order of their outputs (AAFU). This list is shown in table 6.7-6.

To determine if an alternative is cost effective, economically inefficient alternatives must first be identified and eliminated. An economically inefficient alternative is an alternative that cost more for the same level of benefit. No alternatives are eliminated for the reason of economic inefficiency because each alternative produces a different level of benefit.

Table 6.7-6.
All Alternatives Arrayed by Increasing Output

Alternative	AAC	AAFU
No Action	$0	0
6	$124,000	327
5	$114,000	481
4	$407,000	815
2	$526,000	1,352
3	$370,000	1,565
1	$479,000	2,046

Note: The AAC values are rounded to the nearest thousand dollars.

Lastly, economically ineffective alternatives are identified and eliminated to determine which alternatives are cost effective. An economically ineffective alternative is an alternative that cost more or the same as a subsequent alternative but produces less benefit than that subsequent alternative. As shown in table 6.7-7, the three shaded alternatives, 6, 4, and 2 were eliminated because they produced less benefit at greater cost than a subsequent alternative. For example, Alternative 6 produces 327 AAFU at an AAC of $124,000 while Alternative 5 produces 481 AAFU at an AAC $114,000. Alternative 6 produces less AAFU at a greater cost than Alternative 5. Therefore, Alternative 6 is eliminated. As shown in table 6.7-8 and plotted in figure 6.7-3, the cost effective alternatives are Alternative 5 (190 acres of restoration maintained by burning), Alternative 3 (689 acres of restoration maintained by burning) and Alternative 1 (879 acres of restoration maintained by burning).

Table 6.7-7.
Elimination of Economically Ineffective Alternatives

Alternative	Alternative Description	AAC	AAFUs	Cost Effective?
No Action	No Action	$0	0	Yes
6	190 Acre Restoration Maintain by Mowing	$124,000	327	No
5	190 Acre Restoration Maintain by Burning	$114,000	481	Yes
4	689 Acre Restoration Maintain by Mowing	$407,000	815	No
2	879 Acre Restoration Maintain by Mowing	$526,000	1,352	No
3	689 Acre Restoration Maintain by Burning	$370,000	1,565	Yes
1	879 Acre Restoration Maintain by Burning	$479,000	2,046	Yes

Note: The AAC values are rounded to the nearest thousand dollars.

Table 6.7-8.
Cost Effective Alternatives for the Turkey Creek Area

Alternative	Alternative Description	AAC	AAFUs	Cost Effective?
No Action	No Action	$0	0	Yes
5	190 Acre Restoration Maintain by Burning	$114,000	481	Yes
3	689 Acre Restoration Maintain by Burning	$370,000	1,565	Yes
1	879 Acre Restoration Maintain by Burning	$479,000	2,046	Yes

Note: The AAC values are rounded to the nearest thousand dollars.

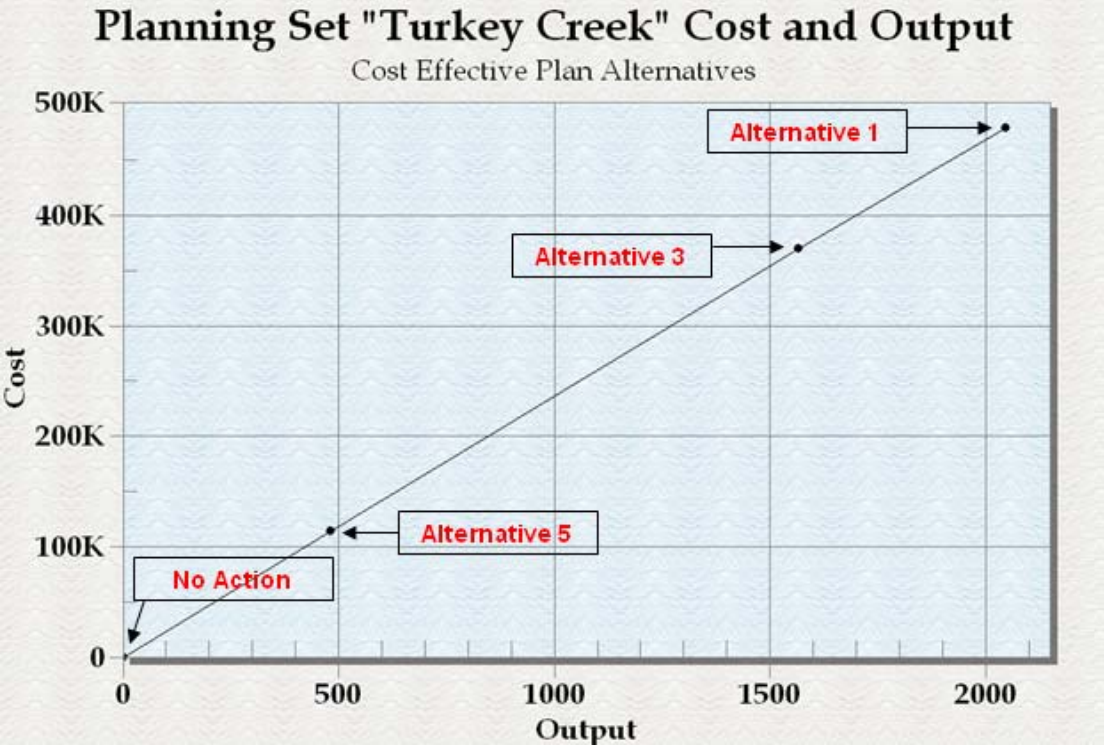


Figure 6.7-3. Display of Cost Effective Alternatives for the Turkey Creek Area

6.7.3 Regional Economic Development Benefits

6.7.3.1 Socioeconomic Impacts using the Economic Impact Forecast System

The purpose of this section is to show the economic impact of the proposed project alternatives on business (sale volumes), income, employment, and population of the local area. Each of the alternatives would affect the local area of Harrison County, Mississippi. The expenditures for the alternatives are estimated to be $7,600,000 for Alternative 1, $5,900,000 for Alternative 3, $1,900,000 for Alternative 5. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $1,112,000 for Alternative 1, $872,000 for Alternative 3, and $240,000 for Alternative 5 (assuming a 50 year period of analysis and an interest rate of 4.875 percent). Tables 6.7-9 through 6.7-12 show the EIFS model inputs and outputs for the cost effect alternatives.

Table 6.7-9.
EIFS Model Implementation Inputs for Turkey Creek Ecosystem

	No Action	Alternative 1	Alternative 3	Alternative 5
Region of Influence (ROI)	Harrison County	Harrison County	Harrison County	Harrison County
Change in Local Expenditures	$0	$7,600,000	$5,900,000	$1,900,000

Based of the given inputs the outputs are as follows:

Table 6.7-10.
EIFS Model Implementation Outputs for Turkey Creek Ecosystem

	No Action	Alternative 1	Alternative 3	Alternative 5
Direct Sales Volume	$0	$7,600,000	$5,900,000	$1,900,000
Induced Sales Volume	$0	$9,500,000	$7,375,000	$2,375,000
Total Sales Volume	$0	$17,100,000	$13,275,000	$4,275,000
Direct Income	$0	$1,608,733	$1,248,884	$402,183
Induced Income	$0	$2,010,916	$1,561,106	$502,729
Total Income	$0	$3,619,648	$2,809,990	$904,912
Direct Employment	0	48	37	12
Induced Employment	0	60	47	15
Total Employment	0	109	84	27
Local Population	0	0	0	0

Table 6.7-11.
EIFS Model O&M Inputs for Turkey Creek Ecosystem

	No Action	Alternative 1	Alternative 3	Alternative 5
Region of Influence (ROI)	Harrison County	Harrison County	Harrison County	Harrison County
Change in Local Expenditures	$0	$1,112,000	$872,000	$240,000

Based of the given inputs the outputs are as follows:

Table 6.7-12.
EIFS Model O&M Outputs for Turkey Creek Ecosystem

	No Action	Alternative 1	Alternative 3	Alternative 5
Direct Sales Volume	$0	$1,112,000	$872,000	$240,000
Induced Sales Volume	$0	$1,390,000	$1,090,000	$300,000
Total Sales Volume	$0	$2,502,000	$1,962,000	$540,000
Direct Income	$0	$235,383	$184,581	$50,802
Induced Income	$0	$294,229	$230,726	$63,503
Total Income	$0	$529,612	$415,307	$114,305
Direct Employment	0	7	6	2
Induced Employment	0	9	7	2
Total Employment	0	16	13	4
Local Population	0	0	0	0

6.8 Evaluation of Ocean Springs Area Measures

6.8.1 General

The Ocean Springs area, shown in figure 6.8-1, is located in the southwestern extent of planning unit three along the eastern shore of the Biloxi Bay. The area is denoted as planning sub-unit 22 and is depicted in the figure below. The pre-Hurricane Katrina conditions for this area represented a mostly residential community. As shown in table 6.8-1, it was estimated from the field inventorying process that planning sub-unit 22 included 3,722 tax parcels, of which 3,371 contained a structure with some economic value and 351 were vacant land. Of those 3,371 parcels that contain structures, 2,995 were residential one-story, 85 were residential two-story, 5 were mobile homes, 220 were commercial, and 66 were municipal.

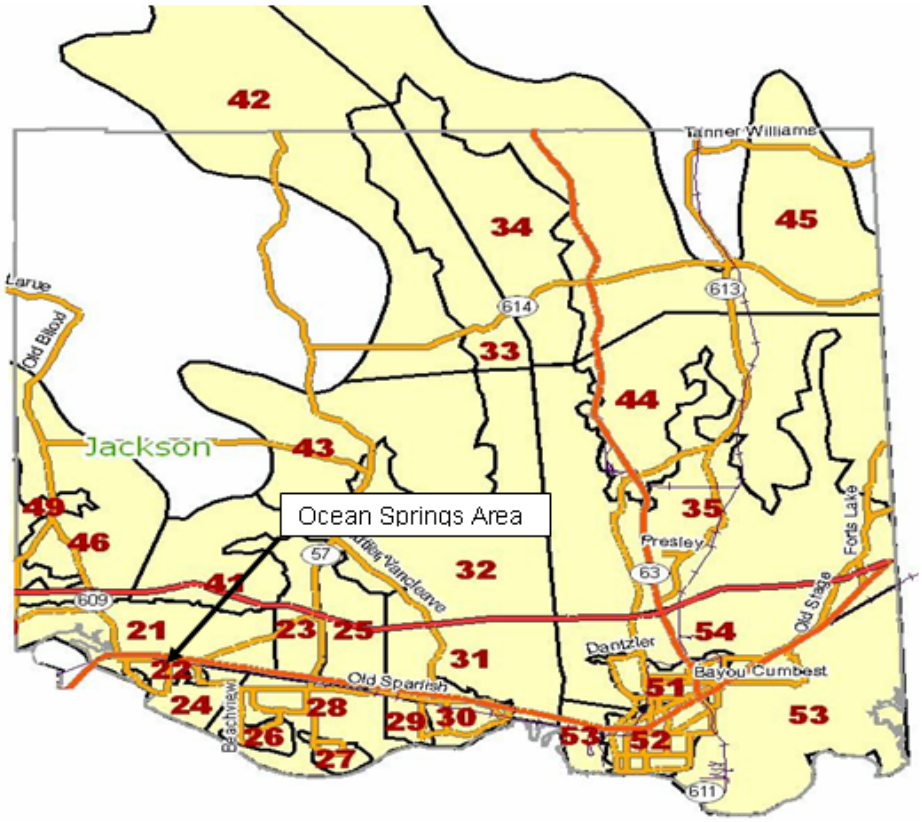


Figure 6.8-1. Ocean Springs Area – Planning Sub-unit 22

Table 6.8-1.
Pre-Hurricane Katrina Estimate of Structures for the Ocean Springs Area Planning Sub-unit 22

Asset Categories	Assets by Category
Residential	3,080
Mobile Homes	5
Commercial	220
Municipal	66
Vacant Land	351
Total Tax Parcels	**3,722**

6.8.2 Opportunities

The following opportunities were identified for this area:

- Hurricane storm damage reduction or remediation

6.8.3 Assumptions

The following assumptions were used in this analysis.

- The FY 2008 discount rate of 4.875 percent was used in estimating average annual benefits and costs
- Price levels are October, 2007 unless otherwise stated.
- A 100-year period of analysis (2012 to 2111) was used to calculate average annual benefits and costs.

6.8.4 Measures

Initially, a comprehensive list of measures was identified for flood damage reduction purposes for planning unit three. This list was screened and vetted for engineering and environmental feasibility and for policy compliance. The MsCIP Comprehensive Main Report and the Engineering and Environmental Appendices contain a detailed description of the measures that were initially screened.

Several potential measures were carried forward for this area for the purpose of flood damage reduction. These measures include both structural features and nonstructural actions. The measures evaluated for economic benefits include:

- Measure A – Ocean Springs 20-foot NAVD88 Ring Levee
  This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 20.0-feet NAVD88.
- Measure B – Ocean Springs 30-foot NAVD88 Ring Levee
  This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 30.0-feet NAVD88.
- Measure C – Ocean Springs Nonstructural One
  This measure includes the acquisition and flood proofing (elevate-in-place) of structures to the FEMA advisory base flood elevation (ABFE).

- Measure D – Ocean Springs Nonstructural Two
  This measure includes the acquisition and flood proofing of structures to approximately elevation 20.0-feet NAVD88.

- Measure E – Ocean Springs Nonstructural Three
  This measure includes the acquisition and flood proofing of structures to approximately elevation 30.0-feet NAVD88.

Figure 6.8-2 shows the measures for the Ocean Springs Area (planning sub-unit 22); the red line represents the approximate footprint of the ring levees, the dark green within the ring levee footprint represents potential ABFE buyout areas and the light green area within the ring levee footprint represents potential flood proof (elevate-in-place) areas.



Figure 6.8-2. Display of Potential Measures for the Ocean Springs Area (Planning Sub-Unit 22)

6.8.5 National Economic Development (NED)

The purpose of this section is to document investigations conducted to identify the National Economic Development (NED) benefits of each of the potential measures previously listed. For this analysis, NED benefits are the reduced inundation damages of assets and their contents when one of the potential measures is in place. Typically, NED benefits are annualized over the period of the analysis (average annual benefits) and then compared to annualized costs over the period of analysis (average annual costs). This comparison is commonly known as the benefit-to-cost ratio (BCR). For purposes of this analysis, no benefit-to-cost ratios will be calculated as per the legislative Congressional language authorizing this study. The Coastal Mississippi Comprehensive Plan Report was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December

2005, which states: "…***that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project plan features based upon maximizing net national economic development benefits…"*** More detail on the authorizing language can be found in the MsCIP Comprehensive Plan Main Report.

6.8.5.1 Existing Conditions Post-Hurricane Katrina)

The effects of Hurricane Katrina storm surge were devastating to the Ocean Springs Area. Peak water elevation in the area ranged from 20-to-21-feet NAVD88. It is estimated that between 95 and 99-percent of the structures in the area sustained significant inundation damage (fifty-percent or more). Destroyed residences and commercial structures have displaced the majority of the residences within the area. Expected redevelopment of the area is described in the following section.

6.8.5.2 Future Without-Project Conditions

Equivalent annual flood damages for several future without-project scenarios were evaluated using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. Each of the measures were evaluated and compared to future without-project scenarios three, and five, as previously discussed in section 5.3. These future scenarios were chosen because the redevelopment projected for this area is anticipated to return to the pre-Katrina development. Futures scenarios two, four, and six were not used for evaluation purposes since this area is not accommodative for commercial and condominium redevelopment under those mixed redevelopment scenarios (see section 5.3 for more detail).

Future scenario one is the full redevelopment of structures within the study area by the year 2012 with no relative sea level rise over the 100-year period of analysis. Table 6.8-2 shows structures by asset category and by elevation. The number of structures per elevation is added to the previous number of structures per elevation in each category. For example, in the residential category there are no structures with an elevation of 1-foot or lower, and there is one structure with an elevation of 2-feet or less, etc. This future scenario, as previously noted in section 5.3, is for sensitivity purposes only and will not be evaluated against all of the potential measures for the Ocean Springs area.

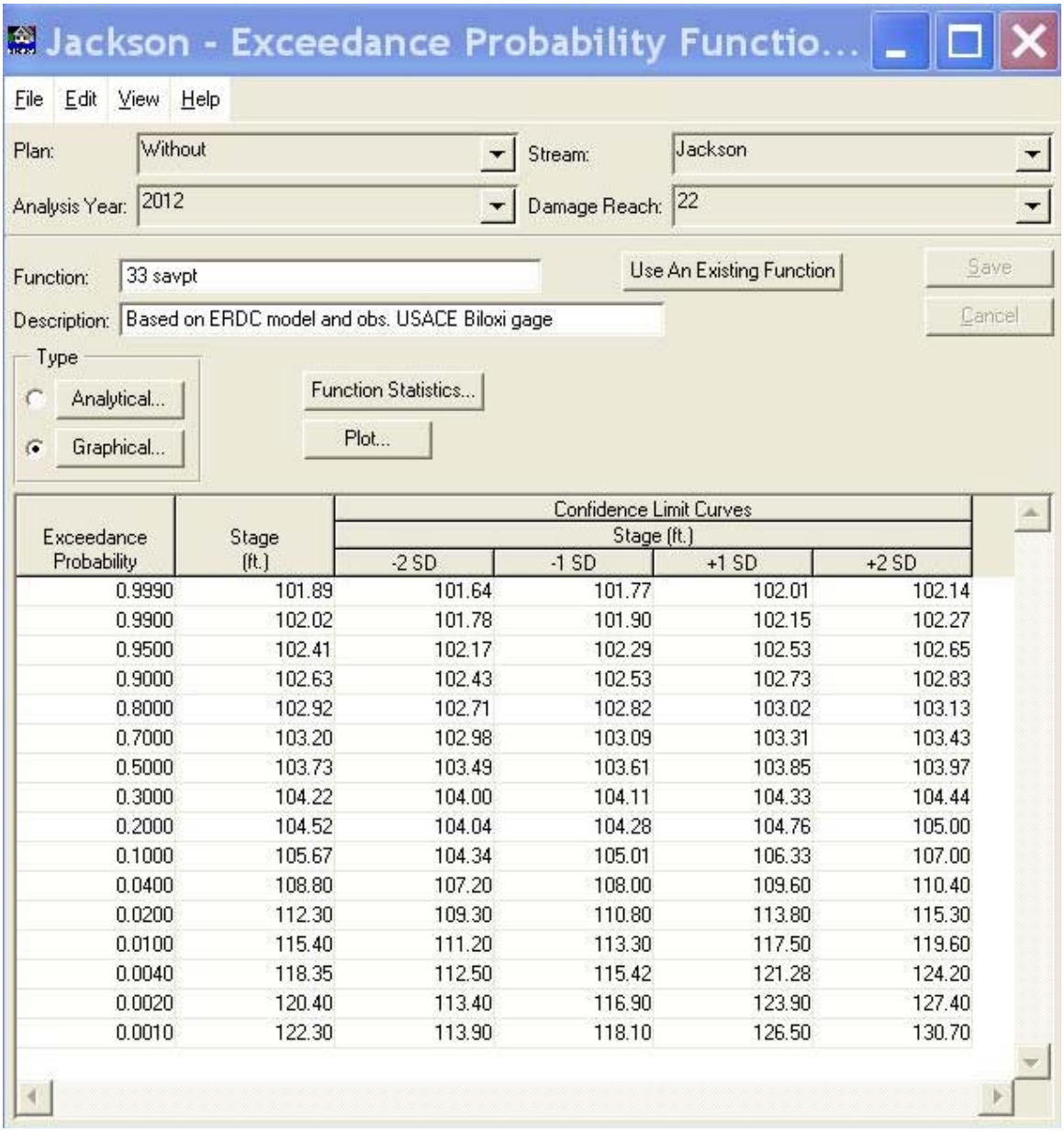
Table 6.8-2.
Cumulative Structures by Category and by Estimated First Floor Elevation Future Scenarios One, Three, and Five Applicable for Base Year and Most Likely Future Years

Estimated First Floor Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
1-foot	0	0	0	0	0
2-foot	1	0	0	0	1
3-foot	2	0	0	0	2
4-foot	4	0	0	0	4
5-foot	5	0	0	0	5
6-foot	9	0	0	0	9
7-foot	13	0	0	0	13
8-foot	22	0	0	0	22
9-foot	33	0	0	0	33
10-foot	48	0	0	0	48
11-foot	56	0	0	0	56

Table 6.8-2.
Cumulative Structures by Category and by Estimated First Floor Elevation Future Scenarios One, Three, and Five Applicable for Base Year and Most Likely Future Years (continued)

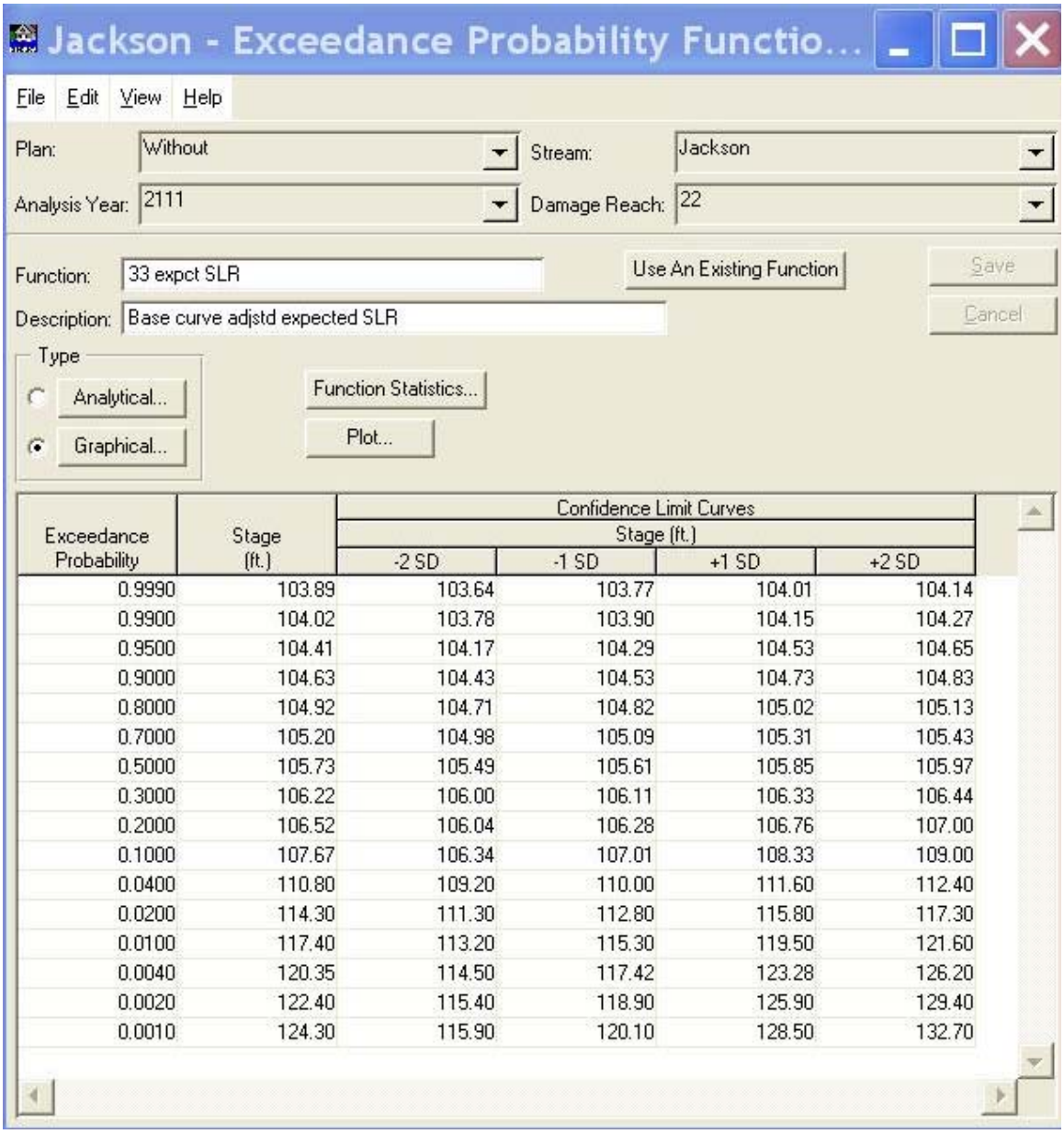
Estimated First Floor Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
12-foot	66	0	0	1	67
13-foot	78	0	0	1	79
14-foot	101	0	0	2	103
15-foot	122	0	0	2	124
16-foot	170	0	0	3	173
17-foot	296	1	9	13	319
18-foot	387	1	11	13	412
19-foot	577	1	17	14	609
20-foot	833	1	31	18	883
21-foot	1,150	1	46	20	1,217
22-foot	1,828	4	86	36	1,954
23-foot	2,687	5	169	52	2,913
24-foot	3,038	5	214	65	3,322
25-foot	3,075	5	220	66	3,366
26-foot	3,076	5	220	66	3,367
27-foot	3,077	5	220	66	3,368
28-foot	3,078	5	220	66	3,369
29-foot	3,079	5	220	66	3,370
30-foot	3,080	5	220	66	3,371
Total	**3,080**	**5**	**220**	**66**	**3,371**

Future scenario three is the full redevelopment of assets within the study area by the year 2012. Under this scenario, assets will be rebuilt as they were pre-Hurricane Katrina. For example, if the asset was a residential structure pre-Hurricane Katrina it will be rebuilt as a residential structure; commercial structures will be built back to commercial structures; etc. Basically, future scenario three is the same structure inventory as future scenario one with the addition of an expected relative sea level rise over the 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $1,958,000 (rounded to the nearest thousand dollars). The total number of structures in this scenario are the same as in scenario one and can be seen above in table 6.8-2. Figures 6.8-3 and 6.8-4 depict the base year and most likely future year exceedance probability functions for the Ocean Springs area (planning sub-unit 22). The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most likely future year exceedance probability function depicted in figure 6.8-4 includes an adjustment for expected relative sea level rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet. For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	101.89	101.64	101.77	102.01	102.14
0.9900	102.02	101.78	101.90	102.15	102.27
0.9500	102.41	102.17	102.29	102.53	102.65
0.9000	102.63	102.43	102.53	102.73	102.83
0.8000	102.92	102.71	102.82	103.02	103.13
0.7000	103.20	102.98	103.09	103.31	103.43
0.5000	103.73	103.49	103.61	103.85	103.97
0.3000	104.22	104.00	104.11	104.33	104.44
0.2000	104.52	104.04	104.28	104.76	105.00
0.1000	105.67	104.34	105.01	106.33	107.00
0.0400	108.80	107.20	108.00	109.60	110.40
0.0200	112.30	109.30	110.80	113.80	115.30
0.0100	115.40	111.20	113.30	117.50	119.60
0.0040	118.35	112.50	115.42	121.28	124.20
0.0020	120.40	113.40	116.90	123.90	127.40
0.0010	122.30	113.90	118.10	126.50	130.70

Figure 6.8-3. Future Scenario 3 Base Year (2012) Exceedance Probability Function for the Ocean Springs Area

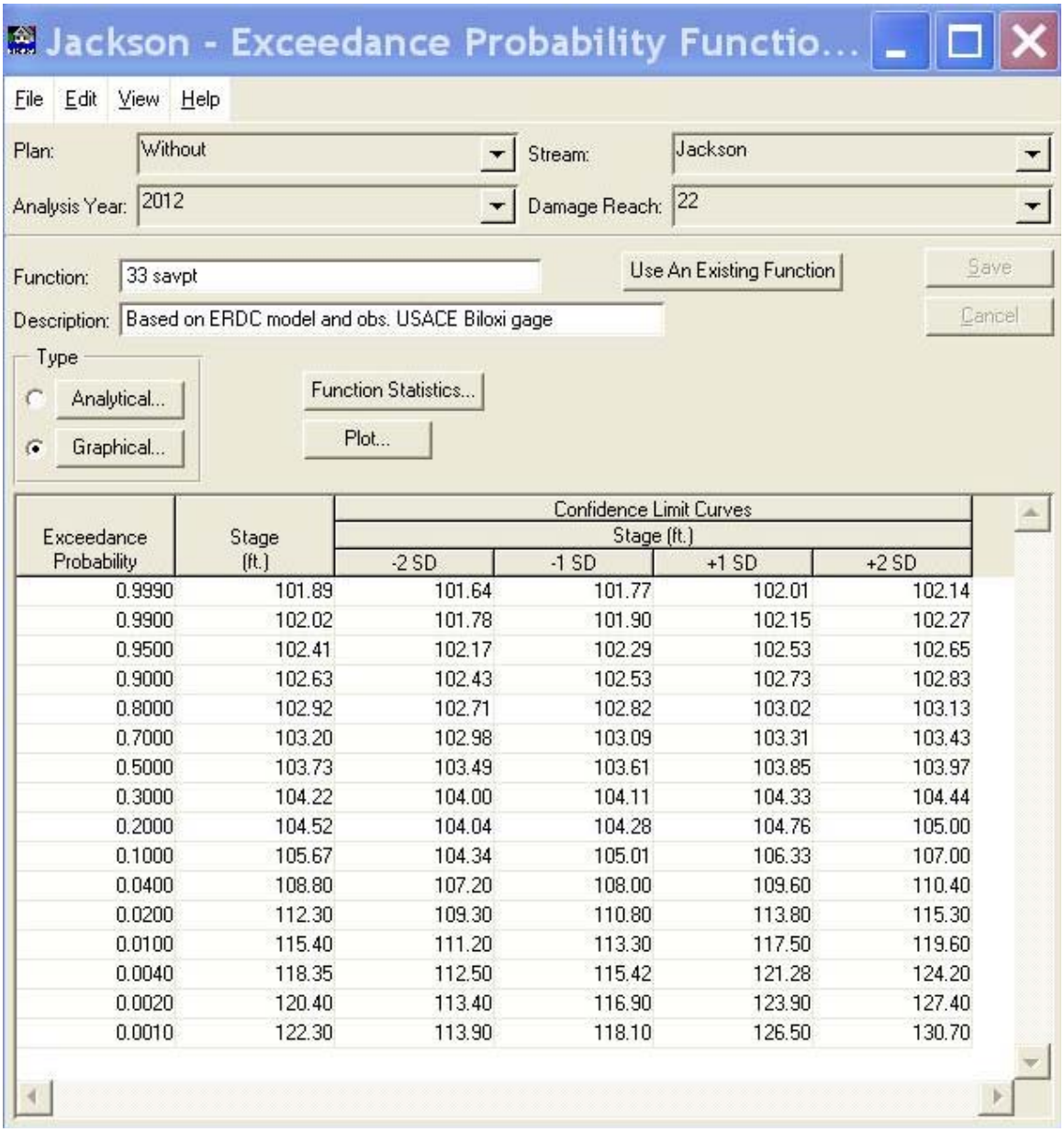


Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	103.89	103.64	103.77	104.01	104.14
0.9900	104.02	103.78	103.90	104.15	104.27
0.9500	104.41	104.17	104.29	104.53	104.65
0.9000	104.63	104.43	104.53	104.73	104.83
0.8000	104.92	104.71	104.82	105.02	105.13
0.7000	105.20	104.98	105.09	105.31	105.43
0.5000	105.73	105.49	105.61	105.85	105.97
0.3000	106.22	106.00	106.11	106.33	106.44
0.2000	106.52	106.04	106.28	106.76	107.00
0.1000	107.67	106.34	107.01	108.33	109.00
0.0400	110.80	109.20	110.00	111.60	112.40
0.0200	114.30	111.30	112.80	115.80	117.30
0.0100	117.40	113.20	115.30	119.50	121.60
0.0040	120.35	114.50	117.42	123.28	126.20
0.0020	122.40	115.40	118.90	125.90	129.40
0.0010	124.30	115.90	120.10	128.50	132.70

Figure 6.8-4. Future Scenario 3 Most Likely Future Year (2012) Exceedance Probability Function for the Ocean Springs Area – Includes an adjustment for relative sea level rise

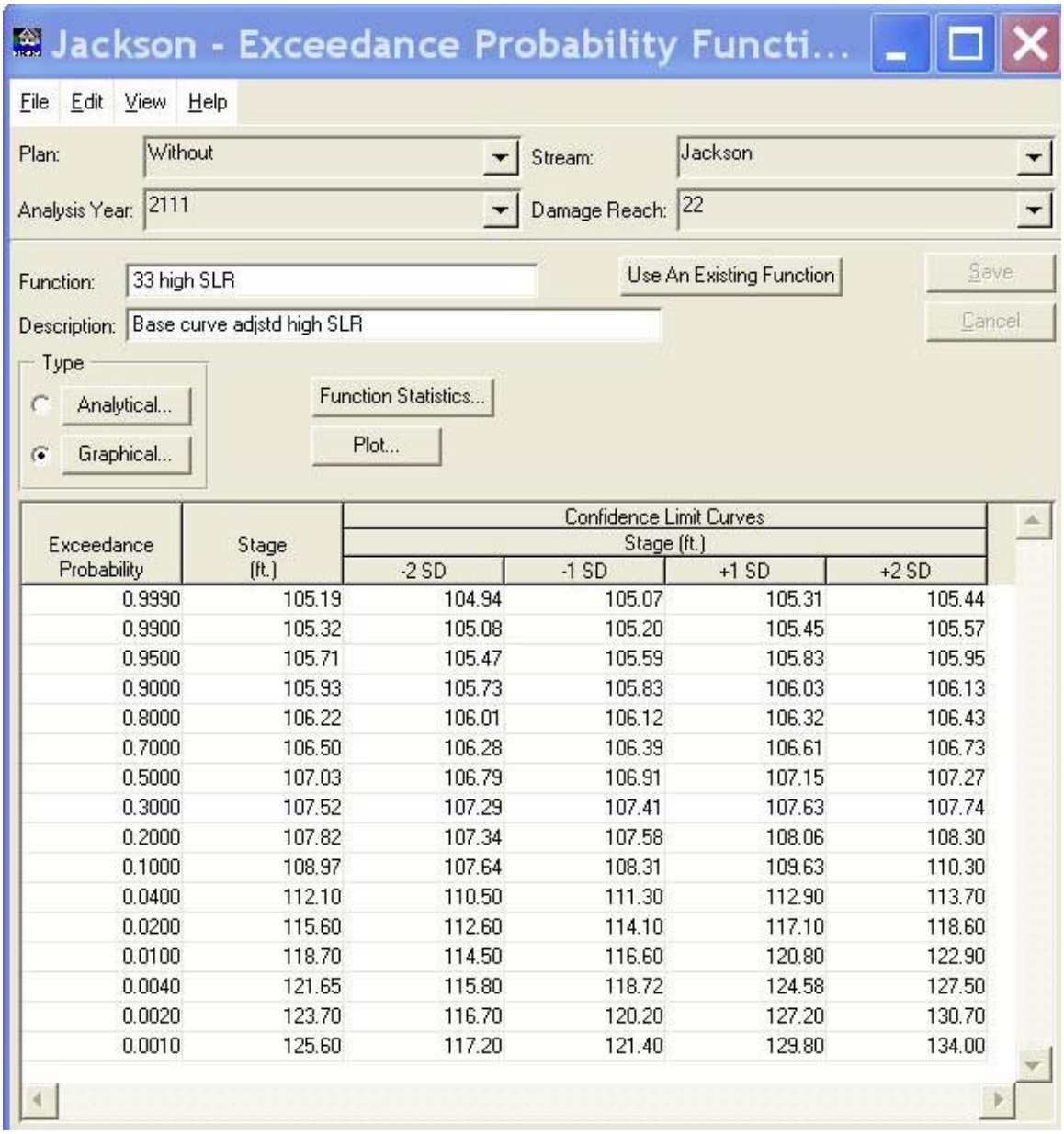
Future scenario five is the same as future scenario one with the addition of a high relative sea level rise 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $2,190,000 (rounded to the nearest thousand). These damages represent a approximately a ten-percent (10.2%) increase over the 2.0-feet of relative sea level rise accounted for in future scenario three. The total number of structures in this scenario is the same as in scenarios one and three and can be seen above in table 6.8-2. Figures 6.8-5 and 6.8-6 depict the base year and most likely future year exceedance probability functions for the Ocean Springs area (planning sub-unit 22). The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most likely future year exceedance probability function depicted in figure 6.8-6 includes an adjustment for expected relative

sea level rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet. For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	101.89	101.64	101.77	102.01	102.14
0.9900	102.02	101.78	101.90	102.15	102.27
0.9500	102.41	102.17	102.29	102.53	102.65
0.9000	102.63	102.43	102.53	102.73	102.83
0.8000	102.92	102.71	102.82	103.02	103.13
0.7000	103.20	102.98	103.09	103.31	103.43
0.5000	103.73	103.49	103.61	103.85	103.97
0.3000	104.22	104.00	104.11	104.33	104.44
0.2000	104.52	104.04	104.28	104.76	105.00
0.1000	105.67	104.34	105.01	106.33	107.00
0.0400	108.80	107.20	108.00	109.60	110.40
0.0200	112.30	109.30	110.80	113.80	115.30
0.0100	115.40	111.20	113.30	117.50	119.60
0.0040	118.35	112.50	115.42	121.28	124.20
0.0020	120.40	113.40	116.90	123.90	127.40
0.0010	122.30	113.90	118.10	126.50	130.70

Figure 6.8-5 Future Scenario 5 Base Year (2012) Exceedance Probability Function for the Ocean Springs Area



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	105.19	104.94	105.07	105.31	105.44
0.9900	105.32	105.08	105.20	105.45	105.57
0.9500	105.71	105.47	105.59	105.83	105.95
0.9000	105.93	105.73	105.83	106.03	106.13
0.8000	106.22	106.01	106.12	106.32	106.43
0.7000	106.50	106.28	106.39	106.61	106.73
0.5000	107.03	106.79	106.91	107.15	107.27
0.3000	107.52	107.29	107.41	107.63	107.74
0.2000	107.82	107.34	107.58	108.06	108.30
0.1000	108.97	107.64	108.31	109.63	110.30
0.0400	112.10	110.50	111.30	112.90	113.70
0.0200	115.60	112.60	114.10	117.10	118.60
0.0100	118.70	114.50	116.60	120.80	122.90
0.0040	121.65	115.80	118.72	124.58	127.50
0.0020	123.70	116.70	120.20	127.20	130.70
0.0010	125.60	117.20	121.40	129.80	134.00

Figure 6.8-6 Future Scenario 5 Most Likely Future Year (2012) Exceedance Probability Function for the Ocean Springs Area – Includes an adjustment for relative sea level rise

6.8.5.3 Equivalent annual damages Reduced

Equivalent annual damages reduced are calculated as the difference between the damages under the future without-project scenarios three and five and the damages incurred with the measure in place. The HECFDA model was run for each measure to determine the damages reduced as compared to the without-project scenario.

In order to provide the HEC-FDA model with accurate information about the economic characteristics of each measure, separate inventories were created for each measure. The inventories are the same as the without project inventory except that footprints of levees and acquisitions were deleted from the inventory and flood proofed structures (structures to be raised in place) were given a higher elevation. The structure inventories for each of the HEC-FDA measure runs are as follows:

- Measure A – Ocean Springs Ring Levee at elevation 20.0-feet NAVD88

This measure includes the without-project inventory less 150 parcels that were deleted out of the inventory. These parcels represent the footprint of the 20.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure B – Ocean Springs Ring Levee at elevation 30.0-feet NAVD88

This measure includes the without-project inventory less 488 parcels that were deleted out of the inventory. These parcels represent the footprint of the 30.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure C – Ocean Springs Nonstructural One

This measure includes the acquisition of 50 parcels that include a structure and the flood proofing (raise structure in place) of 92 structures to an elevation of 16.1-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was determined to be approximately the ABFE level of protection and is defined as still water elevation, plus wave run-up, plus an estimate for waves (depth divided by two), and is the minimum implementation elevation that a nonstructural measure do to the requirements of the National Flood Insurance Program (NFIP).

- Measure D – Ocean Springs Nonstructural Two to elevation 20.0-feet NAVD88

This measure includes the acquisition of 93 parcels that include a structure and the flood proofing (raise structure in place) of 49 structures to an elevation of 20.0-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levee at elevation 20.0-feet NAVD88.

- Measure E – Ocean Springs Nonstructural Three to elevation 30.0-feet NAVD88

This measure includes the acquisition of 142 parcels that include a structure. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing

Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levee at elevation 30.0-feet NAVD88.

Residual damage is the equivalent annual damages that still remain even when a project is in place. Residual damage is calculated as the future without-project equivalent annual damages minus the damages reduced of the various measures. The purpose of residual damages is to calculate and communicate the portions of damages that will not be reduced by the implementation of a plan or "what damages are left on the table." Table 6.8-3 summarizes the equivalent annual without-project damages, damages reduced, and residual damages by measure and by future scenario.

Table 6.8-3.
Summary of Damages by Potential Measure and by Applicable Future Scenario

Measures	Equivalent annual damages Future 3 ($)	Equivalent Annual Damage Reduction Future 3 ($)	Residual Damage Future 3 ($)	Equivalent annual damages Future 5 ($)	Equivalent Annual Damage Reduction Future 5 ($)	Residual Damage Future 5 ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A 20FT Ring Levee	$1,958,000	$1,276,000	$682,000	$2,190,000	$1,434,000	$757,000
Measure B 30FT Ring Levee	$1,958,000	$1,873,000	$85,000	$2,190,000	$2,093,000	$97,000
Measure C ABFE Nonstructural	$1,958,000	$818,000	$1,140,000	$2,190,000	$913,000	$1,277,000
Measure D 20FT Nonstructural	$1,958,000	$1,089,000	$869,000	$2,190,000	$1,235,000	$955,000
Measure E 30FT Nonstructural	$1,958,000	$1,466,000	$492,000	$2,190,000	$1,658,000	$532,000

Damages are rounded to the nearest thousand dollars.

6.8.6 Environmental Quality (EQ)

6.8.6.1 Impacts of Levee Measures

The Engineering Research and Development Center Wetlands and Coastal Ecology Branch were asked to conduct an assessment of potential impacts to wetlands as a result of constructing various levees and seawalls along the Mississippi Gulf Coastal Plain. This report summarizes the results of the assessment. The analysis of impacts included two components:

3) A calculation of total acreage of all wetlands (by type and planning reach) that is directly under the levee footprints.

4) A modified Hydrogeomorphic (HGM) wetland rapid assessment of impacted Estuarine/Tidal Fringe wetlands, based on the Mississippi and Alabama Gulf Coast HGM guidebook (Shafer et al., 2007), with impacts reported as loss of functional units. Tables 6.8-4 and 6.8-5 show the impacts of the Ocean Springs ring levees at elevations 20.0-feet NAVD88, and 30.0-feet NAVD88 respectively.

Table 6.8-4.
Wetland acres impacted by elevation 20' Ocean Springs ring levee

Reach ID	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Total
22	3.7	0.3	1.1	5.1
24	1.1	0.0	0.2	1.2
Total	**4.8**	**0.3**	**1.2**	**6.3**

Table 6.8-5.
Wetland acres impacted by elevation 30' Ocean Springs ring levee

Reach ID	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Total
22	5.2	0.4	4.7	10.3
24	2.4	0.0	2.6	5.0
Total	**7.5**	**0.4**	**7.3**	**15.2**

Nonstructural measures would have no construction activities other than demolition and disposal of building materials in an approved land fill occurs as a result of this measure. More detail on the impacts of the structural and nonstructural measures for the Ocean Springs area can be found in the Environmental Appendix.

6.8.7 Summary of Costs

Table 6.8-6 summarizes the ROM costs at an FY-08 price level by measure for the Ocean Springs area (planning sub-unit 22).

Table 6.8-6.
Summary of Costs by Measure for the Ocean Springs Area

Measures	Implementation Costs (FY-08) ($)	Capital Recovery Factor	Average Annual Implementation Cost ($)	Average Annual O&M ($)	IDC ($)	Total Average Annual Costs ($)
(No Action)	$0	0.049171225	$0	$0	$0	$0
Measure A 20FT Ring Levee	$152,100,000	0.049171225	$7,479.000	$1,414,000	N/A	$8,893,000
Measure B 30FT Ring Levee	$327,000,000	0.049171225	$16,079,000	$2,532,000	N/A	$18,611,000
Measure C ABFE Nonstructural	$59,219,000	0.049171225	$2,912,000	$10,000	N/A	$2,922,000
Measure D 20FT Nonstructural	$872,740,000	0.049171225	$42,914,000	$10,000	N/A	$42,924,000
Measure E 30FT Nonstructural	$872,740,000	0.049171225	$42,914,000	$10,000	N/A	$42,924,000

The implementation costs include 1/ supervision and administration (30 account), 2/ planning, engineering & design (31 account) and 3/ appropriate contingencies. See the Cost Appendix for more detail on the implementation cost breakdowns.

6.8.8 Regional Economic Development (RED)

This section summarizes how each of the measures would affect the local area of Jackson County, Mississippi. The expenditures for the measures are estimated to be $152,100,000 for the 20.0-feet NAVD88 measure, $327,000,000 for the 30.0-feet NAVD88 measure $59,219,000 for ABFE nonstructural measure, $617,965,000 for the 20.0-feet NAVD88 nonstructural measure, and $617,965,000 for the 30.0-feet NAVD88 nonstructural measure. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $28,757,000 for the 20.0-feet NAVD88 ring levee measure, $51,494,000 for the 30.0-feet NAVD88 ring levee measure, $203,000 for the ABFE nonstructural measure, $203,000 for the 20.0-feet NAVD88 nonstructural measure, and $203,000 for the 30.0-feet NAVD88 nonstructural measure respectively (assuming a 100 - year period of analysis and an interest rate of 4.875-percent). Tables 6.8-7 through 6.8-10 summarize the inputs and outputs of the EIFS model runs for the Ocean Springs area (planning sub-unit 22).

Table 6.8-7.
EIFS Model Implementation Costs Inputs for the Ocean Springs Area

	20-foot Ring Levee	30-foot Ring Levee	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$152,100,000	$327,000,000	$59,219,000	$617,965,000	$872,740,000

Based of the given inputs the outputs are as follows:

Table 6.8-8.
EIFS Model Implementation Costs Outputs for the Ocean Springs Area

	20-foot Ring Levee	30-foot Ring Levee	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Direct Sales Volume	$152,100,000	$327,000,000	$59,219,000	$617,965,000	$872,740,000
Induced Sales Volume	$170,352,000	$366,240,000	$66,325,280	$692,120,800	$977,468,800
Total Sales Volume	$322,452,000	$693,240,000	$125,544,280	$1,310,085,800	$1,850,208,800
Direct Income	$29,663,388	$63,773,358	$11,549,219	$120,518,970	$170,206,607
Induced Income	$33,222,990	$71,426,152	$12,935,123	$134,981,230	$190,631,376
Total Income	$62,886,378	$135,199,510	24,484,342	$255,500,200	$360,837,984
Direct Employment	861	1,851	335	3,498	4,940
Induced Employment	964	2,073	375	3,918	5,533
Total Employment	1,825	3,924	711	7,416	10,473
Local Population	0	0	0	0	0

Table 6.8-9.
EIFS Model O&M Cost Inputs for the Ocean Springs Area

	20-foot Ring Levee	30-foot Ring Levee	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$28,757,000	$51,494,000	$203,000	$203,000	$203,000

Based of the given inputs the outputs are as follows:

Table 6.8-10.
EIFS Model O&M Cost Outputs for the Ocean Springs Area

	20-foot Ring Levee	30-foot Ring Levee	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Direct Sales Volume	$28,757,000	$51,494,000	$203,000	$203,000	$203,000
Induced Sales Volume	$32,207,840	$57,673,280	$227,360	$227,360	$227,360
Total Sales Volume	60,964,840	$109,167,280	$430,360	$430,360	$430,360
Direct Income	$5,608,350	$10,042,646	$39,590	$39,590	$39,590
Induced Income	$6,281,351	$11,247,762	$44,341	$44,341	$44,341
Total Income	$11,889,701	$21,290,409	$83,931	$83,931	$83,931
Direct Employment	163	291	1	1	1
Induced Employment	182	326	1	1	1
Total Employment	345	617	2	2	2
Local Population	0	0	0	0	0

6.9 Evaluation of Gautier Area Measures

6.9.1 General

The Gautier area, shown in Figure 6.9-1, is located in the southern portion of planning unit three along the Mississippi Sound. The area is denoted as planning sub-unit 30 and is depicted in the figure below. The pre-Hurricane Katrina conditions for this area represented a mostly residential community. As demonstrated in table 6.9-1, it was estimated from the field inventorying process that planning sub-unit 30 included 3,113 tax parcels, of which 2,555 contained a structure with some economic value and 558 were vacant land. Of those 2,555 parcels that contain structures, 2,166 were residential one-story, 118 were residential two-story, 28 were mobile homes, 182 were commercial, and 61 were municipal.

6.9.2 Opportunities

The following opportunity was identified for this area:

- Hurricane storm damage reduction or remediation

6.9.3 Assumptions

The following assumptions were used in this analysis.

- The FY 2008 discount rate of 4-7/8 percent was used in estimating average annual benefits and costs
- Price levels are October, 2007 unless otherwise stated.
- A 100-year period of analysis (2012 to 2111) was used to calculate average annual benefits and costs.

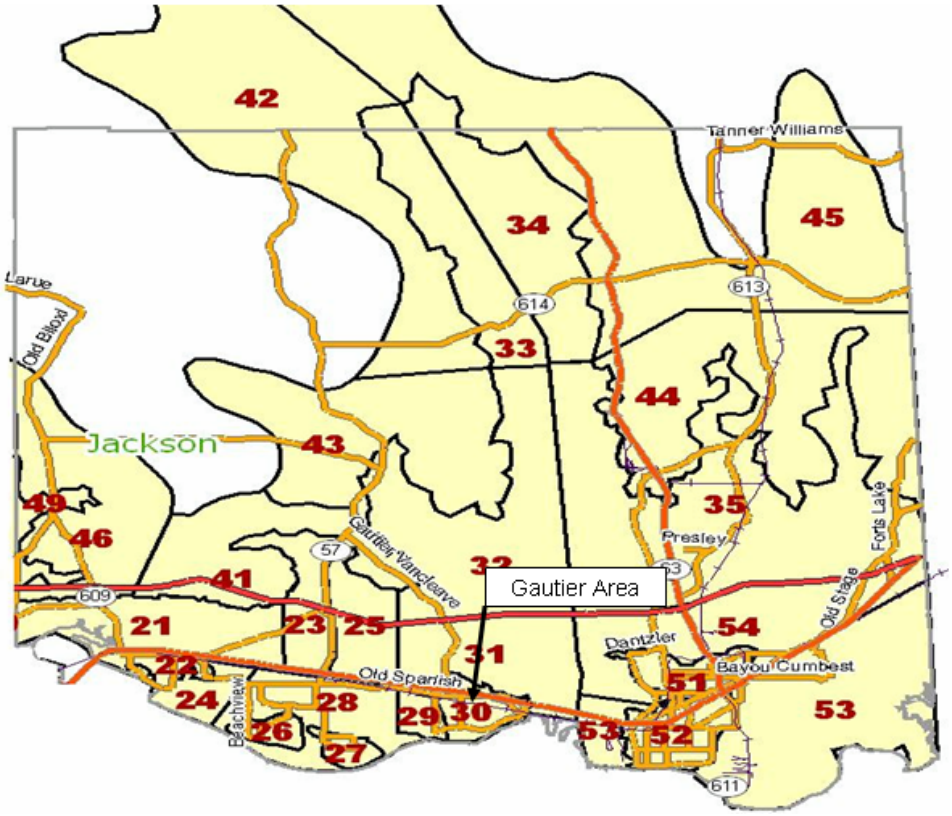


Figure 6.9-1. Gautier Area – Planning Sub-unit 30

Table 6.9-1.
Pre-Hurricane Katrina Estimate of Structures for the Gautier Area (Planning Sub-unit 30)

Asset Categories	Assets by Category
Residential	2,284
Mobile Homes	28
Commercial	182
Municipal	61
Vacant Land	558
Total Tax Parcels	**3,113**

6.9.4 Measures

Initially, a comprehensive list of measures was identified for flood damage reduction purposes for planning unit three. This list was screened and vetted for engineering and environmental feasibility and for policy compliance. The MsCIP Comprehensive Main Report and the Engineering and Environmental Appendices contain a detailed description of the measures that were initially screened.

Several potential measures were carried forward for this area for the purpose of flood damage reduction. These measures include both structural features and nonstructural actions. The measures evaluated for economic benefits include:

Measure A – Gautier Ring Levee

This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 20.0-feet NAVD88.

Measure B – Gautier Ring Levee

This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 30.0-feet NAVD88.

Measure C – Gautier Nonstructural One

This measure includes the acquisition and flood proofing (elevation-in-place) of structures to the FEMA advisory base flood elevation (ABFE).

Measure D – Gautier Nonstructural Two

This measure includes the acquisition and flood proofing of structures to approximately elevation 20-feet NAVD88.

Measure E – Gautier Nonstructural Three

This measure includes the acquisition and flood proofing of structures to approximately elevation 30-feet NAVD88.

Figure 6.9-2 shows the measures for the Gautier Area (planning sub-unit 30); the red line represents the approximate footprint of the ring levees, the dark green within the ring levee footprint represents potential ABFE buyout areas and the light green area within the ring levee footprint represents potential flood proof (elevate-in-place) areas.

6.9.5 National Economic Development (NED)

The purpose of this section is to document investigations conducted to identify the National Economic Development (NED) benefits of each of the potential measures previously listed. For this analysis, NED benefits are the reduced inundation damages of assets and their contents when one of the potential measures is in place. Typically, NED benefits are annualized over the period of the analysis (average annual benefits) and then compared to annualized costs over the period of analysis (average annual costs). This comparison is commonly known as the benefit-to-cost ratio (BCR). For purposes of this analysis, no benefit-to-cost ratios will be calculated as per the legislative Congressional language authorizing this study. The Coastal Mississippi Comprehensive Plan Report was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states: "…***that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project plan features based upon maximizing net national economic development benefits…"*** More detail on the authorizing language can be found in the MsCIP Comprehensive Plan Main Report.

6.9.5.1 Existing Conditions Post-Hurricane Katrina)

The effects of Hurricane Katrina storm surge were devastating to the Gautier Area. Peak water elevation in the area ranged from 15 to 18-feet NAVD88. It is estimated that 450 of the structures in the area, mostly residential structures, and sustained significant inundation damage (fifty-percent or more). Expected redevelopment of the area is described in the following section.

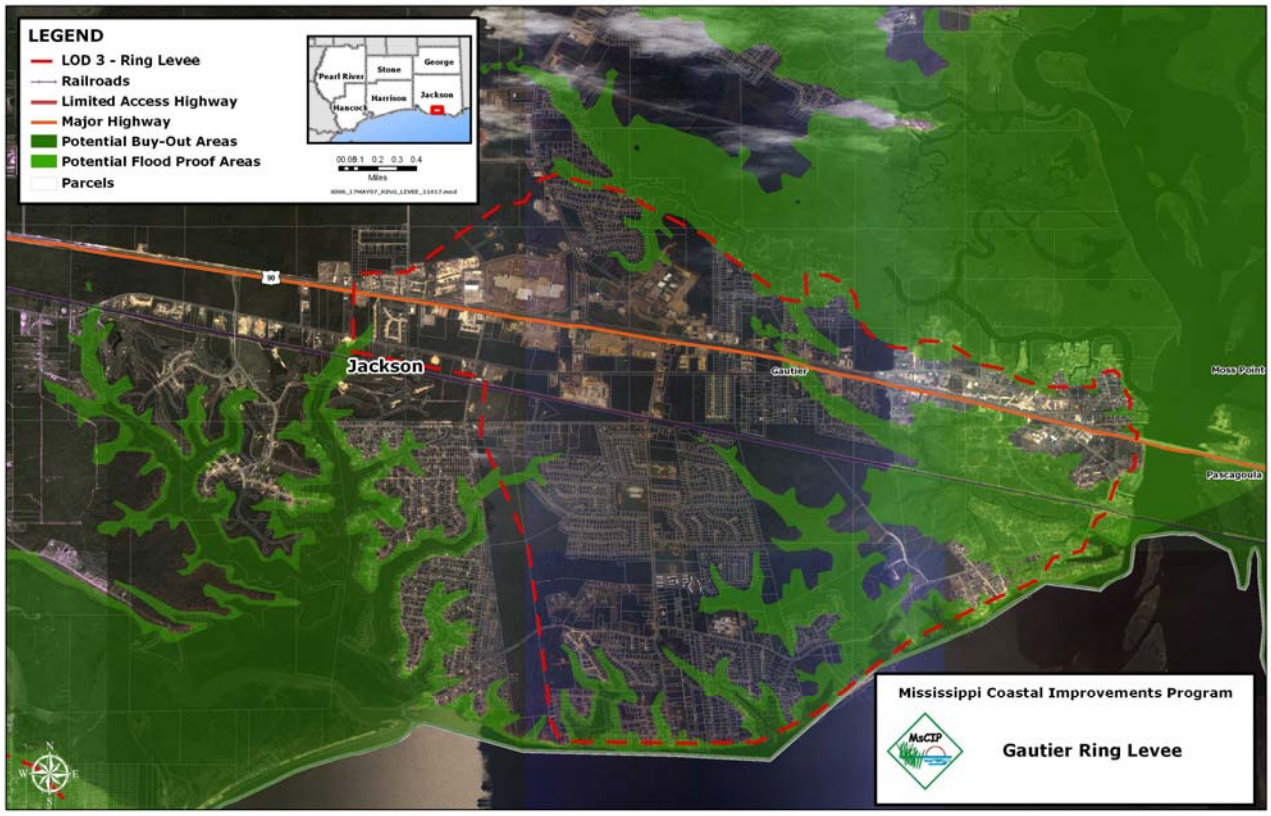


Figure 6.9-2. Display of Potential Measures for the Gautier Area (Planning Sub-Unit 30)

6.9.5.2 Future Without-Project Conditions

Equivalent annual flood damages for several future without-project scenarios were evaluated using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. Each of the measures were evaluated and compared to future without-project scenarios three, and five, as previously discussed in section 5.3. These future scenarios were chosen because the redevelopment projected for this area is anticipated to return to the pre-Katrina development. Futures scenarios two, four, and six were not used for evaluation purposes since this area is not accommodative for commercial and condominium redevelopment under those mixed redevelopment scenarios (see section 5.3 for more detail).

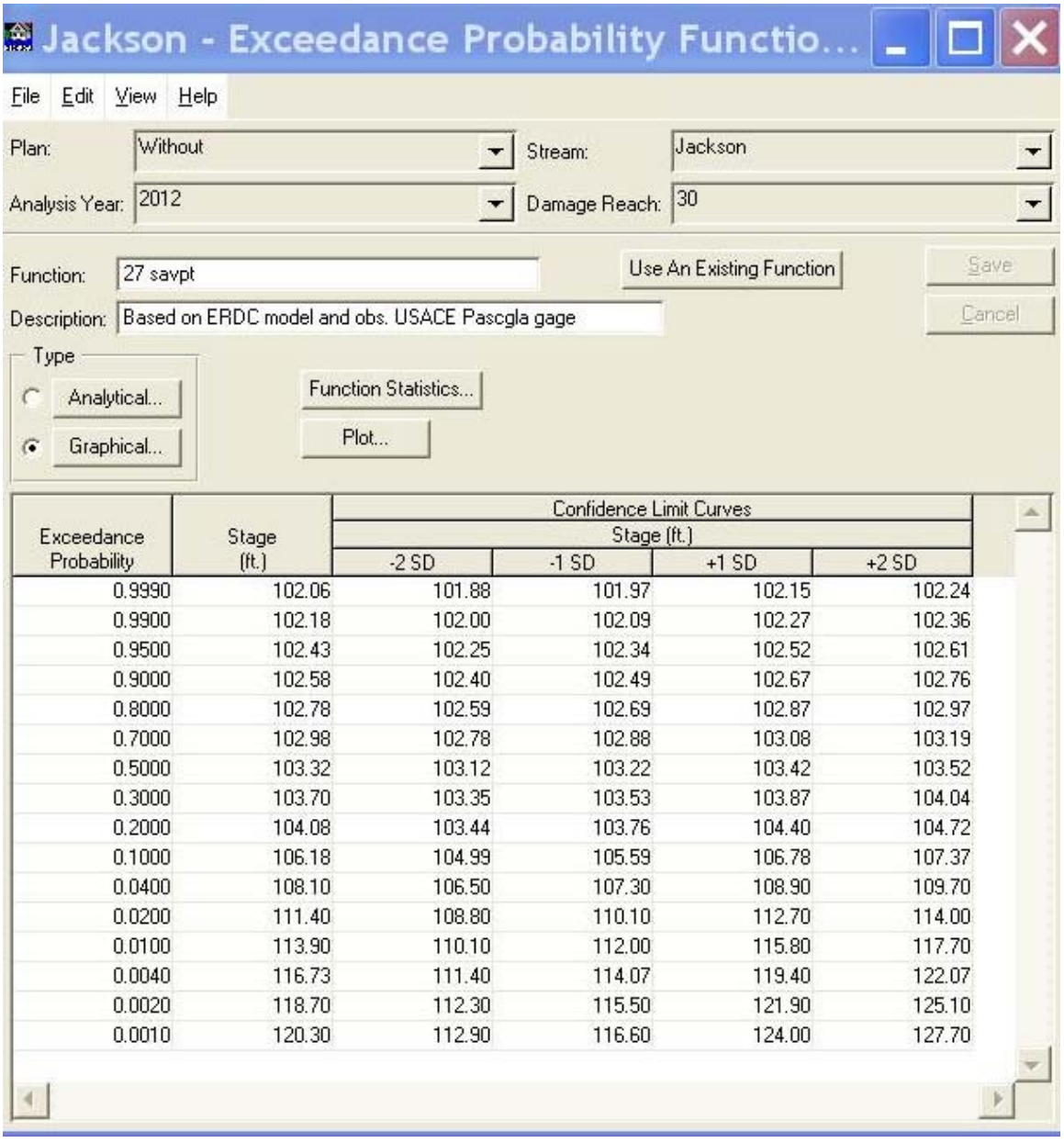
Future scenario one is the full redevelopment of assets within the study area by the year 2012 with no relative sea level rise over the 100-year period of analysis. Table 6.9-2 shows structures by asset category and by elevation. The number of structures per elevation is added to the previous number of structures per elevation in each category. For example, in the residential category there are two structures with an elevation of 1-foot or lower, there are five structures with an elevation of 2-feet or less, etc. This future scenario, as previously noted in section 5.3, is for sensitivity purposes only and will not be evaluated against all of the potential measures for the Gautier area.

Table 6.9-2.
Cumulative Structures by Category and by Estimated First Floor Elevation Future Scenarios One, Three, and Five Applicable for Base Year and Most Likely Future Years

Estimated First Floor Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
1-foot	2	0	0	0	2
2-foot	5	0	0	0	5
3-foot	14	0	0	0	14
4-foot	27	0	0	0	27
5-foot	38	0	0	0	38
6-foot	55	0	0	0	55
7-foot	66	0	0	0	66
8-foot	84	0	0	0	84
9-foot	110	0	0	0	110
10-foot	131	0	0	0	131
11-foot	169	0	0	0	169
12-foot	238	2	5	2	247
13-foot	320	4	15	5	344
14-foot	400	6	23	7	436
15-foot	521	7	34	10	572
16-foot	710	10	51	14	785
17-foot	1,354	16	84	40	1,494
18-foot	1,979	19	106	49	2,153
19-foot	2,221	22	124	52	2,419
20-foot	2,267	24	156	57	2,504
21-foot	2,275	26	171	60	2,532
22-foot	2,279	28	178	61	2,546
23-foot	2,280	28	182	61	2,551
24-foot	2,280	28	182	61	2,551
25-foot	2,282	28	182	61	2,553
26-foot	2,282	28	182	61	2,553
27-foot	2,282	28	182	61	2,553
28-foot	2,282	28	182	61	2,553
29-foot	2,282	28	182	61	2,553
30-foot	2,282	28	182	61	2,553
31-foot	2,283	28	182	61	2,554
32-foot	2,284	28	182	61	2,555
Total	**2,284**	**28**	**182**	**61**	**2,555**

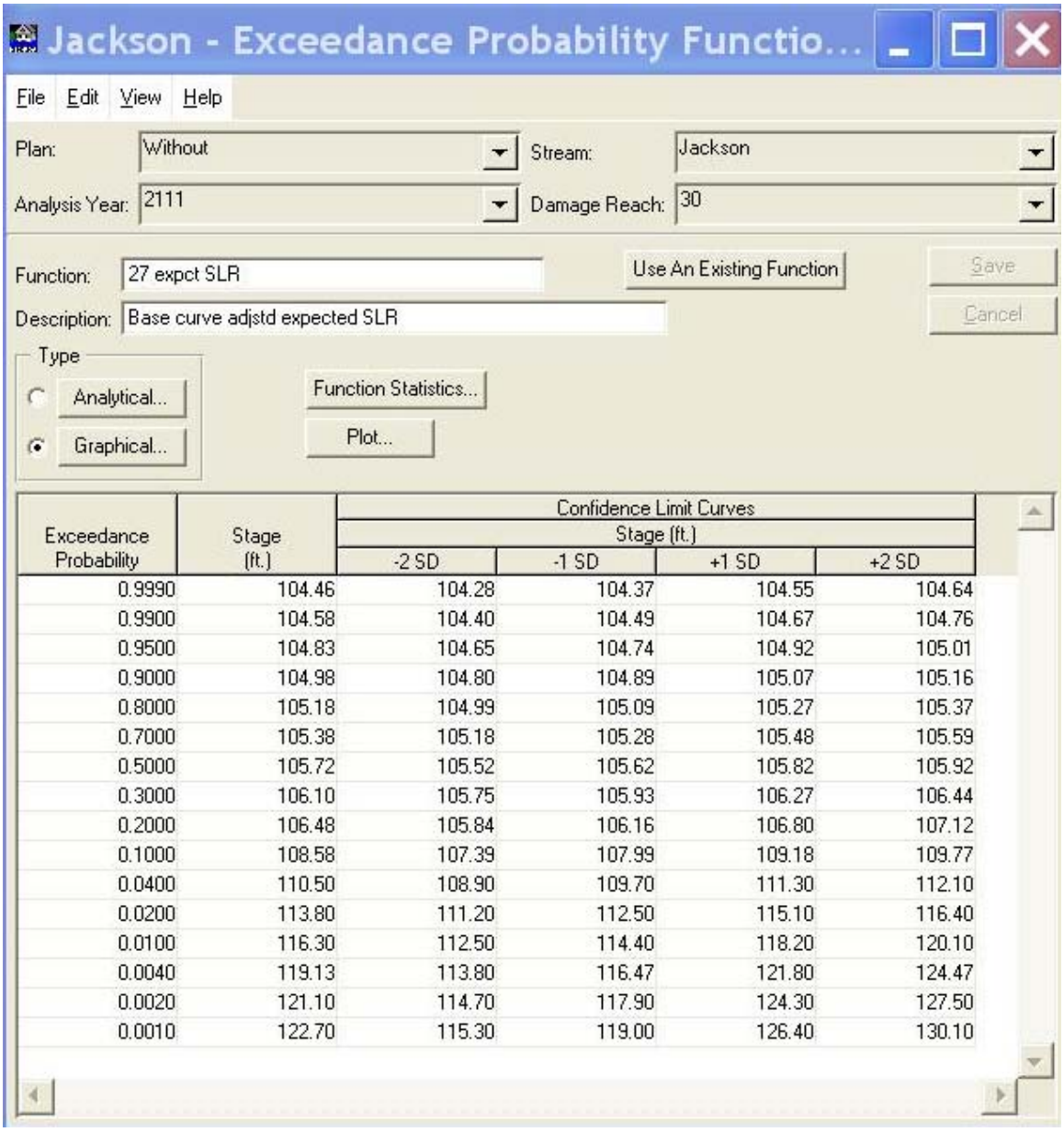
Future scenario three is the full redevelopment of assets within the study area by the year 2012. Under this scenario, assets will be rebuilt as they were pre-Hurricane Katrina. For example, if the asset was a residential structure pre-Hurricane Katrina it will be rebuilt as a residential structure; commercial structures will be built back to commercial structures; etc. Basically, future scenario three is the same structure inventory as future scenario one with the addition of an expected relative sea level rise over the 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $5,831,000 (rounded to the nearest thousand dollars). The total number of structures in this scenario are the same as in scenario one and can be seen above in

table 6.9-2. Figures 6.9-3 and 6.9-4 depict the base year and most likely future year exceedance probability functions for the Gautier area (planning sub-unit 30). The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most likely future year exceedance probability function depicted in figure 6.9-4 includes an adjustment for expected relative sea level rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet. For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	102.06	101.88	101.97	102.15	102.24
0.9900	102.18	102.00	102.09	102.27	102.36
0.9500	102.43	102.25	102.34	102.52	102.61
0.9000	102.58	102.40	102.49	102.67	102.76
0.8000	102.78	102.59	102.69	102.87	102.97
0.7000	102.98	102.78	102.88	103.08	103.19
0.5000	103.32	103.12	103.22	103.42	103.52
0.3000	103.70	103.35	103.53	103.87	104.04
0.2000	104.08	103.44	103.76	104.40	104.72
0.1000	106.18	104.99	105.59	106.78	107.37
0.0400	108.10	106.50	107.30	108.90	109.70
0.0200	111.40	108.80	110.10	112.70	114.00
0.0100	113.90	110.10	112.00	115.80	117.70
0.0040	116.73	111.40	114.07	119.40	122.07
0.0020	118.70	112.30	115.50	121.90	125.10
0.0010	120.30	112.90	116.60	124.00	127.70

Figure 6.9-3. Future Scenario 3 Base Year (2012) Exceedance Probability Function for the Gautier Area

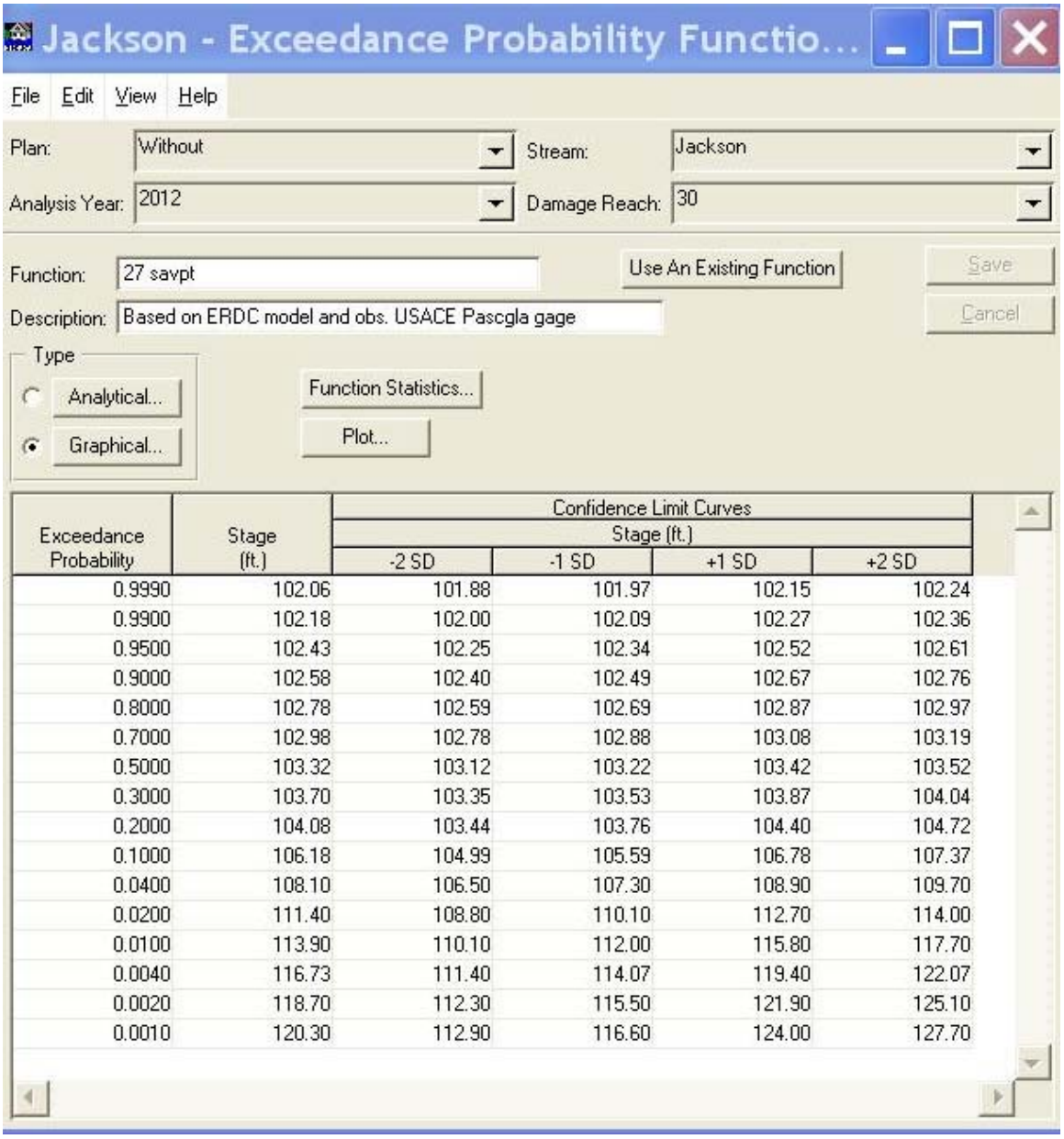


Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	104.46	104.28	104.37	104.55	104.64
0.9900	104.58	104.40	104.49	104.67	104.76
0.9500	104.83	104.65	104.74	104.92	105.01
0.9000	104.98	104.80	104.89	105.07	105.16
0.8000	105.18	104.99	105.09	105.27	105.37
0.7000	105.38	105.18	105.28	105.48	105.59
0.5000	105.72	105.52	105.62	105.82	105.92
0.3000	106.10	105.75	105.93	106.27	106.44
0.2000	106.48	105.84	106.16	106.80	107.12
0.1000	108.58	107.39	107.99	109.18	109.77
0.0400	110.50	108.90	109.70	111.30	112.10
0.0200	113.80	111.20	112.50	115.10	116.40
0.0100	116.30	112.50	114.40	118.20	120.10
0.0040	119.13	113.80	116.47	121.80	124.47
0.0020	121.10	114.70	117.90	124.30	127.50
0.0010	122.70	115.30	119.00	126.40	130.10

Figure 6.9-4. Future Scenario 3 Most Likely Future Year (2012) Exceedance Probability Function for the Gautier Area – Includes an adjustment for relative sea level rise

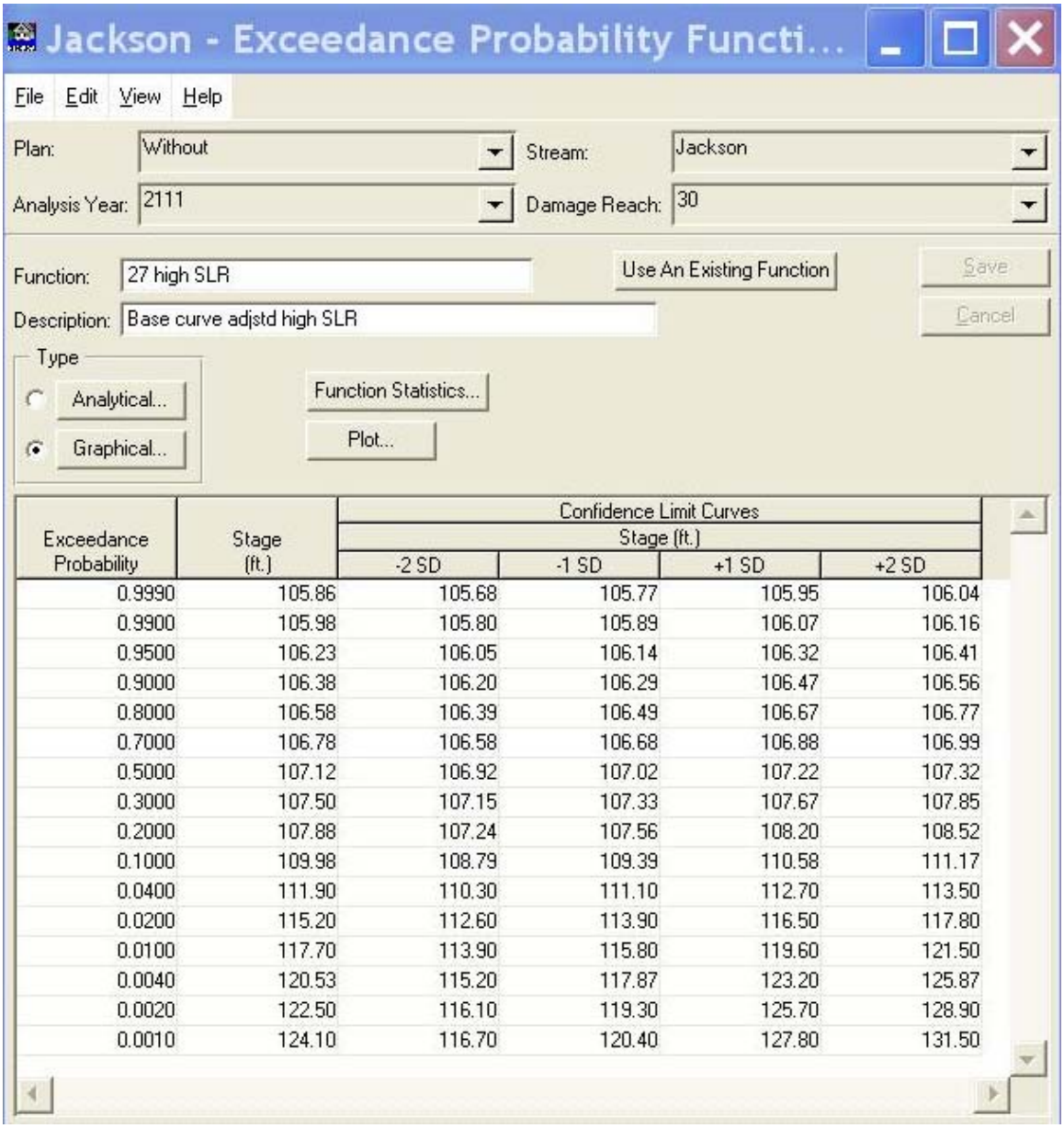
Future scenario five is the same as future scenario one with the addition of a high relative sea level rise 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $6,702,000 (rounded to the nearest thousand). These damages represent approximately a ten-percent (10.2%) increase over the expected relative sea level rise accounted for in future scenario three. The total number of structures in this scenario is the same as in scenarios one and three and can be seen above in table 6.9-2. Figures 6.9-5 and 6.9-6 depict the base year and most likely future year exceedance probability functions for the Gautier area (planning sub-unit 30). The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most likely future year exceedance probability function depicted in figure 6.9-6 includes an adjustment for expected relative sea level

rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet. For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	102.06	101.88	101.97	102.15	102.24
0.9900	102.18	102.00	102.09	102.27	102.36
0.9500	102.43	102.25	102.34	102.52	102.61
0.9000	102.58	102.40	102.49	102.67	102.76
0.8000	102.78	102.59	102.69	102.87	102.97
0.7000	102.98	102.78	102.88	103.08	103.19
0.5000	103.32	103.12	103.22	103.42	103.52
0.3000	103.70	103.35	103.53	103.87	104.04
0.2000	104.08	103.44	103.76	104.40	104.72
0.1000	106.18	104.99	105.59	106.78	107.37
0.0400	108.10	106.50	107.30	108.90	109.70
0.0200	111.40	108.80	110.10	112.70	114.00
0.0100	113.90	110.10	112.00	115.80	117.70
0.0040	116.73	111.40	114.07	119.40	122.07
0.0020	118.70	112.30	115.50	121.90	125.10
0.0010	120.30	112.90	116.60	124.00	127.70

Figure 6.9-5. Future Scenario 5 Base Year (2012) Exceedance Probability Function for the Gautier Area



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	105.86	105.68	105.77	105.95	106.04
0.9900	105.98	105.80	105.89	106.07	106.16
0.9500	106.23	106.05	106.14	106.32	106.41
0.9000	106.38	106.20	106.29	106.47	106.56
0.8000	106.58	106.39	106.49	106.67	106.77
0.7000	106.78	106.58	106.68	106.88	106.99
0.5000	107.12	106.92	107.02	107.22	107.32
0.3000	107.50	107.15	107.33	107.67	107.85
0.2000	107.88	107.24	107.56	108.20	108.52
0.1000	109.98	108.79	109.39	110.58	111.17
0.0400	111.90	110.30	111.10	112.70	113.50
0.0200	115.20	112.60	113.90	116.50	117.80
0.0100	117.70	113.90	115.80	119.60	121.50
0.0040	120.53	115.20	117.87	123.20	125.87
0.0020	122.50	116.10	119.30	125.70	128.90
0.0010	124.10	116.70	120.40	127.80	131.50

Figure 6.9-6. Future Scenario 5 Most Likely Future Year (2012) Exceedance Probability Function for the Gautier Area – Includes an adjustment for relative sea level rise

6.9.5.3 Equivalent Annual Damages Reduced

Equivalent annual damages reduced are calculated as the difference between the damages under the future without-project scenarios three and five and the damages incurred with the measure in place. The HEC-FDA model was run for each measure to determine the damages reduced as compared to the without-project scenario.

In order to provide the HEC-FDA model with accurate information about the economic characteristics of each measure, separate inventories were created for each measure. The inventories are the same as the without-project inventory except that footprints of levees and acquisitions were deleted from the inventory and flood proofed structures (structures to be raised in place) were given a higher elevation. The structure inventories for each of the HEC-FDA measure runs are as follows:

- Measure A – Gautier Ring Levee at elevation 20.0-feet

This measure includes the without-project inventory less 177 parcels that were deleted out of the inventory. These parcels represent the footprint of the 20.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure B – Gautier Ring Levee at elevation 30.0-feet

This measure includes the without-project inventory less 206 parcels that were deleted out of the inventory. These parcels represent the footprint of the 30.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure C – Gautier ABFE Nonstructural One

This measure includes the acquisition of 66 parcels that include a structure and the flood proofing (raise structure in place) of 466 structures to an elevation of 16.1-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was determined to be approximately the ABFE level of protection and is defined as still water elevation, plus wave run-up, plus an estimate for waves (depth divided by two), and is the minimum implementation elevation that a nonstructural measure do to the requirements of the National Flood Insurance Program (NFIP).

- Measure D – Gautier Nonstructural Two to elevation 20.0-feet NAVD88

This measure includes the acquisition of 489 parcels that include a structure and the flood proofing (raise structure in place) of 44 structures to an elevation of 20.0-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levee at elevation 20.0-feet NAVD88.

- Measure E – Gautier Nonstructural Three to elevation 30.0-feet NAVD88

This measure includes the acquisition of 533 parcels that include a structure. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing

Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levee at elevation 30.0-feet NAVD88.

Residual damage is the equivalent annual damages that still remain even when a project is in place. Residual damage is calculated as the future without-project equivalent annual damages minus the damages reduced of the various measures. The purpose of residual damages is to calculate and communicate the portions of damages that will not be reduced by the implementation of a plan or "what damages are left on the table." Table 6.9-3 summarizes the equivalent annual without-project damages, damages reduced, and residual damages by measure and by future scenario.

Table 6.9-3.
Summary of Damages by Potential Measure and by Applicable Future Scenario

Measures	Equivalent annual damages Future 3 ($)	Equivalent Annual Damage Reduction Future 3 ($)	Residual Damage Future 3 ($)	Equivalent annual damages Future 5 ($)	Equivalent Annual Damage Reduction Future 5 ($)	Residual Damage Future 5 ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A 20Ft Ring Levee	$5,831,000	$5,166,000	$665,000	$6,702,000	$5,923,000	$779,000
Measure B 30FT Ring Levee	$5,831,000	$5,800,000	$31,000	$6,702,000	$6,663,000	$39,000
Measure C ABFE Nonstructural	$5,831,000	$3,623,000	$2,208,000	$6,702,000	$3,984,000	$2,718,000
Measure D 20FT Nonstructural	$5,831,000	$ 2,457,000	$3,374,000	$6,702,000	$2,839,000	$3,863,000
Measure E 30FT Nonstructural	$5,831,000	$ 5,278,000	$553,000	$6,702,000	$6,033,000	$669,000

Damages are rounded to the nearest thousand dollars.

6.9.6 Environmental Quality (EQ)

The Engineering Research and Development Center Wetlands and Coastal Ecology Branch were asked to conduct an assessment of potential impacts to wetlands as a result of constructing various levees and seawalls along the Mississippi Gulf Coastal Plain. This report summarizes the results of the assessment. The analysis of impacts included two components:

1. A calculation of total acreage of all wetlands (by type and planning reach) that is directly under the levee footprints.

2. A modified Hydrogeomorphic (HGM) wetland rapid assessment of impacted Estuarine/Tidal Fringe wetlands, based on the Mississippi and Alabama Gulf Coast HGM guidebook (Shafer et al., 2007), with impacts reported as loss of functional units. Tables 6.9-4 and 6.9-5 show the impacts of the Gautier ring levees at elevations 20.0-feet NAVD88, and 30.0-feet NAVD88 respectively.

Table 6.9-4.
Wetland acres impacted by elevation 20' Gautier ring levee.

Reach ID	Estuarine and Marine Deepwater	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Freshwater Pond	Total
29	0.0	0.0	0.0	5.6	0.0	5.6
30	0.2	5.0	0.3	9.0	0.0	14.5
31	0.5	7.1	0.0	2.0	0.1	9.7
Total	**0.7**	**12.1**	**0.3**	**16.9**	**0.1**	**29.8**

Table 6.9-5.
Wetland acres impacted by elevation 30' Gautier ring levee.

Reach ID	Estuarine and Marine Deepwater	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Freshwater Pond	Total
29	0.0	0.0	0.4	9.7	0.0	10.2
30	0.3	7.2	1.2	19.8	0.0	28.5
31	1.2	10.3	0.0	6.1	0.2	17.9
Total	**1.5**	**17.5**	**1.6**	**35.7**	**0.2**	**56.5**

Nonstructural measures would have no construction activities other than demolition and disposal of building materials in an approved land fill occurs as a result of this measure. More detail on the impacts of the structural and nonstructural measures for the Gautier area can be found in the Environmental Appendix.

6.9.7 Summary of Costs

Table 6.9-6 summarizes the ROM costs at an FY-08 price level by measure for the Gautier Area (planning sub-unit 30).

Table 6.9-6.
Summary of Costs by Measure for the Gautier Area

Measures	Implementation Costs (FY-08) ($)	Capital Recovery Factor	Average Annual Implementation Cost ($)	Average Annual O&M ($)	IDC ($)	Total Average Annual Costs ($)
(No Action)	$0	0.049171225	$0	$0	$0	$0
Measure A 20Ft Ring Levee	$348,300,000	0.049171225	$17,126,000	$ 3,744,000	N/A	$20,870,000
Measure B 30FT Ring Levee	$450,100,000	0.049171225	$22,132,000	$ 4,904,000	N/A	$27,036,000
Measure C ABFE Nonstructural	$185,929,000	0.049171225	$9,142,000	$10,000	N/A	$9,152,000
Measure D 20FT Nonstructural	$783,100,000	0.049171225	$38,506,000	$10,000	N/A	$38,516,000
Measure E 30FT Nonstructural	$942,794,000	0.049171225	$46,358,000	$10,000	N/A	$46,368,000

6.9.8 Regional Economic Development (RED)

The purpose of this analysis is to determine the economic impact of the proposed project measures on business (sale volumes), income, employment, and population of the local area. Each of the measures would affect the local area of Jackson County, Mississippi. The expenditures for the measures are estimated to be $348,300,000 for the 20.0-feet NAVD88 measure, $450,100,000 for the 30.0-feet NAVD88 measure $185,929,000 for the ABFE nonstructural measure, $783,100,000 for the 20.0-feet NAVD88 nonstructural measure, and $783,100,000 for the 30.0-feet NAVD88 nonstructural measure. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $76,142,000 for the 20.0-feet NAVD88 ring levee measure, $99,733,000 for the 30.0-feet NAVD88 ring levee measure, $203,000 for the ABFE nonstructural measure, $203,000 for the 20.0-feet NAVD88 nonstructural measure, and $203,000 for the 30.0-feet NAVD88 nonstructural measure respectively (assuming a 100- year period of analysis and an interest rate of 4.875-percent). The following tables 6.9-7 through 6.9-10 summarize the EIFS inputs and outputs for the Gautier area.

Table 6.9-7.
EIFS Model Construction Costs Inputs for the Gautier Area

	20-foot Ring Levee	30-foot Ring Levee	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$348,300,000	$450,100,000	$185,929,000	$783,100,000	$942,794,000

Based of the given inputs the outputs are as follows:

Table 6.9-8.
EIFS Model Construction Costs Outputs for the Gautier Area

	20-foot Ring Levee	30-foot Ring Levee	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Direct Sales Volume	$348,300,000	$450,100,000	$185,929,000	$783,100,000	$942,794,000
Induced Sales Volume	$390,096,000	$504,112,000	$208,240,480	$877,072,000	$1,055,929,280
Total Sales Volume	$738,396,000	$954,212,000	$394,169,480	$1,660,172,000	$1,998,723,280
Direct Income	$67,927,403	$87,781,005	$36,260,907	$152,724,516	$183,868,928
Induced Income	$76,078,681	$98,314,713	$40,612,211	$171,051,437	$205,933,174
Total Income	$144,006,084	$186,095,717	$76,873,119	$323,775,953	$389,802,101
Direct Employment	1,971	2,547	1,052	4,432	5,336
Induced Employment	2,208	2,853	1,179	4,965	5,977
Total Employment	4,179	5,400	2,231	9,397	11,314
Local Population	0	0	0	0	0

Table 6.9-9.
EIFS Model O&M Cost Inputs for the Gautier Area

	20-foot Ring Levee	30-foot Ring Levee	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$69,691,753	$91,284,283	$186,143	$186,143	$186,143

Based of the given inputs the outputs are as follows:

Table 6.9-10.
EIFS Model O&M Cost Outputs for the Gautier Area

	20-foot Ring Levee	30-foot Ring Levee	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Direct Sales Volume	$69,691,753	$91,284,283	$186,143	$186,143	$186,143
Induced Sales Volume	$78,054,763	$102,238,397	$208,480	$208,480	$208,480
Total Sales Volume	$147,746,516	$193,522,680	$394,622	$394,622	$394,622
Direct Income	$13,591,673	$17,802,768	$36,303	$36,303	$36,303
Induced Income	$15,222,672	$19,939,098	$40,659	$40,659	$40,659
Total Income	$28,814,345	$37,741,867	$76,961	$76,961	$76,961
Direct Employment	394	517	1	1	1
Induced Employment	442	579	1	1	1
Total Employment	836	1095	2	2	2
Local Population	0	0	0	0	0

6.10 Evaluation of Gulf Park Estates Area Measures

6.10.1 General

The Gulf Park Estates area is located in the southern portion of planning unit three along the Mississippi Sound. The area is denoted as planning sub-unit 26 and is depicted in the figure 6.10-1, shown below. The pre-Hurricane Katrina conditions for this area represented a mostly residential community. As shown in table 6.10-1, it was estimated from the field inventorying process that planning sub-unit 26 included 2,391 tax parcels, of which 1,782 contained a structure with some economic value and 609 were vacant land. Of those 1,782 parcels that contain structures, 1,663 were residential one-story, 0 were residential two-story, 95 were mobile homes, 22 were commercial, and 2 were municipal.

6.10.2 Opportunities

The following opportunities were identified for this area:

- Hurricane storm damage reduction or remediation

6.10.3 Assumptions

The following assumptions were used in this analysis.

- The FY 2008 discount rate of 4.875 percent was used in estimating average annual benefits and costs.
- Price levels are FY-08, unless otherwise stated.
- A 100-year period of analysis (2012 to 2111) was used to calculate average annual benefits and costs.

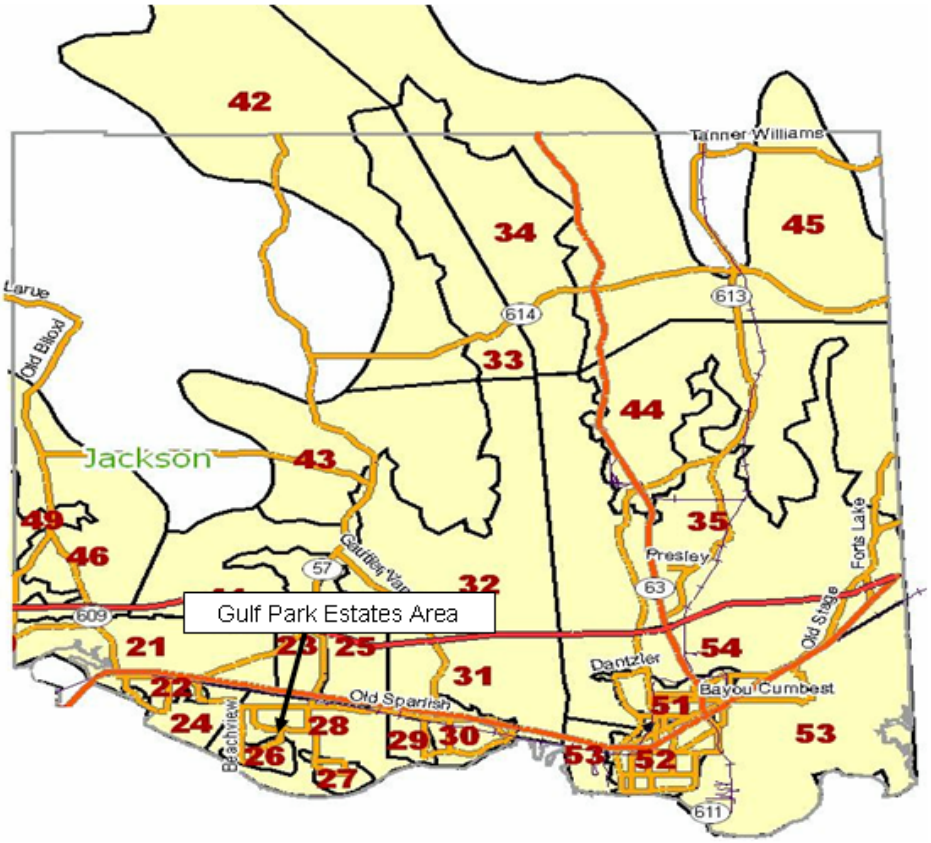


Figure 6.10-1. Gulf Park Estates Area – Planning sub-unit 26

Table 6.10-1.
Pre-Hurricane Katrina Estimate of Structures for the Gulf Park Estates Area Planning Sub-unit 26

Asset Categories	Assets by Category
Residential	1,663
Mobile Homes	95
Commercial	22
Municipal	2
Vacant Land	609
Total Tax Parcels	**2,391**

6.10.4 Measures

Initially, a comprehensive list of measures was identified for flood damage reduction purposes for planning unit three. This list was screened and vetted for engineering and environmental feasibility and for policy compliance. The MsCIP Comprehensive Main Report and the Engineering and Environmental Appendices contain a detailed description of the measures that were initially screened.

Several potential measures were carried forward for this area for the purpose of flood damage reduction. These measures include both structural features and nonstructural actions. The measures evaluated for economic benefits include:

- Measure A – Gulf Park Estates Ring Levee A

This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 20.0-feet NAVD88.

- Measure B – Gulf Park Estates Ring Levee B

This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 30.0-feet NAVD88.

- Measure C – Gulf Park Estates Ring Levee C

This measure would include a ring levee at 20-feet NAVD88 on an alternate footprint from Measure A and the acquisition of structures and parcels that would have been included in measure A but are not within the alternate footprint.

- Measure D – Gulf Park Estates Ring Levee D

This measure would include a ring levee at 30-feet NAVD88 on an alternate footprint from Measure B and the acquisition of structures and parcels that would have been included in measure B but are not within the alternate footprint.

- Measure E – Gulf Park Estates Nonstructural One

This measure includes the acquisition and flood proofing (elevation-in-place) of structures to the FEMA advisory base flood elevation (ABFE).

- Measure F – Gulf Park Estates Nonstructural Two

This measure includes the acquisition and flood proofing of structures to approximately elevation 20-feet NAVD88.

- Measure G – Gulf Park Estates Nonstructural Three

This measure includes the acquisition of structures to approximately elevation 30-feet NAVD88.

Figure 6.10-2 shows the measures for the Gulf Park Estates Area (planning sub-unit 26); the red line represents the approximate footprint of the ring levees A and B, the green line represents the approximate footprint of the ring levees C and D, the dark green within the ring levee footprint represents potential ABFE buyout areas and the light green area within the ring levee footprint represents potential flood proof (elevate-in-place) areas.

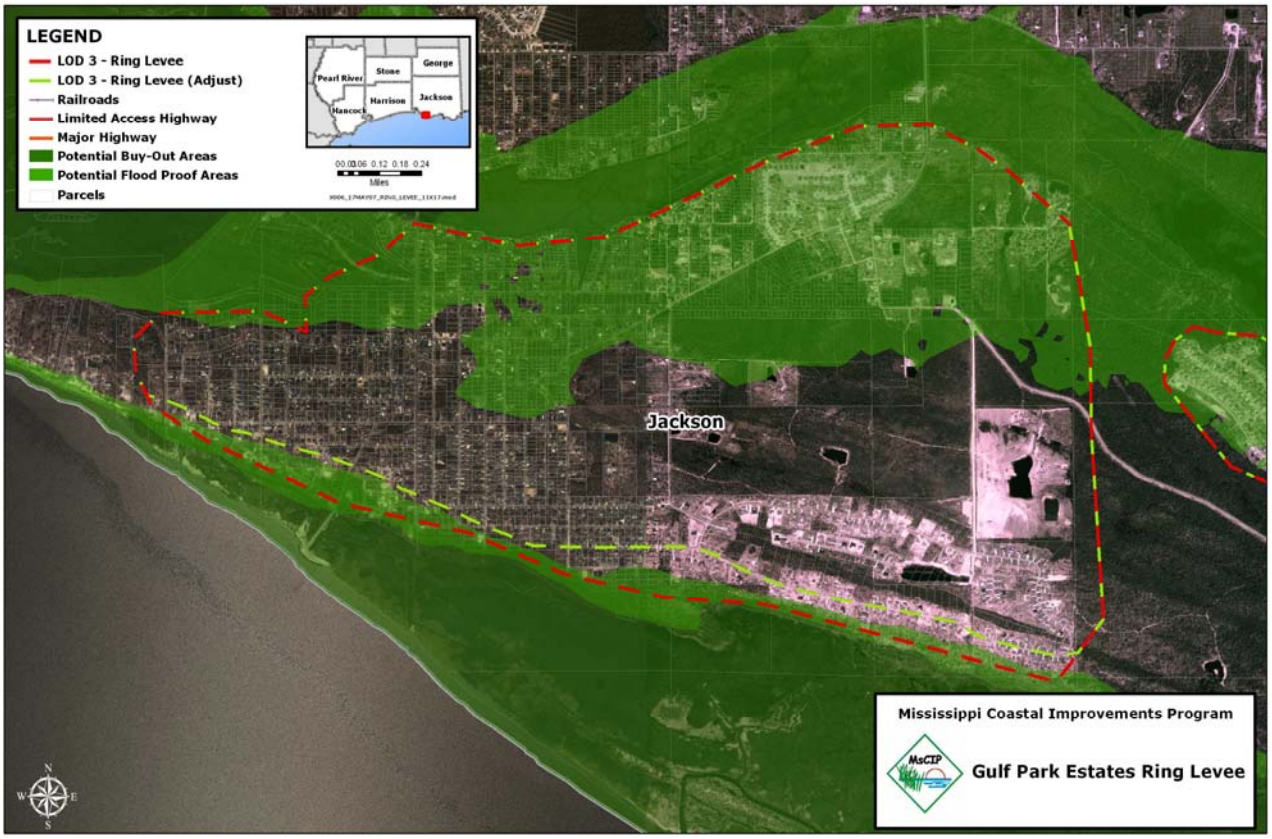


Figure 6.10-2. Display of Potential Measures for the Gulf Park Estates Area (Planning Sub-Unit 26)

6.10.5 National Economic Development (NED)

The purpose of this section is to document investigations conducted to identify the National Economic Development (NED) benefits of each of the potential measures previously listed. For this analysis, NED benefits are the reduced inundation damages of assets and their contents when one of the potential measures is in place. Typically, NED benefits are annualized over the period of the analysis (average annual benefits) and then compared to annualized costs over the period of analysis (average annual costs). This comparison is commonly known as the benefit-to-cost ratio (BCR). For purposes of this analysis, no benefit-to-cost ratios will be calculated as per the legislative Congressional language authorizing this study. The Coastal Mississippi Comprehensive Plan Report was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states: "…***that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project plan features based upon maximizing net national economic development benefits…"*** More detail on the authorizing language can be found in the MsCIP Comprehensive Plan Main Report.

6.10.5.1 Existing Conditions Post-Hurricane Katrina)

The effects of Hurricane Katrina storm surge were devastating to the Gulf Park Estates Area. Peak water elevation in the area ranged from 19-to-20-feet NAVD88. It is estimated that 840 structures in the area, mostly residential, sustained significant inundation damage (fifty-percent or more). Expected redevelopment of the area is described in the following section.

6.10.5.2 Future Without-Project Conditions

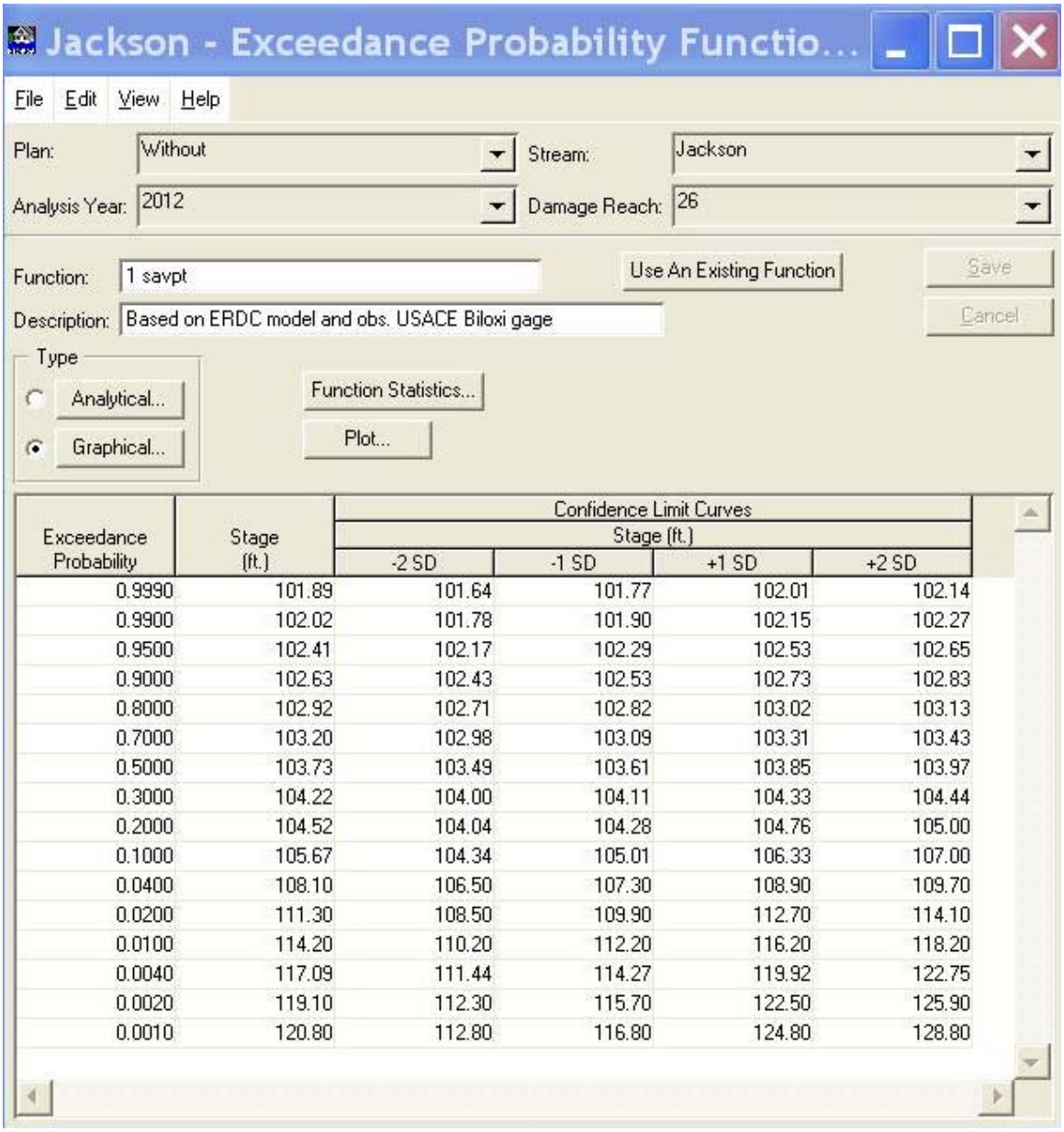
Equivalent annual flood damages for several future without-project scenarios were evaluated using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. Each of the measures was evaluated and compared to future without-project scenarios three, and five, as previously discussed in section 5.3. These future scenarios were chosen because the redevelopment projected for this area is anticipated to return to the pre-Katrina development. Futures scenarios two, four, and six were not used for evaluation purposes since this area is not accommodative for commercial and condominium redevelopment under those mixed redevelopment scenarios (see section 5.3 for more detail).

Future scenario one is the full redevelopment of assets within the study area by the year 2012 with no relative sea level rise over the 100-year period of analysis. Table 6.10-2 shows structures by asset category and by elevation. The number of structures per elevation is added to the previous number of structures per elevation in each category. For example, in the residential category there are two structures with an elevation of 3-foot elevation or lower, there are six structures with an elevation of 4-feet or less, etc. This future scenario, as previously noted in section 5.3, is for sensitivity purposes only and will not be evaluated against all of the potential measures for the Gulf Park Estates area.

Future scenario three is the full redevelopment of assets within the study area by the year 2012. Under this scenario, assets will be rebuilt as they were pre-Hurricane Katrina. For example, if the asset was a residential structure pre-Hurricane Katrina it will be rebuilt as a residential structure; commercial structures will be built back to commercial structures; etc. Basically, future scenario three is the same structure inventory as future scenario one with the addition of an expected relative sea level rise over the 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $6,273,000 (rounded to the nearest thousand dollars). The total number of structures in this scenario are the same as in scenario one and can be seen above in table 6.10-2. Figures 6.10-3 and 6.10-4 depict the base year and most likely future year exceedance probability functions for the Gulf Park Estates area (planning sub-unit 26). The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most likely future year exceedance probability function depicted in figure 6.10-4 includes an adjustment for expected relative sea level rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet. For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.

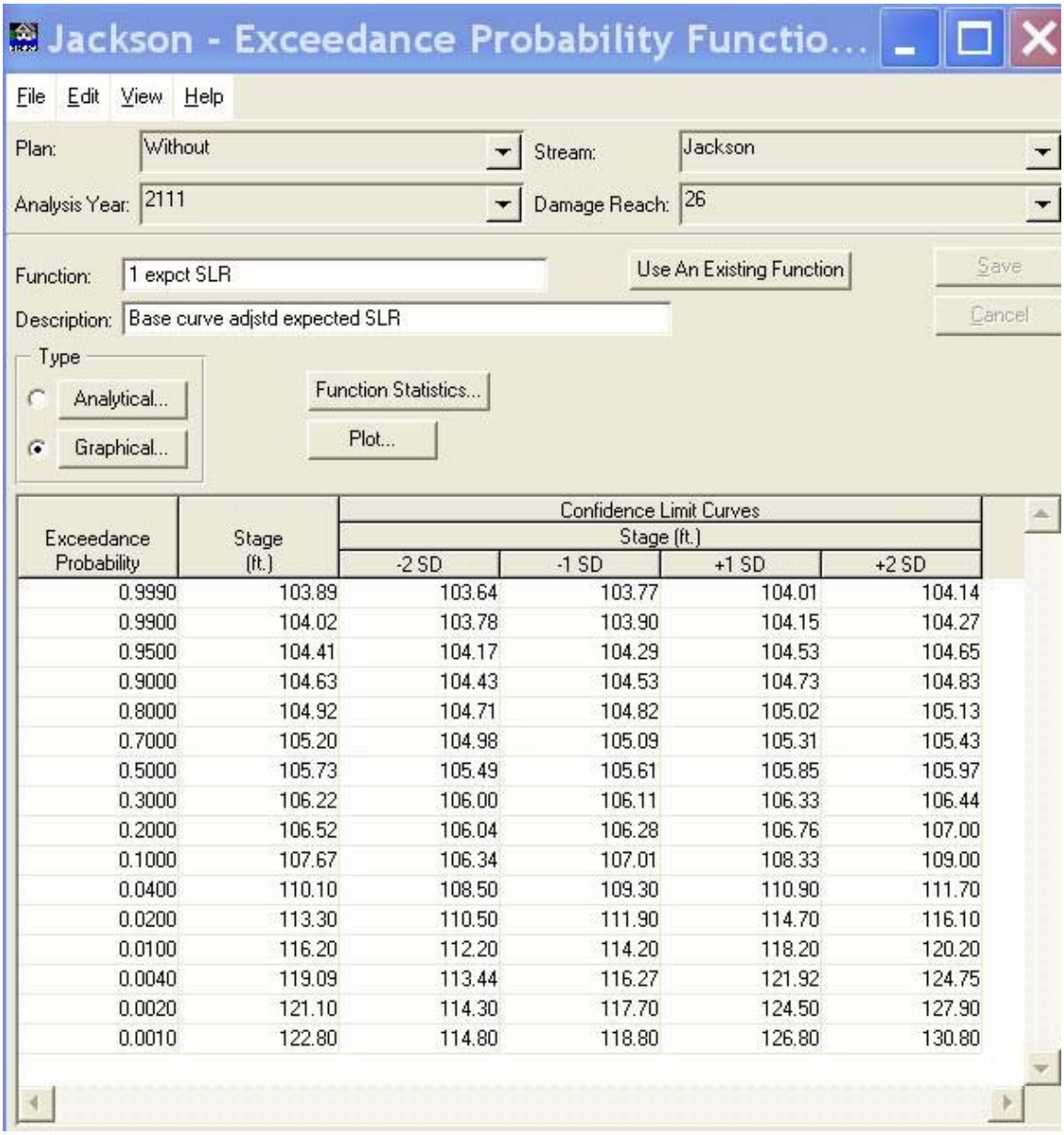
Table 6.10-2.
Cumulative Structures by Category and by Estimated First Floor Elevation
Future Scenarios One, Three, and Five
Applicable for Base Year and Most Likely Future Years

Estimated First Floor Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
1-foot	0	0	0	0	0
2-foot	0	0	0	0	0
3-foot	2	0	0	0	2
4-foot	6	0	0	0	6
5-foot	22	0	0	0	22
6-foot	66	0	0	0	66
7-foot	118	0	0	0	118
8-foot	174	0	0	0	174
9-foot	251	0	0	0	251
10-foot	295	0	0	0	295
11-foot	336	0	0	0	336
12-foot	382	7	1	0	390
13-foot	444	18	3	0	465
14-foot	469	29	4	0	502
15-foot	497	34	4	0	535
16-foot	512	44	5	0	561
17-foot	547	50	8	0	605
18-foot	671	53	8	0	732
19-foot	1,319	91	20	2	1,432
20-foot	1,532	92	22	2	1,648
21-foot	1,644	93	22	2	1,761
22-foot	1,663	94	22	2	1,781
23-foot	1,663	95	22	2	1,782
Total	**1,663**	**95**	**22**	**2**	**1,782**



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	101.89	101.64	101.77	102.01	102.14
0.9900	102.02	101.78	101.90	102.15	102.27
0.9500	102.41	102.17	102.29	102.53	102.65
0.9000	102.63	102.43	102.53	102.73	102.83
0.8000	102.92	102.71	102.82	103.02	103.13
0.7000	103.20	102.98	103.09	103.31	103.43
0.5000	103.73	103.49	103.61	103.85	103.97
0.3000	104.22	104.00	104.11	104.33	104.44
0.2000	104.52	104.04	104.28	104.76	105.00
0.1000	105.67	104.34	105.01	106.33	107.00
0.0400	108.10	106.50	107.30	108.90	109.70
0.0200	111.30	108.50	109.90	112.70	114.10
0.0100	114.20	110.20	112.20	116.20	118.20
0.0040	117.09	111.44	114.27	119.92	122.75
0.0020	119.10	112.30	115.70	122.50	125.90
0.0010	120.80	112.80	116.80	124.80	128.80

Figure 6.10-3. Future Scenario 3 Base Year (2012) Exceedance Probability Function for the Gulf Park Estates Area

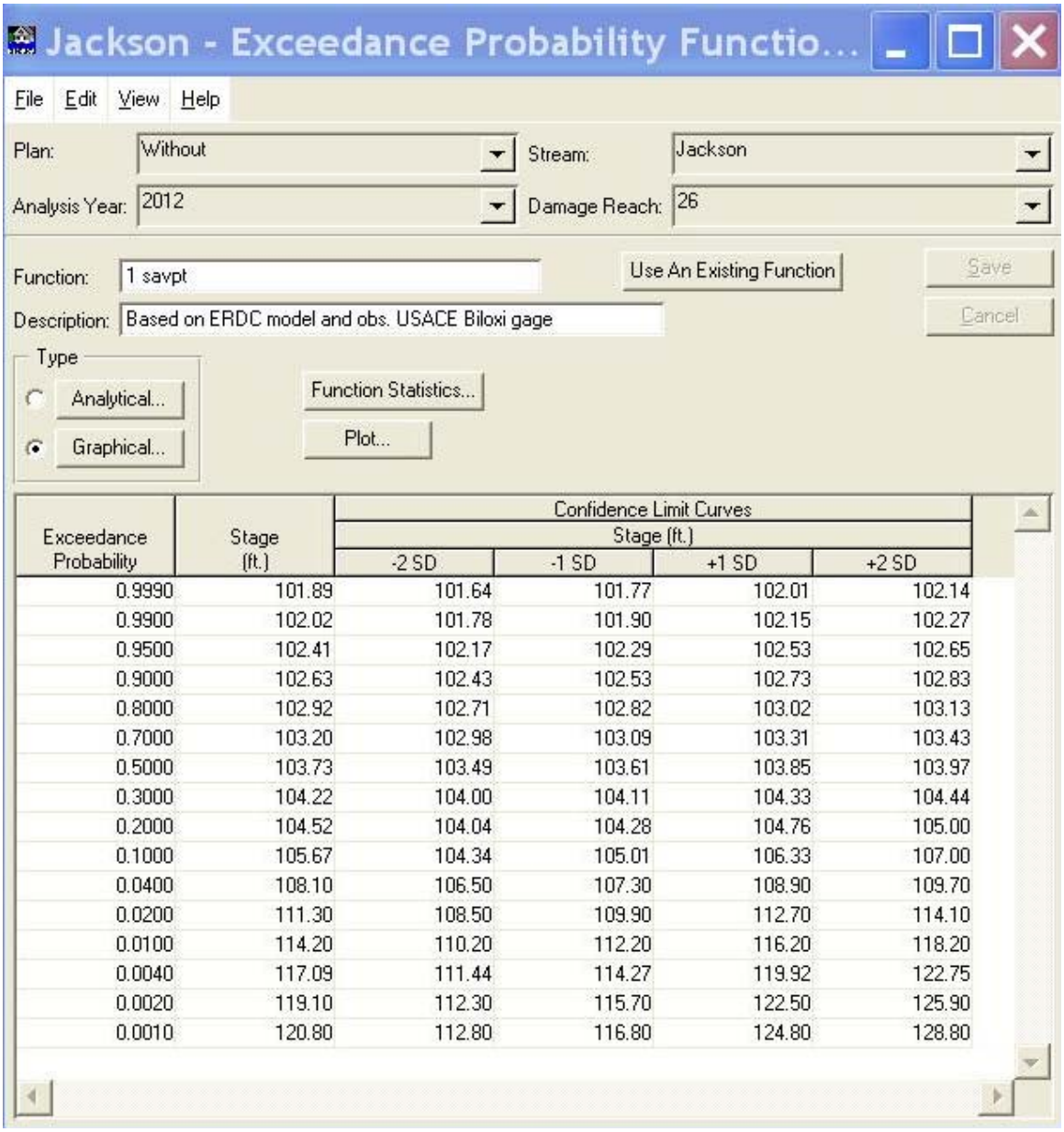


Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	103.89	103.64	103.77	104.01	104.14
0.9900	104.02	103.78	103.90	104.15	104.27
0.9500	104.41	104.17	104.29	104.53	104.65
0.9000	104.63	104.43	104.53	104.73	104.83
0.8000	104.92	104.71	104.82	105.02	105.13
0.7000	105.20	104.98	105.09	105.31	105.43
0.5000	105.73	105.49	105.61	105.85	105.97
0.3000	106.22	106.00	106.11	106.33	106.44
0.2000	106.52	106.04	106.28	106.76	107.00
0.1000	107.67	106.34	107.01	108.33	109.00
0.0400	110.10	108.50	109.30	110.90	111.70
0.0200	113.30	110.50	111.90	114.70	116.10
0.0100	116.20	112.20	114.20	118.20	120.20
0.0040	119.09	113.44	116.27	121.92	124.75
0.0020	121.10	114.30	117.70	124.50	127.90
0.0010	122.80	114.80	118.80	126.80	130.80

Figure 6.10-4. Future Scenario 3 Most Likely Future Year (2012) Exceedance Probability Function for the Gulf Park Estates Area – Includes an adjustment for relative sea level rise

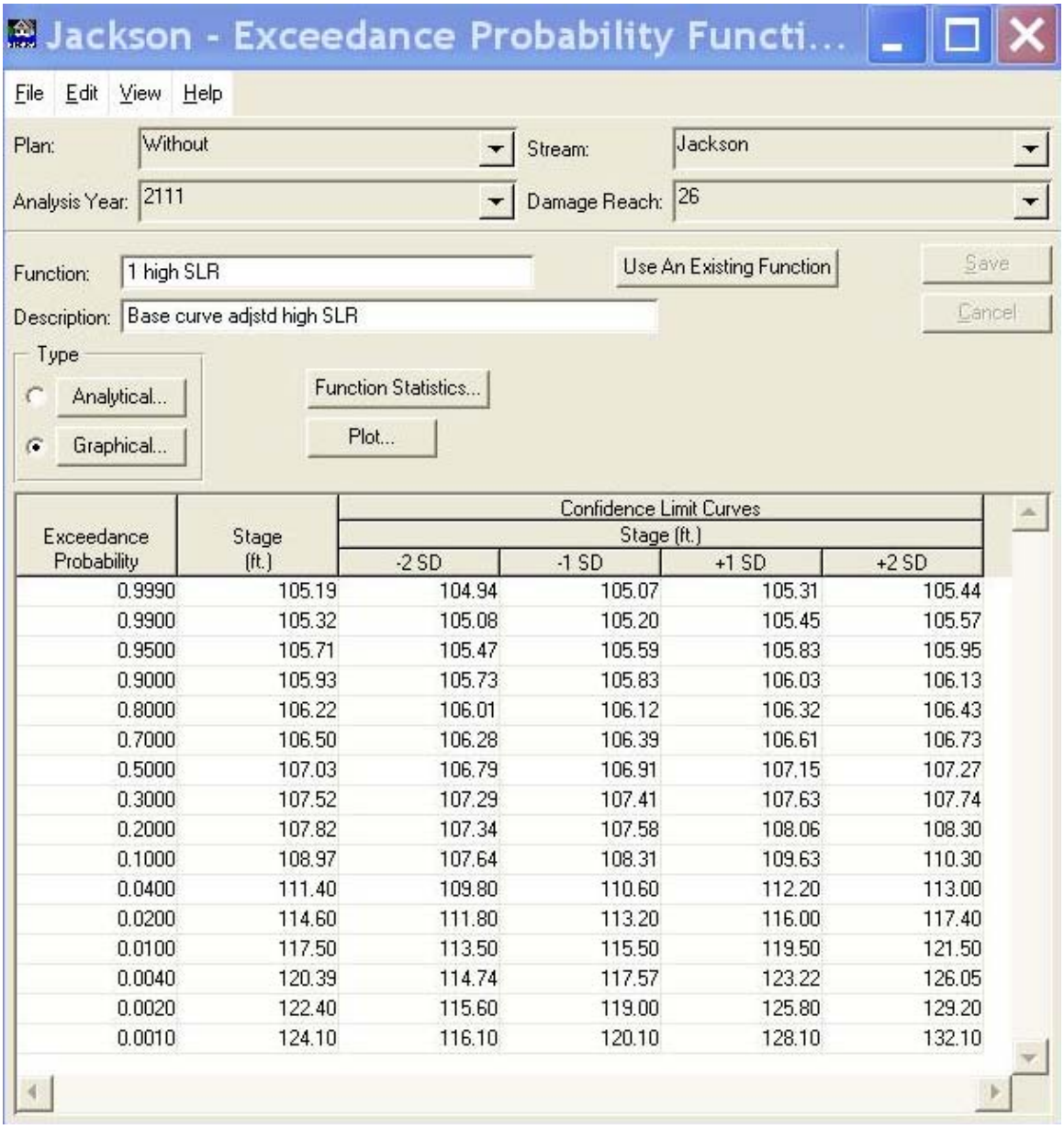
Future scenario five is the same as future scenario one with the addition of a high relative sea level rise 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $7,010,000 (rounded to the nearest thousand). These damages represent a approximately a seven-percent (6.8%) increase over the 2.0-feet relative sea level rise accounted for in future scenario three. The total number of structures in this scenario is the same as in scenarios one and three and can be seen above in table 6.10-2. Figures 6.10-5 and 6.10-6 depict the base year and most likely future year exceedance probability functions for the Gulf Park Estates area (planning sub-unit 26). The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most likely future year exceedance probability function depicted in figure 6.10-6 includes an adjustment for expected

relative sea level rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet. For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	101.89	101.64	101.77	102.01	102.14
0.9900	102.02	101.78	101.90	102.15	102.27
0.9500	102.41	102.17	102.29	102.53	102.65
0.9000	102.63	102.43	102.53	102.73	102.83
0.8000	102.92	102.71	102.82	103.02	103.13
0.7000	103.20	102.98	103.09	103.31	103.43
0.5000	103.73	103.49	103.61	103.85	103.97
0.3000	104.22	104.00	104.11	104.33	104.44
0.2000	104.52	104.04	104.28	104.76	105.00
0.1000	105.67	104.34	105.01	106.33	107.00
0.0400	108.10	106.50	107.30	108.90	109.70
0.0200	111.30	108.50	109.90	112.70	114.10
0.0100	114.20	110.20	112.20	116.20	118.20
0.0040	117.09	111.44	114.27	119.92	122.75
0.0020	119.10	112.30	115.70	122.50	125.90
0.0010	120.80	112.80	116.80	124.80	128.80

Figure 6.10-5. Future Scenario 5 Base Year (2012) Exceedance Probability Function for the Gulf Park Estates Area



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	105.19	104.94	105.07	105.31	105.44
0.9900	105.32	105.08	105.20	105.45	105.57
0.9500	105.71	105.47	105.59	105.83	105.95
0.9000	105.93	105.73	105.83	106.03	106.13
0.8000	106.22	106.01	106.12	106.32	106.43
0.7000	106.50	106.28	106.39	106.61	106.73
0.5000	107.03	106.79	106.91	107.15	107.27
0.3000	107.52	107.29	107.41	107.63	107.74
0.2000	107.82	107.34	107.58	108.06	108.30
0.1000	108.97	107.64	108.31	109.63	110.30
0.0400	111.40	109.80	110.60	112.20	113.00
0.0200	114.60	111.80	113.20	116.00	117.40
0.0100	117.50	113.50	115.50	119.50	121.50
0.0040	120.39	114.74	117.57	123.22	126.05
0.0020	122.40	115.60	119.00	125.80	129.20
0.0010	124.10	116.10	120.10	128.10	132.10

Figure 6.10-6. Future Scenario 5 Most Likely Future Year (2012) Exceedance Probability Function for the Gulf Park Estates Area – Includes an adjustment for relative sea level rise

6.10.5.3 Equivalent annual damages Reduced and Residual Damages

Equivalent annual damages reduced are calculated as the difference between the damages under the future without-project scenarios three and five and the damages incurred with the measure in place. The HECFDA model was run for each measure to determine the damages reduced as compared to the without-project scenario.

In order to provide the HEC-FDA model with accurate information about the economic characteristics of each measure, separate inventories were created for each measure. The inventories are the same as the without-project inventory except that footprints of levees and acquisitions were deleted from the inventory and flood proofed structures (structures to be raised in

place) were given a higher elevation. The structure inventories for each of the HEC-FDA measure runs are as follows:

- Measure A – Gulf Park Estates Ring Levee A at elevation 20.0-feet NAVD88

This measure includes the without-project inventory less 181 parcels that were deleted out of the inventory. These parcels represent the footprint of the 20.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure B – Gulf Park Estates Ring Levee B at elevation 30.0-feet NAVD88

This measure includes the without-project inventory less 210 parcels that were deleted out of the inventory. These parcels represent the footprint of the 30.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure C – Gulf Park Estates Ring Levee C at elevation 20.0-feet NAVD88

This measure would include a ring levee at 20-feet NAVD88 on an alternate footprint from Measure A and the acquisition of structures and parcels that would have been included in measure A but are not within the alternate footprint.

- Measure D – Gulf Park Estates Ring Levee D

This measure would include a ring levee at 30-feet NAVD88 on an alternate footprint from Measure B and the acquisition of structures and parcels that would have been included in measure B but are not within the alternate footprint.

- Measure E – Gulf Park Estates Nonstructural One

This measure includes the acquisition of 35 parcels that include a structure and the flood proofing (raise structure in place) of 951structures to an elevation of 18.3-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was determined to be approximately the ABFE level of protection and is defined as still water elevation, plus wave run-up plus an estimate for waves (depth divided by two), and is the minimum implementation elevation that a nonstructural measure do to the requirements of the National Flood Insurance Program (NFIP).

- Measure F – Gulf Park Estates Nonstructural Two to elevation 20.0-feet NAVD88

This measure includes the acquisition of 939 parcels that include a structure and the flood proofing (raise structure in place) of 47structures to an elevation of 20.0-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levee measures at elevation 20.0-feet NAVD88.

- Measure G – Gulf Park Estates Nonstructural Three to elevation 30.0-feet NAVD88

This measure includes the acquisition of 986 parcels that include a structure to an elevation of 30.0-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levee measures at elevation 30.0-feet NAVD88.

Residual damage is the equivalent annual damages that still remain even when a project is in place. Residual damage is calculated as the future without-project equivalent annual damages minus the damages reduced of the various measures. The purpose of residual damages is to calculate and communicate the portions of damages that will not be reduced by the implementation of a plan or "what damages are left on the table." Table 6.10-3 summarizes the equivalent annual without-project damages, damages reduced, and residual damages by measure and by future scenario.

Table 6.10-3.
Summary of Damages by Potential Measure and by Applicable Future Scenario

Measures	Equivalent annual damages Future 3 ($)	Equivalent Annual Damage Reduction Future 3 ($)	Residual Damage Future 3 ($)	Equivalent annual damages Future 5 ($)	Equivalent Annual Damage Reduction Future 5 ($)	Residual Damage Future 5 ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A 20Ft Ring Levee	$6,273,000	$5,924,000	$349,000	$7,010,000	$6,616,000	$394,000
Measure B 30FT Ring Levee	$6,273,000	$6,251,000	$23,000	$7,010,000	$6,984,000	$26,000
Measure C 20Ft Ring Levee	$6,273,000	$6,021,000	$252,000	$7,010,000	$6,762,000	$248,000
Measure D 30FT Ring Levee	$6,273,000	$6,258,000	$15,000	$7,010,000	$7,010,000	$0
Measure E ABFE Nonstructural	$6,273,000	$5,668,000	$605,000	$7,010,000	$6,327,000	$683,000
Measure F 20FT Nonstructural	$6,273,000	$5,924,000	$349,000	$7,010,000	$6,616,000	$394,000
Measure G 30FT Nonstructural	$6,273,000	$6,273,000	$0	$7,010,000	$7,010,000	$0

Damages are rounded to the nearest thousand dollars.

6.10.6 Environmental Quality (EQ)

6.10.6.1 Impacts of Ring Levee Measures

The Engineering Research and Development Center Wetlands and Coastal Ecology Branch were asked to conduct an assessment of potential impacts to wetlands as a result of constructing various levees and seawalls along the Mississippi Gulf Coastal Plain. This report summarizes the results of the assessment. The analysis of impacts included two components:

1. A calculation of total acreage of all wetlands (by type and planning reach) that is directly under the levee footprints.

2. A modified Hydrogeomorphic (HGM) wetland rapid assessment of impacted Estuarine/Tidal Fringe wetlands, based on the Mississippi and Alabama Gulf Coast HGM guidebook (Shafer et al., 2007), with impacts reported as loss of functional units. Tables 6.10-4 and 6.10-5 show the impacts of the Gulf Park Estates ring levees at elevations 20.0-feet NAVD88, and 30.0-feet NAVD88 respectively.

Table 6.10-4.
Wetland Acres Impacted by Elevation 20' Gulf Park Estates Ring Levee

Reach ID	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Freshwater Pond	Grand Total
26	1.1	1.2	8.1	0.0	10.4
28	3.4	0.3	9.6	0.2	13.4
Total	**4.5**	**1.5**	**17.7**	**0.2**	**23.9**

Table 6.10-5.
Wetland Acres Impacted by Elevation 30' Gulf Park Estates Ring Levee.

Reach ID	Estuarine and Marine Deepwater	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Freshwater Pond	Total
26	0.0	1.5	1.9	10.6	0.0	14.0
28	0.1	5.9	0.5	14.0	0.3	20.8
Total	**0.1**	**7.4**	**2.3**	**24.6**	**0.3**	**34.8**

Nonstructural measures would have no construction activities other than demolition and disposal of building materials in an approved land fill occurs as a result of this measure. More detail on the impacts of the structural and nonstructural measures for the Gulf Park Estates area can be found in the Environmental Appendix.

6.10.7 Summary of Costs

Table 6.10-6 summarizes the ROM costs at an FY-08 price level for the Gulf Park Estates measures (planning sub-unit 26).

Table 6.10-6.
Summary of Costs by Measure for Gulf Park Estates Area

Measures	Implementation Costs (FY-08) ($)	Capital Recovery Factor	Average Annual Implementation Cost ($)	Average Annual O&M ($)	IDC ($)	Total Average Annual Costs ($)
(No Action)	$0	0.049171225	$0	$0	$0	$0
Measure A 20FT Ring Levee A	$149,200,000	0.049171225	$7,336,000	$1,499,000	N/A	$8,835,000
Measure B 30FT Ring Levee B	$220,600,000	0.049171225	$10,847,000	$2,404,000	N/A	$13,251,000
Measure C 20FT Ring Levee C	$158,900,000	0.049171225	$7,813,000	$1,295,000	N/A	$9,108,000
Measure D 30FT Ring Levee D	$208,700,000	0.049171225	$10,262,000	$1,906,000	N/A	$12,168,000
Measure E ABFE Nonstructural	$270,873,000	0.049171225	$13,319,000	$10,000	N/A	$13,329,000
Measure F 20FT Nonstructural	$294,188,000	0.049171225	$14,466,000	$10,000	N/A	$14,476,000
Measure G 30FT Nonstructural	$438,492,000	0.049171225	$21,561,000	$10,000	N/A	$21,571,000

The implementation costs include 1/ supervision and administration (30 account), 2/ planning, engineering & design (31 account) and 3/ appropriate contingencies. See the Cost Appendix for more detail on the implementation cost breakdowns. Numbers are rounded to the nearest thousand.

6.10.8 Regional Economic Development (RED)

The purpose of this section is to describe the economic impact of the proposed measures would affect the local area of Jackson County, Mississippi. The expenditures for the measures are estimated to be $149,200,000 for the 20.0-feet NAVD88 ring levee measure A, $220,600,000 for the 30.0-feet NAVD88 ring levee measure B, $158,900,000 for the 20.0-feet NAVD88 ring levee measure C, $208,700,000 for the 30-foot ring levee measure D, $270,873,000 for the ABFE nonstructural measure, $294,188,000 for the 20.0-feet NAVD88 nonstructural measure, and $294,188,000 for the 30.0-feet NAVD88 nonstructural measure. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $30,485,000 for the 20.0-feet NAVD88 ring levee A measure, $48,890,000 for the 30.0-feet NAVD88 ring levee B measure, $26,337,000 the 20.0-feet NAVD88 ring levee C measure, $38,763,000 30.0-feet NAVD88 ring levee D measure, $203,000 for the ABFE nonstructural measure, $203,000 for the 20.0-feet NAVD88 nonstructural measure, and $203,000 for the 30.0-feet NAVD88 nonstructural measure respectively (assuming a 100- year period of analysis and an interest rate of 4.875-percent). The following tables, 6.10-7 through 6.10-10, summarize the EIFS model inputs and outputs for the Gulf Park Estates area.

Table 6.10-7.
EIFS Model Implementation Cost Inputs for the Gulf Park Estates Area

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$149,200,000	$220,600,000	$158,900,000	$208,700,000	$270,873,000	$294,188,000	$438,492,000

Table 6.10-8.
EIFS Model Implementation Cost Outputs for the Gulf Park Estates Area

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Direct Sales Volume	$149,200,000	$220,600,000	$158,900,000	$208,700,000	$270,873,000	$294,188,000	$438,492,000
Induced Sales Volume	$167,104,000	$247,072,000	$177,968,000	$233,744,000	$303,377,760	$329,490,560	$491,111,040
Total Sales Volume	$316,304,000	$467,672,000	$336,868,000	$442,444,000	$574,250,760	$623,678,560	$929,603,040
Direct Income	$29,097,814	$43,022,639	$30,989,561	$40,701,834	$52,827,159	$57,374,179	$85,517,148
Induced Income	$32,589,547	$48,185,349	$34,708,305	$45,586,049	$59,166,410	$64,259,073	$95,779,194
Total Income	$61,687,361	$91,207,988	$65,697,866	$86,287,883	$111,993,569	$121,633,252	$181,296,342
Direct Employment	844	1,249	899	1,181	1,533	1,665	2,482
Induced Employment	946	1,399	1,007	1,323	1,717	1,865	2,780
Total Employment	1,790	2,647	1,907	2,504	3,250	3,530	5,262
Local Population	0	0	0	0	0	0	0

Table 6.10-9.
EIFS Model O&M Cost Inputs for the Gulf Park Estates Area

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	ABFE Nonstructl	20-foot Nonstructural	30-foot Nonstructural
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$30,485,000	$48,890,000	$26,337,000	$38,763,000	$203,000	$203,000	$203,000

Table 6.10-10.
EIFS Model O&M Cost Outputs for the Gulf Park Estates Area

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Direct Sales Volume	$30,485,000	$48,890,000	$26,337,000	$38,763,000	$203,000	$203,000	$203,000
Induced Sales Volume	$34,143,200	$54,756,800	$29,497,440	$43,414,560	$227,360	$227,360	$227,360
Total Sales Volume	$64,628,200	$103,646,800	$55,834,440	$82,177,560	$430,360	$430,360	$430,360
Direct Income	$5,945,354	$9,534,800	$5,136,388	$7,559,776	$39,590	$39,590	$39,590
Induced Income	$6,658,796	$10,678,974	$5,752,754	$8,466,948	$44,341	$44,341	$44,341
Total Income	$12,604,150	$20,213,774	$10,889,142	$16,026,724	$83,931	$83,931	$83,931
Direct Employment	173	277	149	219	1	1	1
Induced Employment	193	310	167	246	1	1	1
Total Employment	366	587	316	465	2	2	2
Local Population	0	0	0	0	0	0	0

6.11 Evaluation of Belle Fontaine Area Measures

6.11.1 General

The Belle Fontaine area is located in the southern portion of planning unit three along the Mississippi Sound. The area is denoted as planning sub-unit 27 and is depicted in the figure, 6.11-1, below. The pre-Hurricane Katrina conditions for this area represented a mostly residential community. As demonstrated in Table 6.11-1, it was estimated from the field inventorying process that planning sub-unit 27 included 2,930 tax parcels, of which 1,389 contained a structure with some economic value and 1,541 were vacant land. Of those 1,389 parcels that contain structures, 1,357 were residential one-story, 0 were residential two-story, 17 were mobile homes, 12 were commercial, and 3 were municipal.

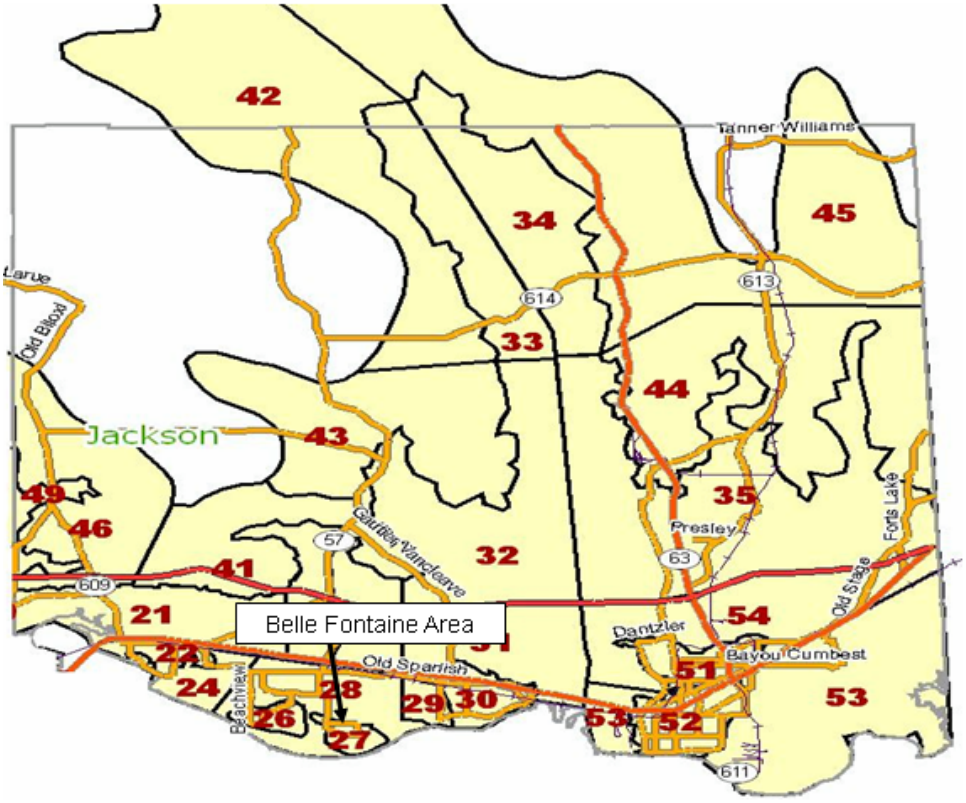


Figure 6.11-1. Belle Fontaine Area – Planning Sub-unit 27

Table 6.11-1.
Pre-Hurricane Katrina Estimate of Structures for the Belle Fontaine Area Planning Sub-unit 27

Structure Categories	Structures by Category
Residential	1,357
Mobile Homes	17
Commercial	12
Municipal	3
Vacant Land	1,541
Total Tax Parcels	**2,930**

6.11.2 Opportunities

The following opportunities were identified for this area:

- Hurricane storm damage reduction or remediation,
- Preservation of Fish and Wildlife Habitat.

6.11.3 Assumptions

The following assumptions were used in this analysis.

- The FY 2008 discount rate of 4-7/8 percent was used in estimating average annual benefits and costs
- Price levels are October, 2007 unless otherwise stated.
- A 100-year period of analysis (2012 to 2111) was used to calculate average annual benefits and costs pertaining to the evaluation of measures for hurricane and storm damage reduction.

6.11.4 Measures

Initially, a comprehensive list of measures was identified for flood damage reduction purposes for planning unit three. This list was screened and vetted for engineering and environmental feasibility and for policy compliance. The MsCIP Comprehensive Main Report and the Engineering and Environmental Appendices contain a detailed description of the measures that were initially screened.

Several potential measures were carried forward for this area for the purpose of flood damage reduction. These measures include both structural features and nonstructural actions. The measures evaluated for economic benefits include:

- Measure A – Belle Fontaine Ring Levee A

This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 20.0-feet NAVD88.

- Measure B – Belle Fontaine Ring Levee B

This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 30.0-feet NAVD88.

- Measure C – Belle Fontaine Ring Levee C

This measure would include a ring levee at 20-feet NAVD88 on an alternate footprint from Measure A and the acquisition of structures and parcels that would have been included in measure A but are not within the alternate footprint.

- Measure D – Belle Fontaine Ring Levee D

This measure would include a ring levee at 30-feet NAVD88 on an alternate footprint from Measure B and the acquisition of structures and parcels that would have been included in measure B but are not within the alternate footprint.

- Measure E – Belle Fontaine Nonstructural One

This measure includes the acquisition and flood proofing (elevate-in-place) of structures to the FEMA advisory base flood elevation (ABFE).

- Measure F – Belle Fontaine Nonstructural Two

This measure includes the acquisition and flood proofing of structures to approximately elevation 20-feet NAVD88.

- Measure G – Belle Fontaine Nonstructural Three

This measure includes the acquisition and flood proofing of structures to approximately elevation 30-feet NAVD88.

Figure 6.11-2 shows the measures for the Belle Fontaine Area (planning sub-unit 27); the red line represents the approximate footprint of the ring levee A and B measures, the green line represents the approximate footprint of the ring levee C and D measures, the dark green within the ring levee footprint represents potential ABFE buyout areas and the light green area within the ring levee footprint represents potential flood proof (elevate-in-place) areas.

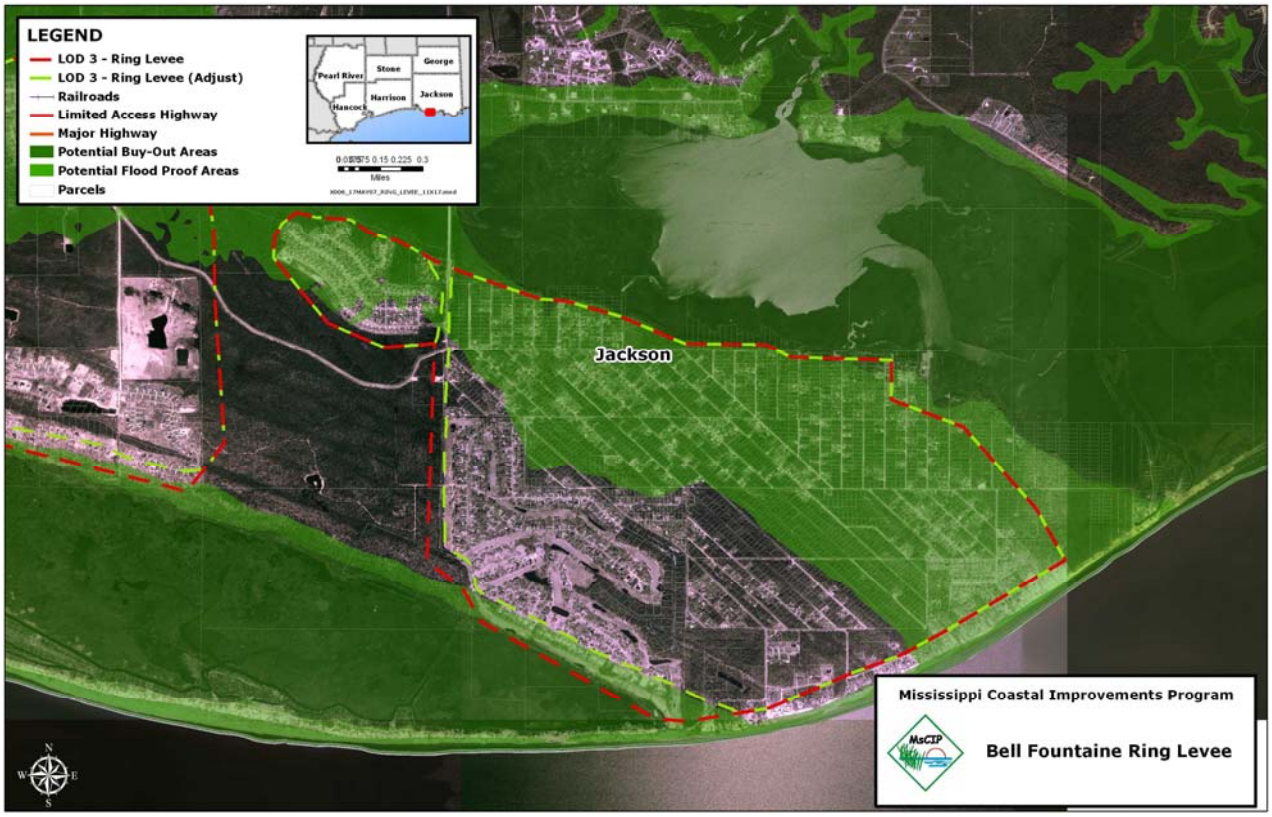


Figure 6.11-2. Display of Potential Measures for the Belle Fontaine Area (Planning Sub-unit 27)

6.11.5 National Economic Development (NED)

The purpose of this section is to document investigations conducted to identify the National Economic Development (NED) benefits of each of the potential measures previously listed. For this analysis, NED benefits are the reduced inundation damages of assets and their contents when one of the potential measures is in place. Typically, NED benefits are annualized over the period of the analysis (average annual benefits) and then compared to annualized costs over the period of analysis (average annual costs). This comparison is commonly known as the benefit-to-cost ratio (BCR). For purposes of this analysis, no benefit-to-cost ratios will be calculated as per the legislative Congressional language authorizing this study. The Coastal Mississippi Comprehensive Plan Report was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states: "…***that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project plan features based upon maximizing net national economic development benefits…"*** More detail on the authorizing language can be found in the MsCIP Comprehensive Plan Main Report.

6.11.5.1 Existing Conditions Post-Hurricane Katrina)

The effects of Hurricane Katrina storm surge were devastating to the Belle Fontaine Area. Peak water elevation in the area was approximately19-feet NAVD88. It is estimated that 420 of the structures in the area (mostly residential) sustained significant inundation damage (fifty-percent or more). Expected redevelopment of the area is described in the following section.

6.11.5.2 Future Without-Project Conditions

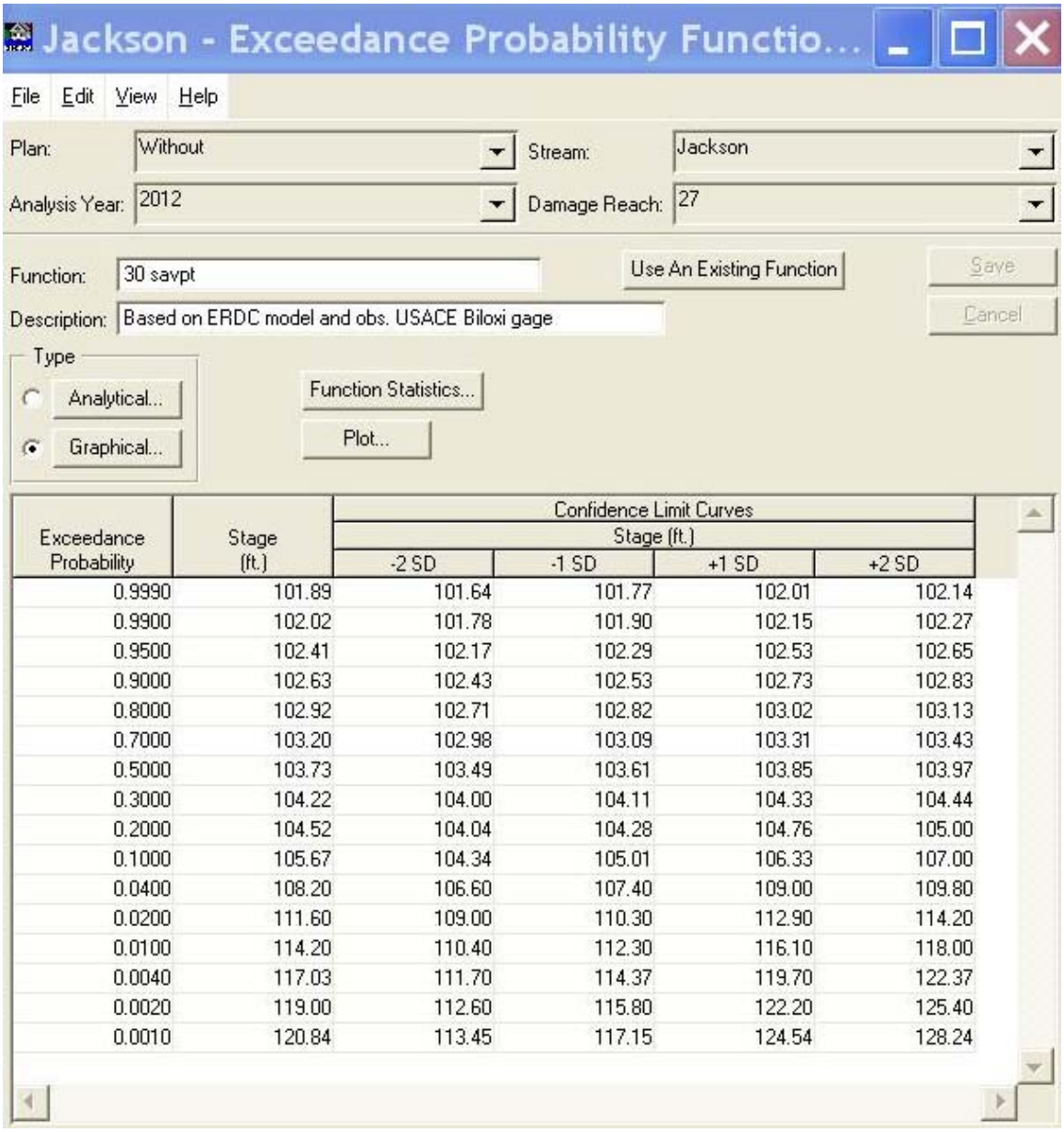
Equivalent annual flood damages for several future without-project scenarios were evaluated using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. Each of the measures were evaluated and compared to future without-project scenarios three, and five, as previously discussed in section 5.3. These future scenarios were chosen because the redevelopment projected for this area is anticipated to return to the pre-Katrina development. Futures scenarios two, four, and six were not used for evaluation purposes since this area is not accommodative for commercial and condominium redevelopment under those mixed redevelopment scenarios (see section 5.3 for more detail).

Future scenario one is the full redevelopment of structures within the study area by the year 2012 with no relative sea level rise over the 100-year period of analysis. Table 6.11-2 shows structures by category and by elevation. The number of structures per elevation is added to the previous number of structures per elevation in each category. For example, in the residential category there are three structures with an elevation of 5-feet or lower, and there are fourteen structures with an elevation of 6-feet or less, etc. This future scenario, as previously noted in section 5.3, is for sensitivity purposes only and will not be evaluated against all of the potential measures for the Belle Fontaine area.

Table 6.11-2.
Cumulative Structures by Category and by Estimated First Floor Elevation Future Scenarios One, Three, and Five Applicable for Base Year and Most Likely Future Years

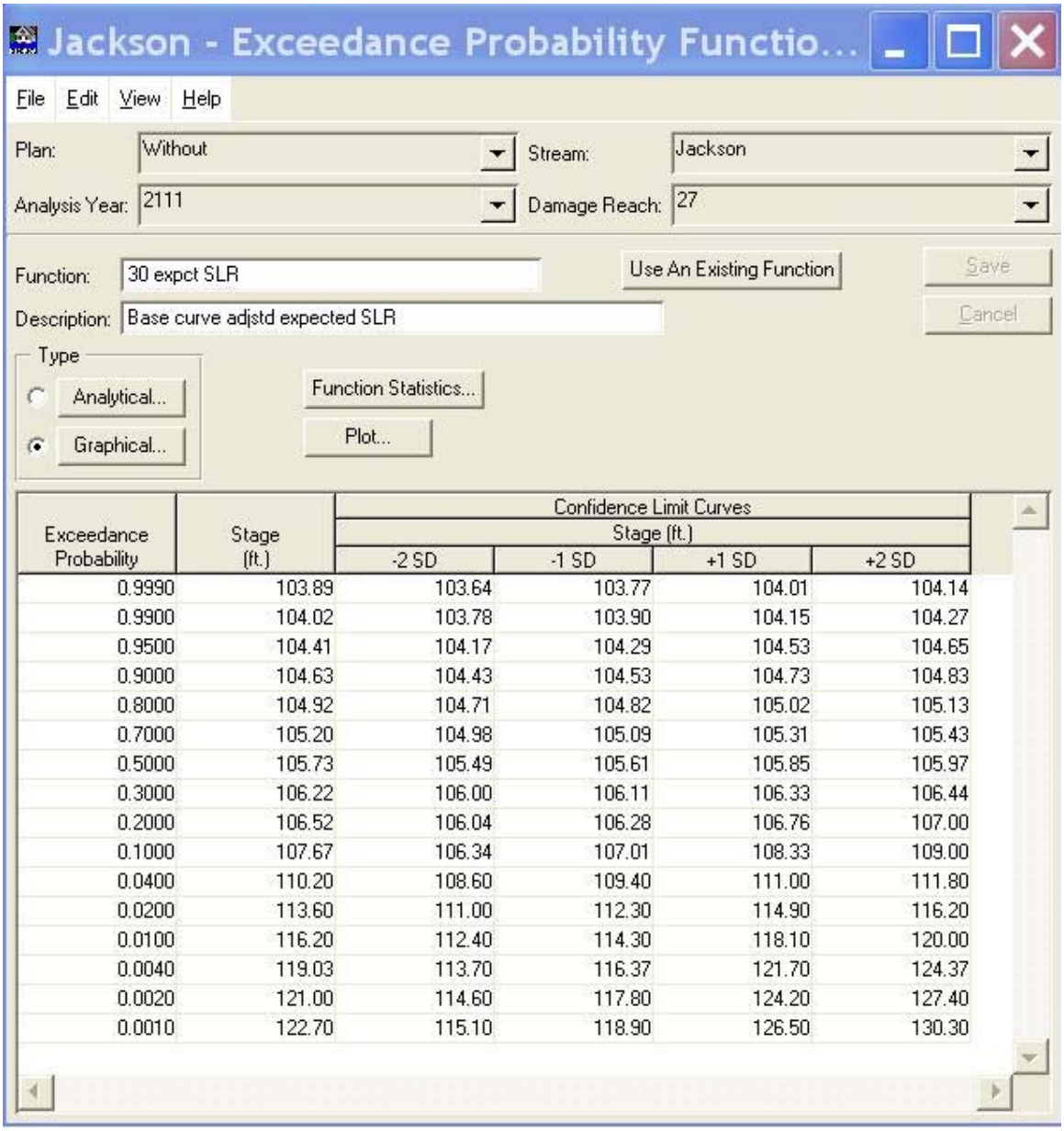
Estimated First Floor Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
1-foot	0	0	0	0	0
2-foot	0	0	0	0	0
3-foot	0	0	0	0	0
4-foot	0	0	0	0	0
5-foot	3	0	0	0	3
6-foot	14	0	0	0	14
7-foot	16	0	0	0	16
8-foot	18	0	0	0	18
9-foot	19	0	0	0	19
10-foot	28	0	0	0	28
11-foot	170	0	0	0	170
12-foot	208	0	1	0	209
13-foot	376	1	5	0	382
14-foot	707	2	7	0	716
15-foot	1,111	3	8	2	1,124
16-foot	1,166	5	9	3	1,183
17-foot	1,245	6	10	3	1,264
18-foot	1,298	7	11	3	1,319
19-foot	1,339	13	11	3	1,366
20-foot	1,346	17	12	3	1,378
21-foot	1,355	17	12	3	1,387
22-foot	1,357	17	12	3	1,389
Total	**1,357**	**17**	**12**	**3**	**1,389**

Future scenario three is the full redevelopment of assets within the study area by the year 2012. Under this scenario, assets will be rebuilt as they were pre-Hurricane Katrina. For example, if the asset was a residential structure pre-Hurricane Katrina it will be rebuilt as a residential structure; commercial structures will be built back to commercial structures; etc. Basically, future scenario three is the same structure inventory as future scenario one with the addition of an expected relative sea level rise over the 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $2,506,000 (rounded to the nearest thousand dollars). The total number of structures in this scenario are the same as in scenario one and can be seen above in table 6.11-2. Figures 6.11-3 and 6.11-4 depict the base year and most likely future year exceedance probability functions for the Belle Fontaine area (planning sub-unit 27). The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most likely future year exceedance probability function depicted in figure 6.11-4 includes an adjustment for expected relative sea level rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet.For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	101.89	101.64	101.77	102.01	102.14
0.9900	102.02	101.78	101.90	102.15	102.27
0.9500	102.41	102.17	102.29	102.53	102.65
0.9000	102.63	102.43	102.53	102.73	102.83
0.8000	102.92	102.71	102.82	103.02	103.13
0.7000	103.20	102.98	103.09	103.31	103.43
0.5000	103.73	103.49	103.61	103.85	103.97
0.3000	104.22	104.00	104.11	104.33	104.44
0.2000	104.52	104.04	104.28	104.76	105.00
0.1000	105.67	104.34	105.01	106.33	107.00
0.0400	108.20	106.60	107.40	109.00	109.80
0.0200	111.60	109.00	110.30	112.90	114.20
0.0100	114.20	110.40	112.30	116.10	118.00
0.0040	117.03	111.70	114.37	119.70	122.37
0.0020	119.00	112.60	115.80	122.20	125.40
0.0010	120.84	113.45	117.15	124.54	128.24

Figure 6.11-3. Future Scenario 3 Base Year (2012) Exceedance Probability Function for the Belle Fontaine Area

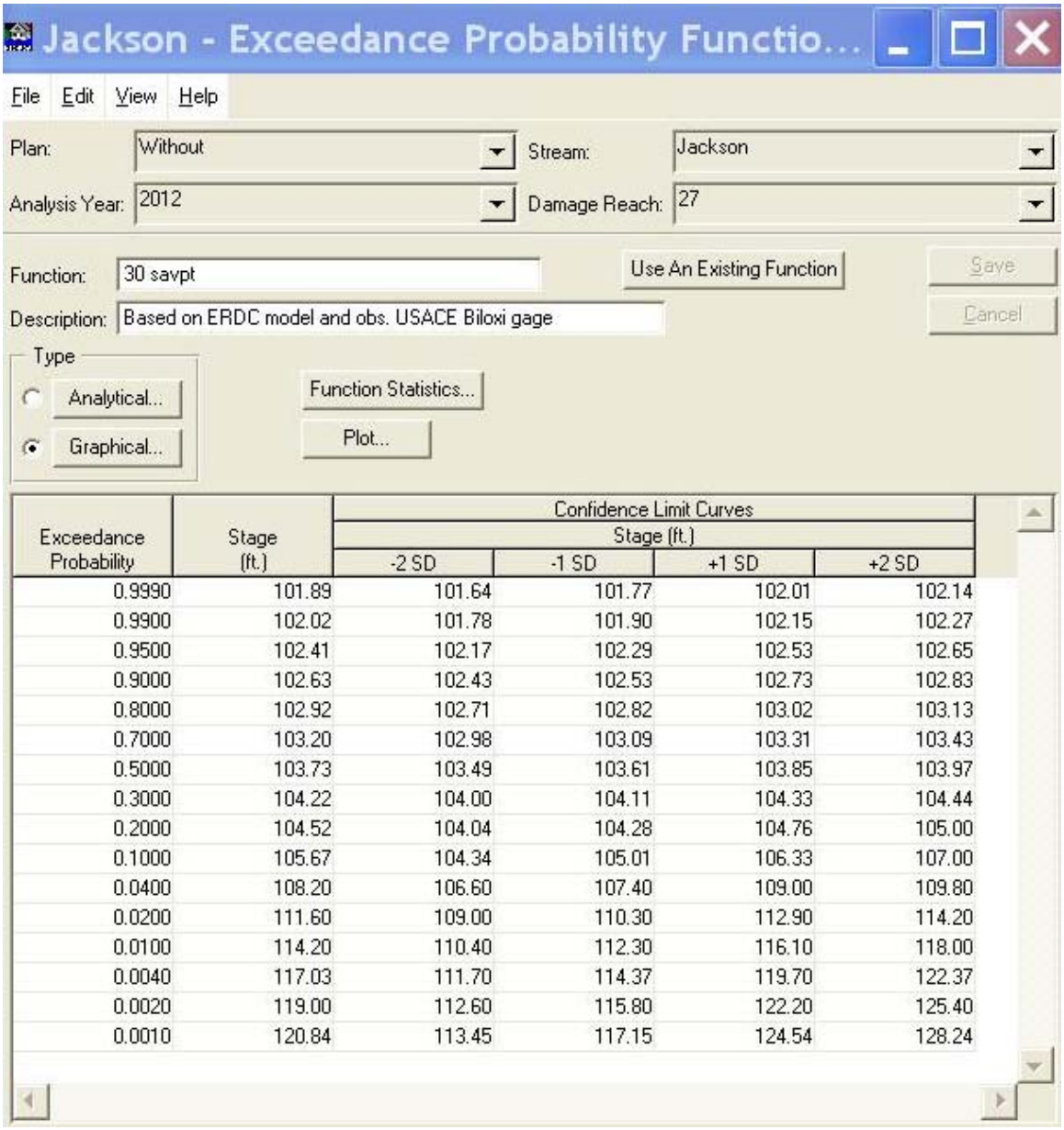


Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	103.89	103.64	103.77	104.01	104.14
0.9900	104.02	103.78	103.90	104.15	104.27
0.9500	104.41	104.17	104.29	104.53	104.65
0.9000	104.63	104.43	104.53	104.73	104.83
0.8000	104.92	104.71	104.82	105.02	105.13
0.7000	105.20	104.98	105.09	105.31	105.43
0.5000	105.73	105.49	105.61	105.85	105.97
0.3000	106.22	106.00	106.11	106.33	106.44
0.2000	106.52	106.04	106.28	106.76	107.00
0.1000	107.67	106.34	107.01	108.33	109.00
0.0400	110.20	108.60	109.40	111.00	111.80
0.0200	113.60	111.00	112.30	114.90	116.20
0.0100	116.20	112.40	114.30	118.10	120.00
0.0040	119.03	113.70	116.37	121.70	124.37
0.0020	121.00	114.60	117.80	124.20	127.40
0.0010	122.70	115.10	118.90	126.50	130.30

Figure 6.11-4. Future Scenario 3 Most Likely Future Year (2012) Exceedance Probability Function for the Belle Fontaine Area – Includes an adjustment for relative sea level rise

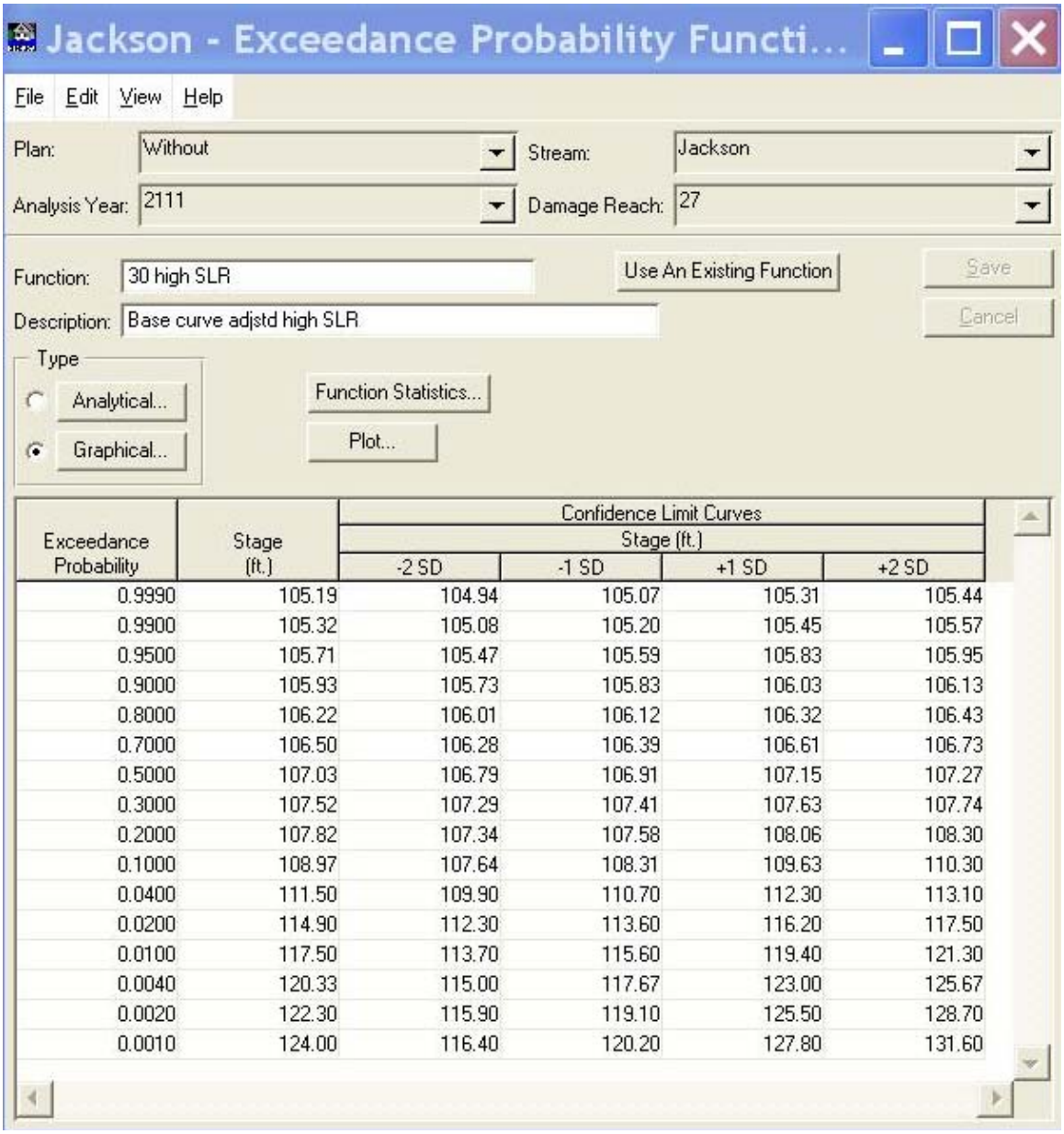
Future scenario five is the same as future scenario one with the addition of a high relative sea level rise 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $2,950,000 (rounded to the nearest thousand). These damages represent approximately an eighteen-percent (17.7%) increase over the expected relative sea level rise accounted for in future scenario three. The total number of structures in this scenario is the same as in scenarios one and three and can be seen above in table 6.11-2. Figures 6.11-5 and 6.11-6 depict the base year and most likely future year exceedance probability functions for the Belle Fontaine area (planning sub-unit 27). The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most likely future year exceedance probability function depicted in figure 6.11-6 includes an adjustment for

expected relative sea level rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet.For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	101.89	101.64	101.77	102.01	102.14
0.9900	102.02	101.78	101.90	102.15	102.27
0.9500	102.41	102.17	102.29	102.53	102.65
0.9000	102.63	102.43	102.53	102.73	102.83
0.8000	102.92	102.71	102.82	103.02	103.13
0.7000	103.20	102.98	103.09	103.31	103.43
0.5000	103.73	103.49	103.61	103.85	103.97
0.3000	104.22	104.00	104.11	104.33	104.44
0.2000	104.52	104.04	104.28	104.76	105.00
0.1000	105.67	104.34	105.01	106.33	107.00
0.0400	108.20	106.60	107.40	109.00	109.80
0.0200	111.60	109.00	110.30	112.90	114.20
0.0100	114.20	110.40	112.30	116.10	118.00
0.0040	117.03	111.70	114.37	119.70	122.37
0.0020	119.00	112.60	115.80	122.20	125.40
0.0010	120.84	113.45	117.15	124.54	128.24

Figure 6.11-5. Future Scenario 5 Base Year (2012) Exceedance Probability Function for the Belle Fontaine Area



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	105.19	104.94	105.07	105.31	105.44
0.9900	105.32	105.08	105.20	105.45	105.57
0.9500	105.71	105.47	105.59	105.83	105.95
0.9000	105.93	105.73	105.83	106.03	106.13
0.8000	106.22	106.01	106.12	106.32	106.43
0.7000	106.50	106.28	106.39	106.61	106.73
0.5000	107.03	106.79	106.91	107.15	107.27
0.3000	107.52	107.29	107.41	107.63	107.74
0.2000	107.82	107.34	107.58	108.06	108.30
0.1000	108.97	107.64	108.31	109.63	110.30
0.0400	111.50	109.90	110.70	112.30	113.10
0.0200	114.90	112.30	113.60	116.20	117.50
0.0100	117.50	113.70	115.60	119.40	121.30
0.0040	120.33	115.00	117.67	123.00	125.67
0.0020	122.30	115.90	119.10	125.50	128.70
0.0010	124.00	116.40	120.20	127.80	131.60

Figure 6.11-6. Future Scenario 5 Most Likely Future Year (2012) Exceedance Probability Function for the Belle Fontaine Area – Includes an adjustment for relative sea level rise

6.11.5.3 Equivalent annual damages Reduced

Equivalent annual damages reduced are calculated as the difference between the damages under the future without-project scenarios three and five and the damages incurred with the measure in place. The HECFDA model was run for each measure to determine the damages reduced as compared to the without-project scenario.

In order to provide the HEC-FDA model with accurate information about the economic characteristics of each measure, separate inventories were created for each measure. The inventories are the same as the without project inventory except that footprints of levees and acquisitions were deleted from the inventory and flood proofed structures (structures to be raised in

place) were given a higher elevation. The structure inventories for each of the HEC-FDA measure runs are as follows:

- Measure A – Belle Fontaine Ring Levee A at elevation 20.0-feet NAVD88

This measure includes the without-project inventory less 101 parcels that were deleted out of the inventory. These parcels represent the footprint of the 20.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure B – Belle Fontaine Ring Levee B at elevation 30.0-feet NAVD88

This measure includes the without-project inventory less 118 parcels that were deleted out of the inventory. These parcels represent the footprint of the 30.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure C – Belle Fontaine Ring Levee C at elevation 20.0-feet NAVD88

This measure would include a ring levee at 20-feet NAVD88 on an alternate footprint from Measure A and the acquisition of structures and parcels that would have been included in measure A but are not within the alternate footprint.

- Measure D – Belle Fontaine Ring Levee D

This measure would include a ring levee at 30-feet NAVD88 on an alternate footprint from Measure B and the acquisition of structures and parcels that would have been included in measure B but are not within the alternate footprint.

- Measure E – Belle Fontaine Nonstructural One

This measure includes the acquisition of 32 parcels that include a structure and the flood proofing (raise structure in place) of 1,028 structures to an elevation of 14.55-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was determined to be approximately the ABFE level of protection and is defined as still water elevation, plus wave run-up, plus an estimate for waves (depth divided by two), and is the minimum implementation elevation that a nonstructural measure do to the requirements of the National Flood Insurance Program (NFIP).

- Measure F – Belle Fontaine Nonstructural Two to elevation 20.0-feet NAVD88

This measure includes the acquisition of 177 parcels that include a structure and the flood proofing (raise structure in place) of 883 structures to an elevation of 20.0-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levee measures at elevation 20.0-feet NAVD88.

- Measure G – Belle Fontaine Nonstructural Three to elevation 30.0-feet NAVD88

This measure includes the acquisition of 1,060 parcels that include a structure. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing

Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levee measures at elevation 30.0-feet NAVD88.

Residual damage is the equivalent annual damages that still remain even when a project is in place. Residual damage is calculated as the future without-project equivalent annual damages minus the damages reduced of the various measures. The purpose of residual damages is to calculate and communicate the portions of damages that will not be reduced by the implementation of a plan or "what damages are left on the table." Table 6.11-3 summarizes the without project damages, damages reduced, and residual damages by measure and by future scenario.

Table 6.11-3.
Summary of Damages by Measure

Measures	Equivalent Annual Damages Future 3 ($)	Equivalent Annual Damage Reduction Future 3 ($)	Residual Damage Future 3 ($)	Equivalent Annual Damages Future 5 ($)	Equivalent Annual Damage Reduction Future 5 ($)	Residual Damage Future 5 ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A 20FT Ring Levee A	$2,506,000	$2,235,000	$271,000	$2,950,000	$2,641,000	$309,000
Measure B 30FT Ring Levee B	$2,506,000	$2,493,000	$13,000	$2,950,000	$2,933,000	$17,000
Measure C 20FT Ring Levee C	$2,506,000	$2,350,000	$156,000	$2,950,000	$2,765,000	$185,000
Measure D 30FT Ring Levee D	$2,506,000	$2,506,000	$0	$2,950,000	$2,950,000	$0
Measure C ABFE Nonstructural	$2,506,000	$1,425,000	$1,081,000	$2,950,000	$1,652,000	$1,298,000
Measure D 20FT Nonstructural	$2,506,000	$2,235,000	$271,000	$2,950,000	$2,641,000	$309,000
Measure E 30FT Nonstructural	$2,506,000	$2,506,000	$0	$2,950,000	$2,950,000	$0

Damages are rounded to the nearest thousand dollars.

6.11.6 Environmental Quality (EQ)

6.11.6.1 Impacts of Ring Levee Measures

The Engineering Research and Development Center Wetlands and Coastal Ecology Branch were asked to conduct an assessment of potential impacts to wetlands as a result of constructing various levees and seawalls along the Mississippi Gulf Coastal Plain. This report summarizes the results of the assessment. The analysis of impacts included two components:

1. A calculation of total acreage of all wetlands (by type and planning reach) that is directly under the levee footprints.

2. A modified Hydrogeomorphic (HGM) wetland rapid assessment of impacted Estuarine/Tidal Fringe wetlands, based on the Mississippi and Alabama Gulf Coast HGM guidebook (Shafer et al., 2007), with impacts reported as loss of functional units. Tables 6.11-4 and 6.11-5 show the impacts of the Belle Fontaine ring levees at elevations 20.0-feet NAVD88, and 30.0-feet NAVD88 respectively.

Table 6.11-4.
Wetland Acres Impacted by Elevation 20' Belle Fontaine Ring Levee A

Reach ID	Estuarine and Marine Wetland	Freshwater Forested/ Shrub Wetland	Freshwater Pond	Total
27	4.7	14.2	0.4	19.3
28	9.5	18.0	0.2	27.6
Total	**14.2**	**32.2**	**0.5**	**46.9**

Table 6.11-5.
Wetland Acres Impacted by Elevation 30' Belle Fontaine Ring Levee B

Reach ID	Estuarine and Marine Wetland	Freshwater Forested/ Shrub Wetland	Freshwater Pond	Total
27	6.11	20.5	0.6	27.5
28	13.0	25.4	0.2	38.5
Total	**19.4**	**45.9**	**0.8**	**66.0**

Nonstructural measures would have no construction activities other than demolition and disposal of building materials in an approved land fill occurs as a result of this measure. More detail on the impacts of the structural and nonstructural measures for the Belle Fontaine area can be found in the Environmental Appendix.

6.11.7 Summary of Costs

Table 6.11-6 summarizes the ROM costs at an FY-08 price level by measure for the Belle Fontaine area (planning sub-unit 26).

Table 6.11-6.
Summary of Costs by Measure for the Belle Fontaine Area

Measures	Total Cost to Implement (First Cost) ($)	Average Annual Implementation Cost ($)	Average Annual O&M ($)	IDC ($)	Total Average Annual Costs ($)
(No Action)	$0	$0	$0	$0	$0
Measure A 20FT Ring Levee A	$137,600,000	$6,766,000	$1,371,000	N/A	$8,137,000
Measure B 30FT Ring Levee B	$191,900,000	$9,436,000	$1,939,000	N/A	$11,375,000
Measure C 20FT Ring Levee C	$103,900,000	$5,109,000	$989,000	N/A	$6,098,000
Measure D 30FT Ring Levee D	$142,900,000	$7,027,000	$1,414,000	N/A	$8,441,000
Measure E ABFE Nonstructural	$227,800,000	$11,201,000	$10,000	N/A	$11,211,000
Measure F 20FT Nonstructural	$290,726,000	$14,295,000	$10,000	N/A	$14,305,000
Measure G 30FT Nonstructural	$453,067,000	$22,278,000	$10,000	N/A	$22,288,000

The implementation costs include 1/ supervision and administration (30 account), 2/ planning, engineering & design (31 account) and 3/ appropriate contingencies. See the Cost Appendix for more detail on the implementation cost breakdowns. Numbers are rounded to the nearest thousand.

6.11.8 Regional Economic Development (RED)

The purpose of this analysis is to determine the economic impact of the proposed project measures on business (sale volumes), income, employment, and population of the local area. Each of the measures would affect the local area of Jackson County, Mississippi. The expenditures for the measures are estimated to be $137,600,000 for the 20.0-feet NAVD88 ring levee A measure, $191,900,000 for the 30.0-feet NAVD88 ring levee B measure, $103,900,000 for the 20.0-feet NAVD88 ring levee C measure, $142,900,000 for the 30.0-feet NAVD88 ring levee D measure, $227,800,000 for the ABFE nonstructural measures, $290,726,000 for the 20.0-feet NAVD88 nonstructural measures, and $290,726,000 for the 30.0-feet NAVD88 nonstructural measures. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $27,882,000 for the 20.0-feet NAVD88 ring levee A measure, $39,434,000 for the 30.0-feet NAVD88 ring levee B measure, $20,113,000 for the 20.0-feet NAVD88 ring levee C measure, $28,757,000 for the 30.0-feet NAVD88 ring levee D measure, $203,000 for the ABFE nonstructural measure, $203,000 for the 20.0-feet NAVD88 nonstructural measure, and $203,000 for the 30.0-feet NAVD88 nonstructural measure respectively (assuming a 100 year period of analysis and an interest rate of 4.875 percent). The following tables, 6.11-7 through 6.11-10, summarize the EIFS model inputs and outputs for the Belle Fontaine area.

Table 6.11-7.
EIFS Model Construction Costs Inputs for the Belle Fontaine Area

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$137,600,000	$191,900,000	$103,900,000	$142,900,000	$227,800,000	$290,726,000	$453,067,000

Based of the given inputs the outputs are as follows:

Table 6.11-8.
EIFS Model Construction Costs Outputs for the Belle Fontaine Area

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Direct Sales Volume	$137,600,000	$191,900,000	$103,900,000	$142,900,000	$227,800,000	$290,726,000	$453,067,000
Induced Sales Volume	$154,112,000	$214,928,000	$116,368,000	$160,048,000	$255,136,000	$325,613,120	$507,435,040
Total Sales Volume	$291,712,000	$406,828,000	$220,268,000	$302,948,000	$482,936,000	$616,339,120	$960,502,040
Direct Income	$26,835,517	$37,425,405	$20,263,156	$27,869,153	$44,426,823	$56,699,001	$88,359,645
Induced Income	$30,055,775	$41,916,448	$22,694,732	$31,213,447	$49,758,035	$63,502,873	$98,962,791
Total Income	$56,891,292	$79,341,853	$42,957,887	$59,082,599	$94,184,858	$120,201,874	$187,322,436
Direct Employment	778	1,086	588	809	1,289	1,646	2,564
Induced Employment	872	1,216	659	906	1,444	1,843	2,872
Total Employment	1,650	2,302	1,247	1,715	2,734	3,489	5,437
Local Population	0	0	0	0	0	0	0

Table 6.11-9.
EIFS Model O&M Cost Inputs for the Belle Fontaine Area (Planning Sub-unit 27)

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$27,882,000	$39,434,000	$20,113,000	$28,757,000	$203,000	$203,000	$203,000

Based of the given inputs the outputs are as follows:

Table 6.11-10.
EIFS Model O&M Cost Outputs for the Belle Fontaine Area (Planning Sub-unit 27)

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Direct Sales Volume	$27,882,000	$39,434,000	$20,113,000	$28,757,000	$203,000	$203,000	$203,000
Induced Sales Volume	$31,227,840	$44,166,080	$22,526,560	$32,207,840	$227,360	$227,360	$227,360
Total Sales Volume	$59,109,840	$83,600,000	$42,639,560	$60,964,840	$430,360	$430,360	$430,360
Direct Income	$5,437,703	$7,690,638	$3,922,549	$5,608,350	$39,590	$39,590	$39,590
Induced Income	$6,090,226	$8,613,513	$4,393,254	$6,281,351	$44,341	$44,341	$44,341
Total Income	$11,527,929	$16,304,151	$8,315,804	$11,889,701	$83,931	$83,931	$83,931
Direct Employment	158	223	114	163	1	1	1
Induced Employment	177	250	128	182	1	1	1
Total Employment	335	473	241	345	2	2	2
Local Population	0	0	0	0	0	0	0

6.12 Evaluation of Pascagoula - Moss Point Area Measures

6.12.1 General

The Pascagoula - Moss Point area, shown in Figure 6.12-1, is located in the southeastern portion of planning unit three along the eastern bank of the Pascagoula River. The area is denoted as planning sub-units 51 and 52 and is depicted in the figure below. The pre-Hurricane Katrina conditions for this area represented a mostly residential community. As shown in table 6.12-1, it was estimated from the field inventorying process that planning sub-units 51 and 52 included 16,158 tax parcels; of which 13,638 contained a structure with some economic value and 2,520 were vacant land. Of those 13,638 parcels that contain structures, 11,449 were residential one-story, 314 were residential two-story, 52 were mobile homes, 1,565 were commercial, and 258 were municipal.

6.12.2 Opportunities

The following opportunities were identified for this area:

- Hurricane storm damage reduction or remediation
- Preservation of Fish and Wildlife

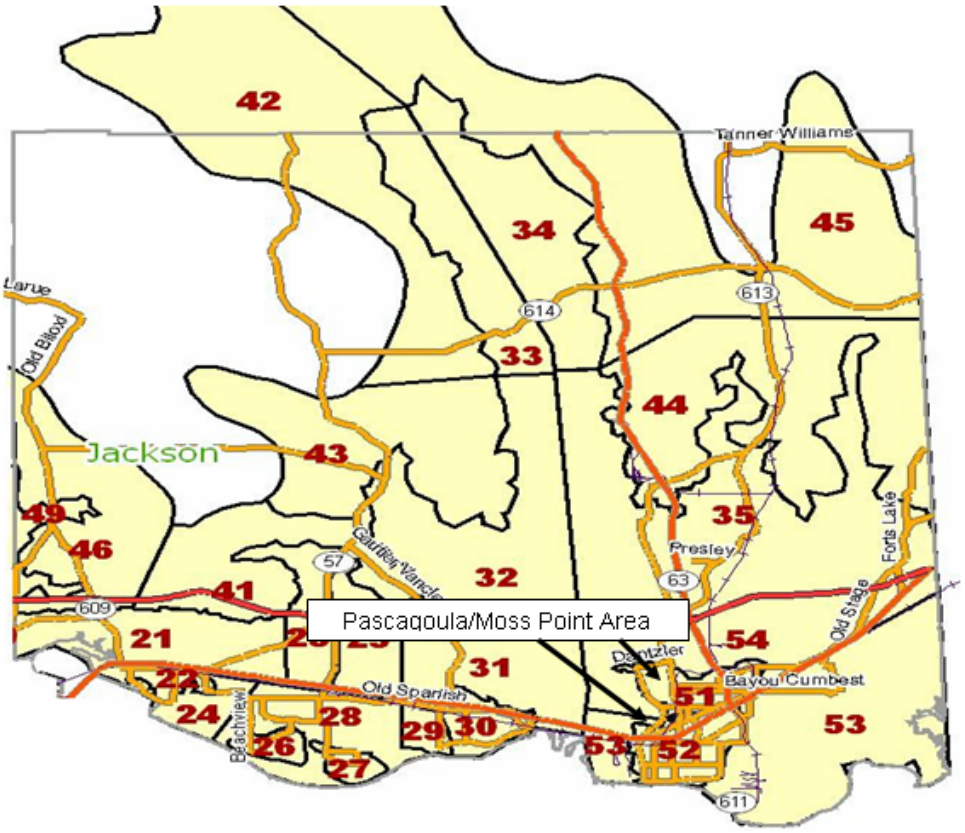


Figure 6.12-1. Pascagoula - Moss Point Area – Planning Sub-units 51 and 52

Table 6.12-1.
Pre-Hurricane Katrina Estimate of Structures for the
Pascagoula-Moss Point Area Planning Sub-units 51 and 52

Structure Categories	Structures by Category
Residential	11,763
Mobile Homes	52
Commercial	1,565
Municipal	258
Vacant Land	2,520
Total Tax Parcels	**16,158**

6.12.3 Assumptions

The following assumptions were used in this analysis.

- The FY 2008 discount rate of 4.875 percent was used in estimating average annual benefits and costs
- Price levels are October, 2007 unless otherwise stated.
- A 100-year period of analysis (2012 to 2111) was used to calculate average annual benefits and costs.

6.12.4 Measures

Initially, a comprehensive list of measures was identified for flood damage reduction purposes for planning unit three. This list was screened and vetted for engineering and environmental feasibility and for policy compliance. The MsCIP Comprehensive Main Report and the Engineering and Environmental Appendices contain a detailed description of the measures that were initially screened.

Several potential measures were carried forward for this area for the purpose of flood damage reduction. These measures include both structural features and nonstructural actions. The measures evaluated for economic benefits include:

- Measure A – Pascagoula - Moss Point Ring Levee at Elevation 20.0-feet NAVD88

This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 20.0-feet NAVD88.

- Measure B – Pascagoula - Moss Point Ring Levee Elevation 30.0-feet NAVD88

This measure will provide a ring levee with interior drainage, pumping stations, and roadway access up to a crest elevation of 30.0-feet NAVD88.

- Measure C – Pascagoula - Moss Point Ring Levee at Elevation 20.0-feet NAVD88

This measure includes a combination of a ring levee at 20-feet NAVD88 on an alternate footprint from measure A that would include the acquisition of structures and parcels in the Moss Point area.

- Measure D – Pascagoula - Moss Point Ring Levee Elevation 30.0-feet NAVD88

This measure includes a combination of a ring levee at 30-feet NAVD88 on an alternate footprint from measure B that would include the acquisition of structures and parcels in the Moss Point area.

- Measure E – Pascagoula - Moss Point Ring Levee at Elevation 20.0-feet NAVD88

This measure includes a combination of a ring levee at 20-feet NAVD88 on an alternate footprint from measure A that would include the acquisition of structures and parcels in the Washington Avenue area.

- Measure F – Pascagoula - Moss Point Ring Levee Elevation 30.0-feet NAVD88

This measure includes a combination of a ring levee at 30-feet NAVD88 on an alternate footprint from measure B that would include the acquisition of structures and parcels in the Washington Avenue area.

- Measure G – Pascagoula - Moss Point Ring Levee at Elevation 20.0-feet NAVD88

This measure includes a combination of a ring levee at 20-feet NAVD88 on an alternate footprint from measure A that would include the acquisition of structures and parcels in the Moss Point and Washington Avenue areas.

- Measure H – Pascagoula - Moss Point Ring Levee Elevation 30.0-feet NAVD88

This measure includes a combination of a ring levee at 30-feet NAVD88 on an alternate footprint from measure B that would include the acquisition of structures and parcels in the Moss Point and Washington Avenue areas.

- Measure I – Pascagoula - Moss Point Nonstructural One

This measure includes the acquisition and flood proofing (elevate-in-place) of structures to the FEMA advisory base flood elevation (ABFE).

- Measure J – Pascagoula - Moss Point Nonstructural Two

This measure includes the acquisition and flood proofing of structures to approximately elevation 20-feet NAVD88.

- Measure K – Pascagoula - Moss Point Nonstructural Three

This measure includes the acquisition and flood proofing of structures to approximately elevation 30-feet NAVD88.

Figure 6.12-2 shows the measures for the Pascagoula-Moss Point Area (planning sub-units 51 and 52); the red line represents the approximate footprint of the ring levees A and B, the green line represents the approximate footprints of ring levees C through H, the dark green within the ring levee footprint represents potential ABFE buyout areas and the light green area within the ring levee footprint represents potential flood proof (elevate-in-place) areas.

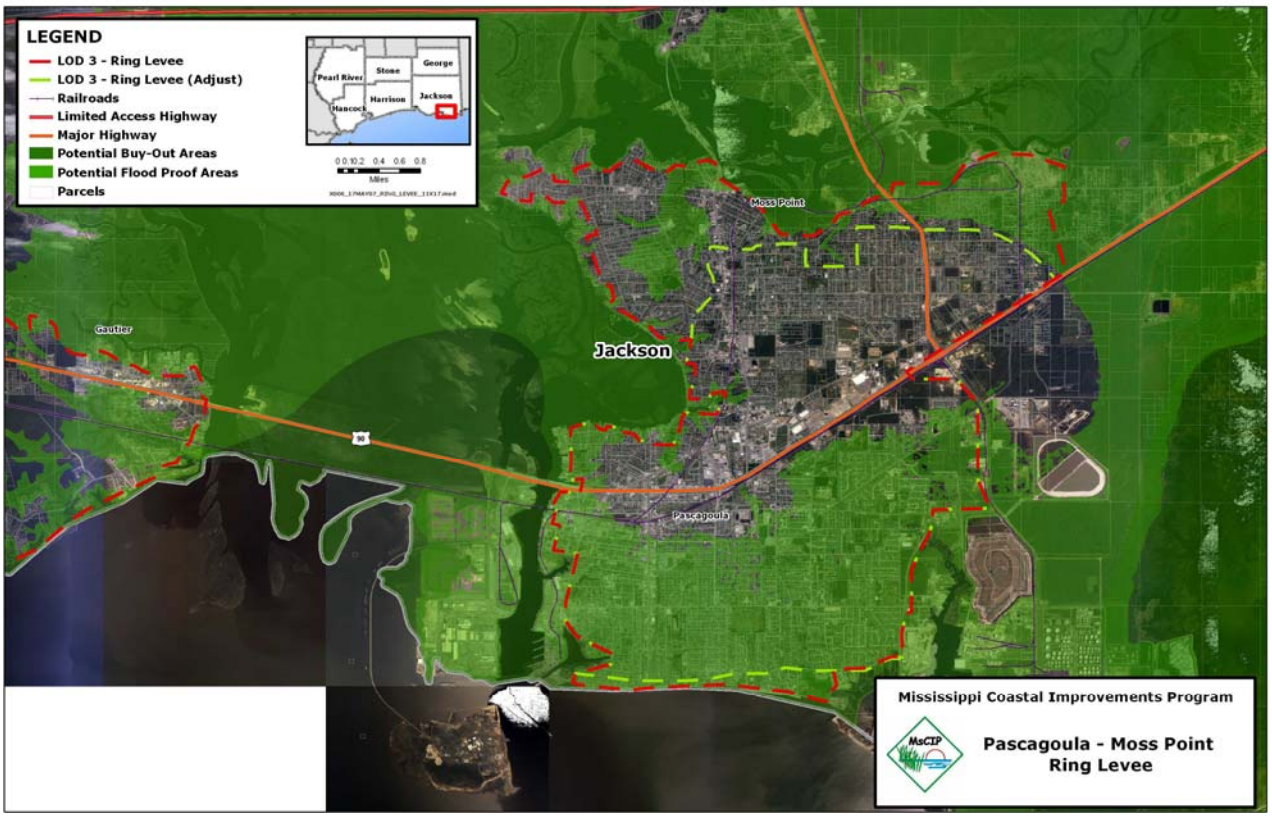


Figure 6.12-2. Display of Potential Measures for the Pascagoula-Moss Point Area (Planning Sub-units 51 and 52)

6.12.5 National Economic Development (NED)

The purpose of this section is to document investigations conducted to identify the National Economic Development (NED) benefits of each of the potential measures previously listed. For this analysis, NED benefits are the reduced inundation damages of assets and their contents when one of the potential measures is in place. Typically, NED benefits are annualized over the period of the analysis (average annual benefits) and then compared to annualized costs over the period of analysis (average annual costs). This comparison is commonly known as the benefit-to-cost ratio (BCR). For purposes of this analysis, no benefit-to-cost ratios will be calculated as per the legislative Congressional language authorizing this study. The Coastal Mississippi Comprehensive Plan Report was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states: "…***that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project plan features based upon maximizing net national economic development benefits…"*** More detail on the authorizing language can be found in the MsCIP Comprehensive Plan Main Report.

6.12.5.1 Existing Conditions Post-Hurricane Katrina)

The effects of Hurricane Katrina storm surge were devastating to the Pascagoula-Moss Point Area. Peak water elevation in the area ranged from 14 and 16-feet NAVD88. It is estimated that approximately 3,840 (101 in planning sub-unit 51 and 3,743 in planning sub-unit 52) of the structures in the area (sustained significant inundation damage (fifty-percent or more). Expected redevelopment of the area is described in the following section.

6.12.5.2 Future Without-Project Conditions

Equivalent annual flood damages for several future without-project scenarios were evaluated using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. Each of the measures were evaluated and compared to future without-project scenarios three, and five, as previously discussed in section 5.3. These future scenarios were chosen because the redevelopment projected for this area is anticipated to return to the pre-Katrina development. Futures scenarios two, four, and six were not used for evaluation purposes since this area is not accommodative for commercial and condominium redevelopment under those mixed redevelopment scenarios (see section 5.3 for more detail).

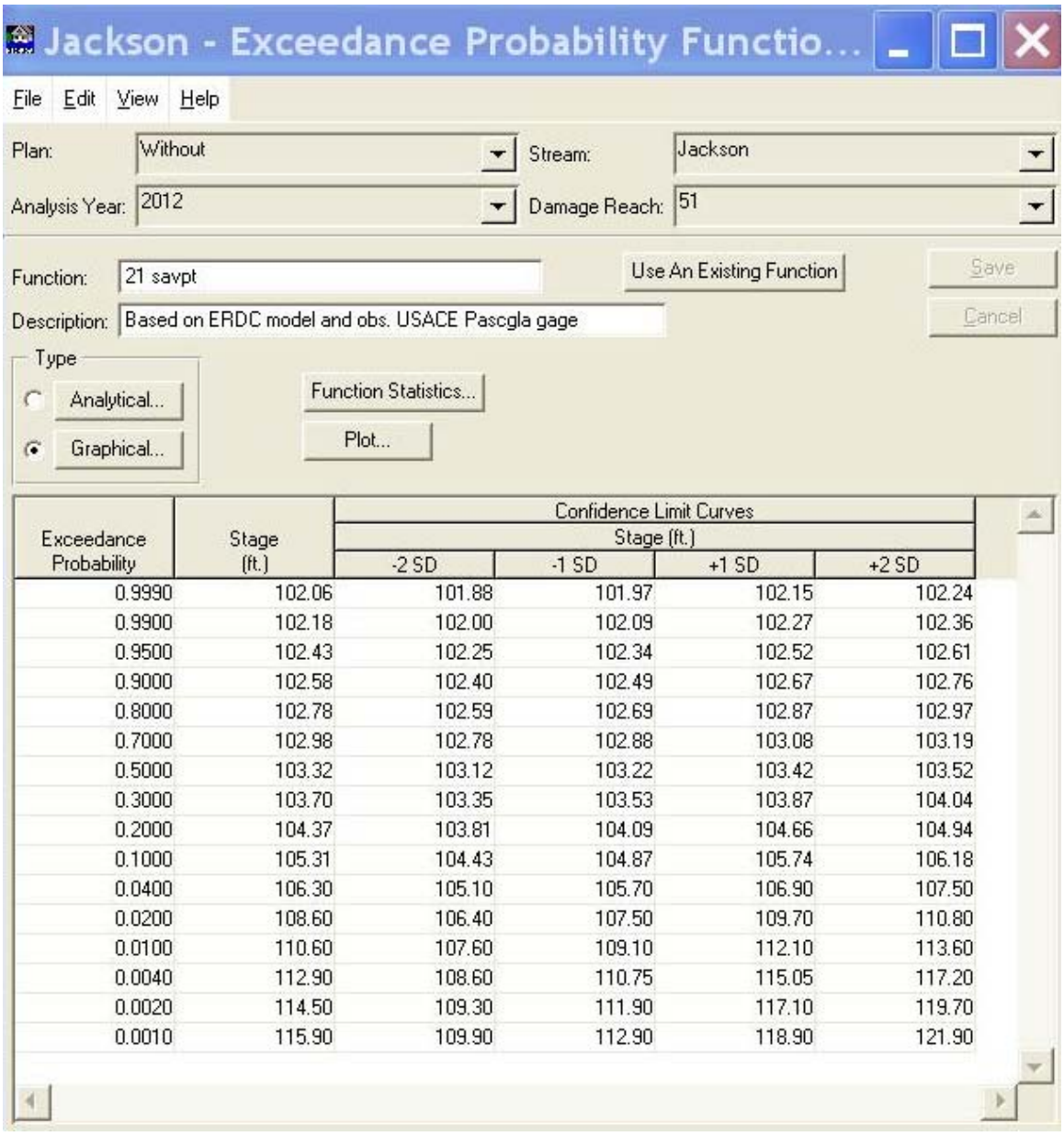
Future scenario one is the full redevelopment of structures within the study area by the year 2012 with no relative sea level rise over the 100-year period of analysis. Table 6.12-2 shows structures by category and by elevation. The number of structures per elevation is added to the previous number of structures per elevation in each category. For example, in the residential category there are four structures with an elevation of 1-foot or lower, there are twelve structures with an elevation of 2-feet or less, etc. This future scenario, as previously noted in section 5.3, is for sensitivity purposes only and will not be evaluated against all of the potential measures for the Pascagoula-Moss Point area.

Table 6.12-2.
Cumulative Structures by Category and by Estimated First Floor Elevation
Future Scenarios One, Three, and Five
Applicable for Base Year and Most Likely Future Years

Estimated First Floor Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
1-foot	4	0	0	0	4
2-foot	12	0	0	0	12
3-foot	31	0	0	0	31
4-foot	62	0	0	0	62
5-foot	107	0	0	0	107
6-foot	158	0	2	1	161
7-foot	263	0	8	2	273
8-foot	435	0	16	5	456
9-foot	691	0	35	8	734
10-foot	1,002	1	50	11	1,064
11-foot	1,574	1	59	13	1,647
12-foot	2,850	2	148	32	3,032
13-foot	4,367	9	330	74	4,780
14-foot	5,344	13	597	104	6,058
15-foot	7,951	21	1,090	165	9,227
16-foot	8,367	22	1,231	174	9,794
17-foot	9,053	23	1,294	180	10,550
18-foot	10,153	23	1,384	202	11,762
19-foot	10,966	36	1,464	222	12,688
20-foot	11,346	51	1,499	231	13,127
21-foot	11529	52	1,531	237	13,349
22-foot	11,612	52	1,549	245	13,458
23-foot	11,650	52	1,557	248	13,507
24-foot	11,700	52	1,564	252	13,568
25-foot	11,749	52	1,565	256	13,622
26-foot	11,763	52	1,565	258	13,638
Total	**11,763**	**52**	**1,565**	**258**	**13,638**

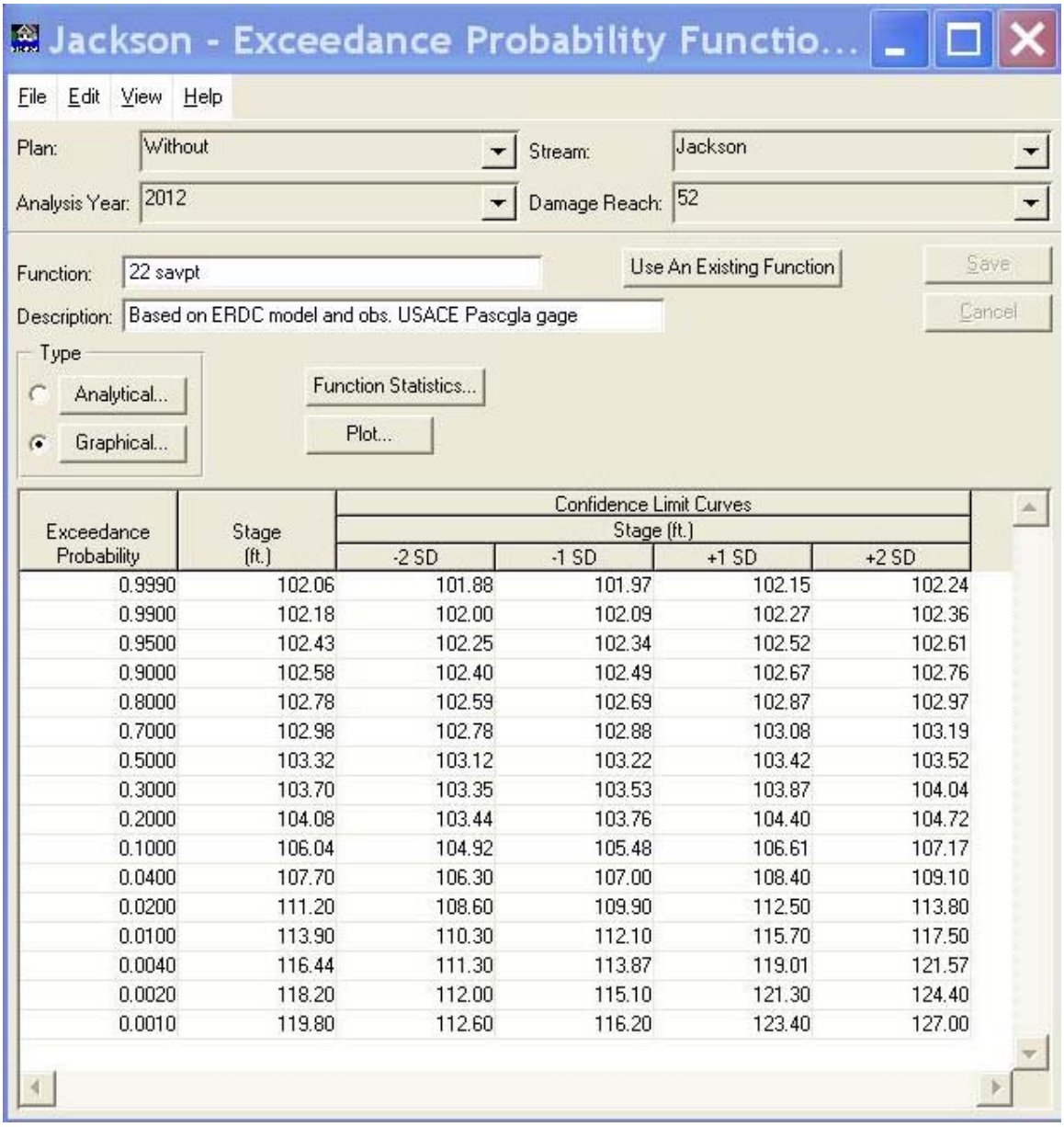
Future scenario three is the full redevelopment of assets within the study area by the year 2012. Under this scenario, assets will be rebuilt as they were pre-Hurricane Katrina. For example, if the asset was a residential structure pre-Hurricane Katrina it will be rebuilt as a residential structure; commercial structures will be built back to commercial structures; etc. Basically, future scenario three is the same structure inventory as future scenario one with the addition of an expected relative sea level rise over the 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $26,078,000 (rounded to the nearest thousand dollars). The total number of structures in this scenario are the same as in scenario one and can be seen above in table 6.12-2. Figures 6.12-3 and 6.12-4 depict the base years for planning sub-units 51 and 52 respectively, and figures 6.12-5 and 6.12-6 show the most likely future year exceedance probability functions for planning sub-units 51 and 52. The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most

likely future year exceedance probability function depicted in figure 6.12-5 ad 6.12-6 includes an adjustment for expected relative sea level rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet. For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.



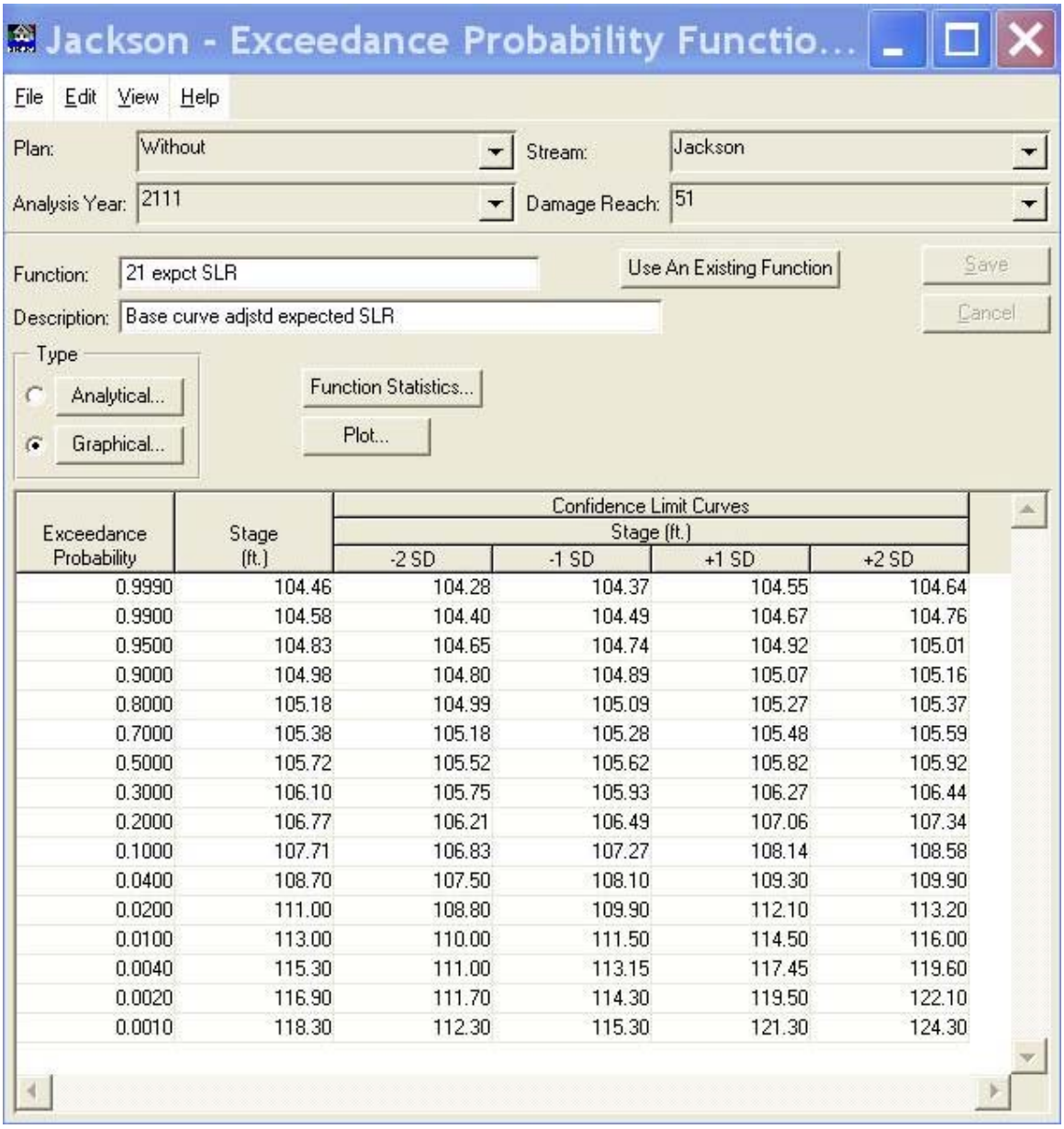
Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	102.06	101.88	101.97	102.15	102.24
0.9900	102.18	102.00	102.09	102.27	102.36
0.9500	102.43	102.25	102.34	102.52	102.61
0.9000	102.58	102.40	102.49	102.67	102.76
0.8000	102.78	102.59	102.69	102.87	102.97
0.7000	102.98	102.78	102.88	103.08	103.19
0.5000	103.32	103.12	103.22	103.42	103.52
0.3000	103.70	103.35	103.53	103.87	104.04
0.2000	104.37	103.81	104.09	104.66	104.94
0.1000	105.31	104.43	104.87	105.74	106.18
0.0400	106.30	105.10	105.70	106.90	107.50
0.0200	108.60	106.40	107.50	109.70	110.80
0.0100	110.60	107.60	109.10	112.10	113.60
0.0040	112.90	108.60	110.75	115.05	117.20
0.0020	114.50	109.30	111.90	117.10	119.70
0.0010	115.90	109.90	112.90	118.90	121.90

Figure 6.12-3. Future Scenario 3 Base Year (2012) Exceedance Probability Function for the Planning Sub-unit 51



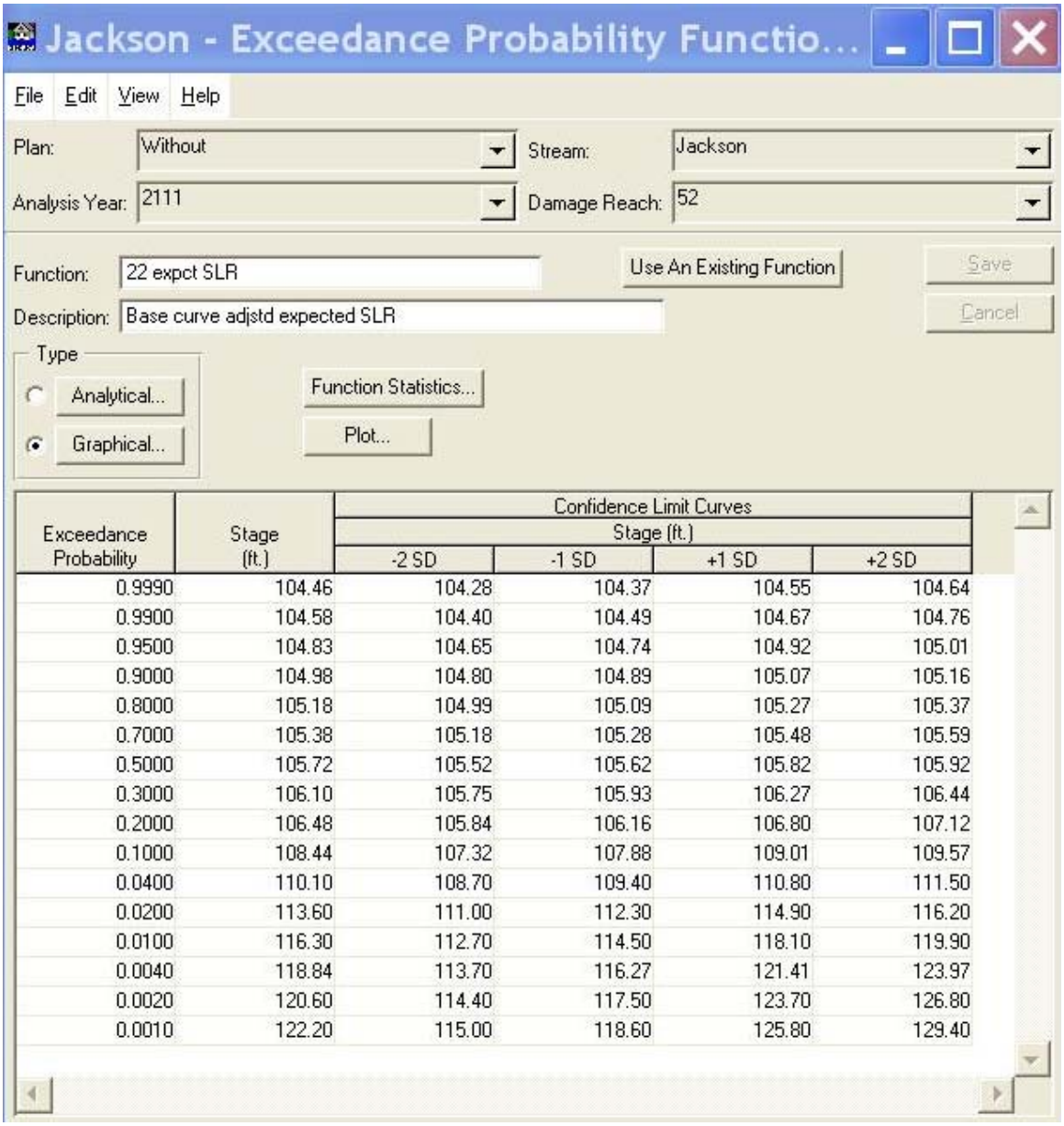
Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	102.06	101.88	101.97	102.15	102.24
0.9900	102.18	102.00	102.09	102.27	102.36
0.9500	102.43	102.25	102.34	102.52	102.61
0.9000	102.58	102.40	102.49	102.67	102.76
0.8000	102.78	102.59	102.69	102.87	102.97
0.7000	102.98	102.78	102.88	103.08	103.19
0.5000	103.32	103.12	103.22	103.42	103.52
0.3000	103.70	103.35	103.53	103.87	104.04
0.2000	104.08	103.44	103.76	104.40	104.72
0.1000	106.04	104.92	105.48	106.61	107.17
0.0400	107.70	106.30	107.00	108.40	109.10
0.0200	111.20	108.60	109.90	112.50	113.80
0.0100	113.90	110.30	112.10	115.70	117.50
0.0040	116.44	111.30	113.87	119.01	121.57
0.0020	118.20	112.00	115.10	121.30	124.40
0.0010	119.80	112.60	116.20	123.40	127.00

Figure 6.12-4. Future Scenario 3 Base Year (2012) Exceedance Probability Function for the Planning Sub-unit 52



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	104.46	104.28	104.37	104.55	104.64
0.9900	104.58	104.40	104.49	104.67	104.76
0.9500	104.83	104.65	104.74	104.92	105.01
0.9000	104.98	104.80	104.89	105.07	105.16
0.8000	105.18	104.99	105.09	105.27	105.37
0.7000	105.38	105.18	105.28	105.48	105.59
0.5000	105.72	105.52	105.62	105.82	105.92
0.3000	106.10	105.75	105.93	106.27	106.44
0.2000	106.77	106.21	106.49	107.06	107.34
0.1000	107.71	106.83	107.27	108.14	108.58
0.0400	108.70	107.50	108.10	109.30	109.90
0.0200	111.00	108.80	109.90	112.10	113.20
0.0100	113.00	110.00	111.50	114.50	116.00
0.0040	115.30	111.00	113.15	117.45	119.60
0.0020	116.90	111.70	114.30	119.50	122.10
0.0010	118.30	112.30	115.30	121.30	124.30

Figure 6.12-5. Future Scenario 3 Most Likely Future Year (2012) Exceedance Probability Function for the Planning Sub-unit 51 – Includes an adjustment for relative sea level rise

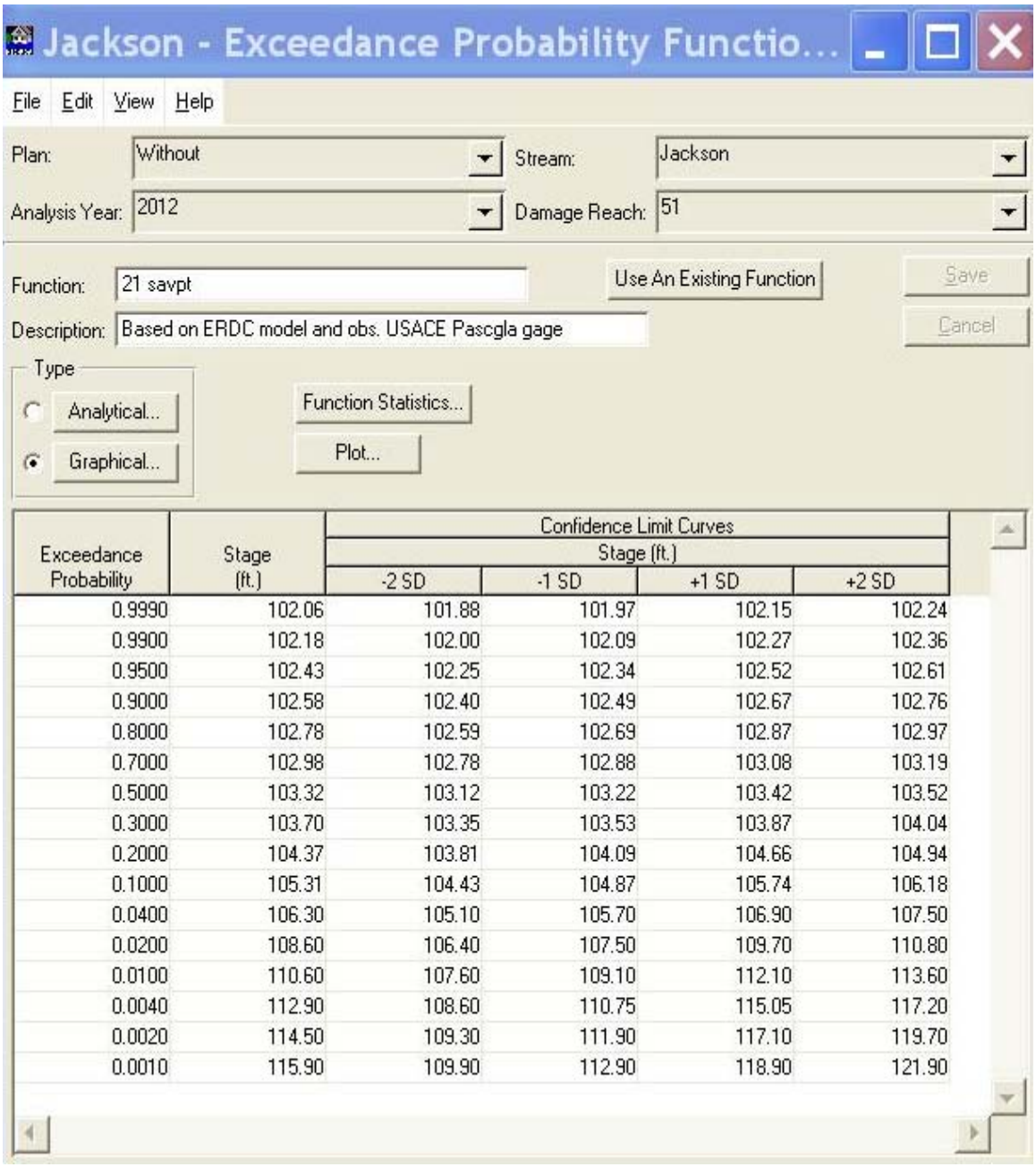


Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	104.46	104.28	104.37	104.55	104.64
0.9900	104.58	104.40	104.49	104.67	104.76
0.9500	104.83	104.65	104.74	104.92	105.01
0.9000	104.98	104.80	104.89	105.07	105.16
0.8000	105.18	104.99	105.09	105.27	105.37
0.7000	105.38	105.18	105.28	105.48	105.59
0.5000	105.72	105.52	105.62	105.82	105.92
0.3000	106.10	105.75	105.93	106.27	106.44
0.2000	106.48	105.84	106.16	106.80	107.12
0.1000	108.44	107.32	107.88	109.01	109.57
0.0400	110.10	108.70	109.40	110.80	111.50
0.0200	113.60	111.00	112.30	114.90	116.20
0.0100	116.30	112.70	114.50	118.10	119.90
0.0040	118.84	113.70	116.27	121.41	123.97
0.0020	120.60	114.40	117.50	123.70	126.80
0.0010	122.20	115.00	118.60	125.80	129.40

Figure 6.12-6. Future Scenario 3 Most Likely Future Year (2012) Exceedance Probability Function for the Planning Sub-unit 52 – Includes an adjustment for relative sea level rise.

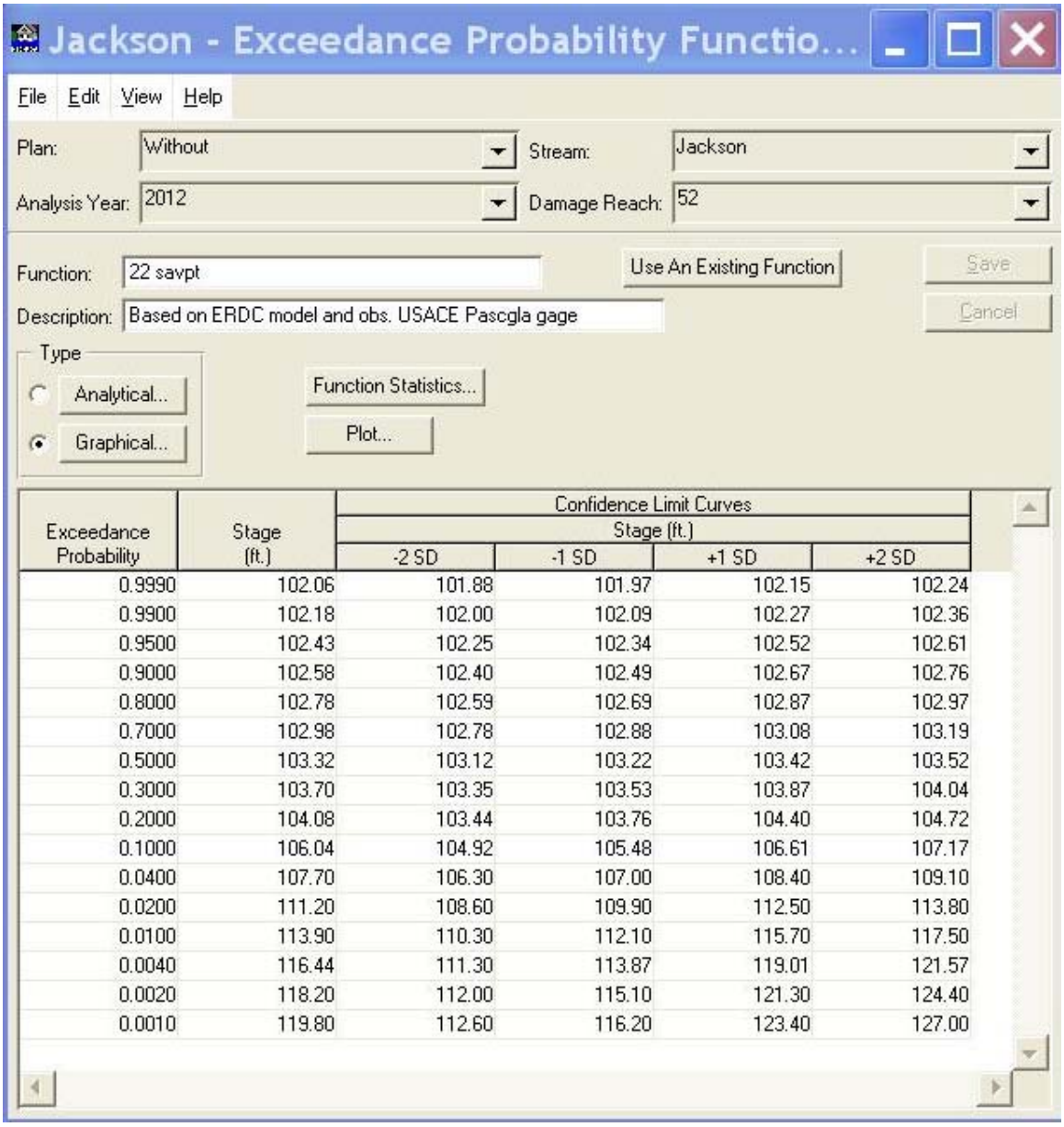
Future scenario five is the same as future scenario one with the addition of a high relative sea level rise 100-year period of analysis (2012–2111). Equivalent annual damages that could occur under this scenario are $32,812,000 (rounded to the nearest thousand). These damages represent a approximately a twenty-six-percent (25.8%) increase over the expected relative sea level rise accounted for in future scenario three. The total number of structures in this scenario is the same as in scenarios one and three and can be seen above in table 6.12-2. Figures 6.12-7 and 6.12-8 depict the base year for planning sub-units 51 and 52 respectively, and figures 6.12-9 and 6.12-10 show the most likely future year exceedance probability functions for planning sub-units 51 and 52. The exceedance probability functions are for still water elevation (SWEL's) and based on a combination of observed data from USACE gauges and from modeling efforts conducted by the Engineer Research and Development Center (ERDC). The most likely future year exceedance probability

function depicted in figures 6.12-9 and 6.12-10 includes an adjustment for expected relative sea level rise over the 100-year period of analysis. **Note**: Due to uncertainty issues regarding the first floor elevations, a base of 100-feet was applied to the exceedance probability functions and the first floor elevations. For example, if the stage for a given event probability shows 102-feet, the stage is really 2-feet. For more detail on the estimation and use of the exceedance probability functions see the Engineering Appendix.



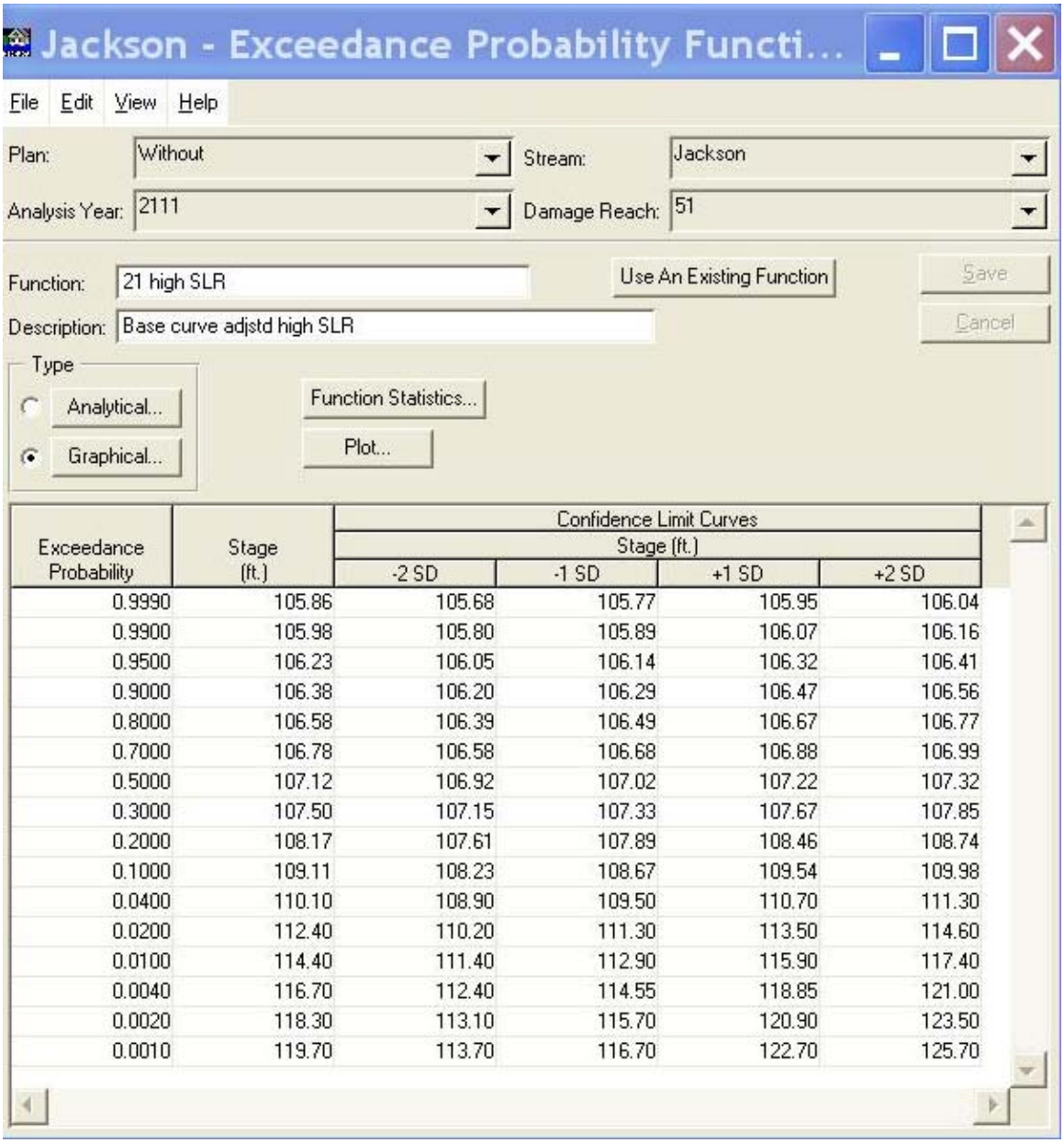
Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	102.06	101.88	101.97	102.15	102.24
0.9900	102.18	102.00	102.09	102.27	102.36
0.9500	102.43	102.25	102.34	102.52	102.61
0.9000	102.58	102.40	102.49	102.67	102.76
0.8000	102.78	102.59	102.69	102.87	102.97
0.7000	102.98	102.78	102.88	103.08	103.19
0.5000	103.32	103.12	103.22	103.42	103.52
0.3000	103.70	103.35	103.53	103.87	104.04
0.2000	104.37	103.81	104.09	104.66	104.94
0.1000	105.31	104.43	104.87	105.74	106.18
0.0400	106.30	105.10	105.70	106.90	107.50
0.0200	108.60	106.40	107.50	109.70	110.80
0.0100	110.60	107.60	109.10	112.10	113.60
0.0040	112.90	108.60	110.75	115.05	117.20
0.0020	114.50	109.30	111.90	117.10	119.70
0.0010	115.90	109.90	112.90	118.90	121.90

Figure 6.12-7. Future Scenario 3 Base Year (2012) Exceedance Probability Function for the Planning Sub-unit 51



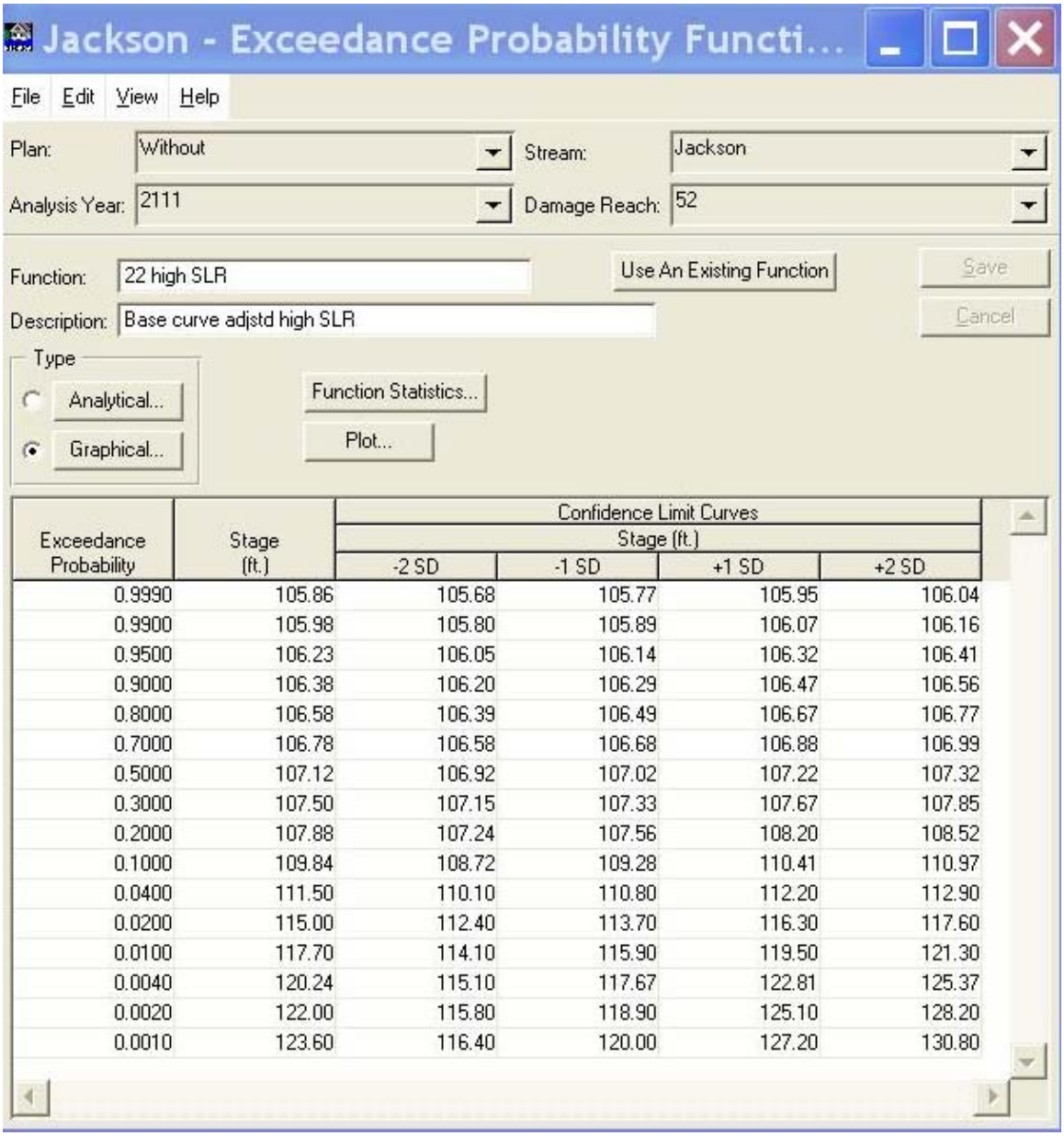
Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	102.06	101.88	101.97	102.15	102.24
0.9900	102.18	102.00	102.09	102.27	102.36
0.9500	102.43	102.25	102.34	102.52	102.61
0.9000	102.58	102.40	102.49	102.67	102.76
0.8000	102.78	102.59	102.69	102.87	102.97
0.7000	102.98	102.78	102.88	103.08	103.19
0.5000	103.32	103.12	103.22	103.42	103.52
0.3000	103.70	103.35	103.53	103.87	104.04
0.2000	104.08	103.44	103.76	104.40	104.72
0.1000	106.04	104.92	105.48	106.61	107.17
0.0400	107.70	106.30	107.00	108.40	109.10
0.0200	111.20	108.60	109.90	112.50	113.80
0.0100	113.90	110.30	112.10	115.70	117.50
0.0040	116.44	111.30	113.87	119.01	121.57
0.0020	118.20	112.00	115.10	121.30	124.40
0.0010	119.80	112.60	116.20	123.40	127.00

Figure 6.12-8. Future Scenario 3 Base Year (2012) Exceedance Probability Function for the Planning Sub-unit 52



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	105.86	105.68	105.77	105.95	106.04
0.9900	105.98	105.80	105.89	106.07	106.16
0.9500	106.23	106.05	106.14	106.32	106.41
0.9000	106.38	106.20	106.29	106.47	106.56
0.8000	106.58	106.39	106.49	106.67	106.77
0.7000	106.78	106.58	106.68	106.88	106.99
0.5000	107.12	106.92	107.02	107.22	107.32
0.3000	107.50	107.15	107.33	107.67	107.85
0.2000	108.17	107.61	107.89	108.46	108.74
0.1000	109.11	108.23	108.67	109.54	109.98
0.0400	110.10	108.90	109.50	110.70	111.30
0.0200	112.40	110.20	111.30	113.50	114.60
0.0100	114.40	111.40	112.90	115.90	117.40
0.0040	116.70	112.40	114.55	118.85	121.00
0.0020	118.30	113.10	115.70	120.90	123.50
0.0010	119.70	113.70	116.70	122.70	125.70

Figure 6.12-9. Future Scenario 5 Most Likely Future Year (2012) Exceedance Probability Function for the Planning Sub-unit 51 – Includes an adjustment for high relative sea level rise



Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	105.86	105.68	105.77	105.95	106.04
0.9900	105.98	105.80	105.89	106.07	106.16
0.9500	106.23	106.05	106.14	106.32	106.41
0.9000	106.38	106.20	106.29	106.47	106.56
0.8000	106.58	106.39	106.49	106.67	106.77
0.7000	106.78	106.58	106.68	106.88	106.99
0.5000	107.12	106.92	107.02	107.22	107.32
0.3000	107.50	107.15	107.33	107.67	107.85
0.2000	107.88	107.24	107.56	108.20	108.52
0.1000	109.84	108.72	109.28	110.41	110.97
0.0400	111.50	110.10	110.80	112.20	112.90
0.0200	115.00	112.40	113.70	116.30	117.60
0.0100	117.70	114.10	115.90	119.50	121.30
0.0040	120.24	115.10	117.67	122.81	125.37
0.0020	122.00	115.80	118.90	125.10	128.20
0.0010	123.60	116.40	120.00	127.20	130.80

Figure 6.12-10. Future Scenario 5 Most Likely Future Year (2012) Exceedance Probability Function for the Planning Sub-unit 52 – Includes an adjustment for high relative sea level rise

6.12.5.3 Equivalent annual damages Reduced

Equivalent annual damages reduced are calculated as the difference between the damages under the future without-project scenarios three and five and the damages incurred with the measure in place. The HECFDA model was run for each measure to determine the damages reduced as compared to the without-project scenario.

In order to provide the HEC-FDA model with accurate information about the economic characteristics of each measure, separate inventories were created for each measure. The inventories are the same as the without project inventory except that footprints of levees and acquisitions were deleted from the inventory and flood proofed structures (structures to be raised in place) were given a higher elevation. The structure inventories for each of the HEC-FDA measure runs are as follows:

- Measure A – Pascagoula - Moss Point Ring Levee A at elevation 20.0-feet NAVD88

This measure includes the without-project inventory less 589 parcels that were deleted out of the inventory. These parcels represent the footprint of the 20.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its implementation. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure B – Pascagoula - Moss Point Ring Levee B at elevation 30.0-feet NAVD88

This measure includes the without-project inventory less 666 parcels that were deleted out of the inventory. These parcels represent the footprint of the 30.0-feet NAVD88 elevation ring levee and some portion of the total would have to be purchased for its implementation. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure C – Pascagoula - Moss Point Ring Levee at Elevation 20.0-feet NAVD88

This measure includes a combination of a ring levee at 20-feet NAVD88 on an alternate footprint from measure A that would include the acquisition of structures and parcels in the Moss Point area.

- Measure D – Pascagoula - Moss Point Ring Levee Elevation 30.0-feet NAVD88

This measure includes a combination of a ring levee at 30-feet NAVD88 on an alternate footprint from measure B that would include the acquisition of structures and parcels in the Moss Point area.

- Measure E – Pascagoula - Moss Point Ring Levee at Elevation 20.0-feet NAVD88

This measure includes a combination of a ring levee at 20-feet NAVD88 on an alternate footprint from measure A that would include the acquisition of structures and parcels in the Washington Avenue area.

- Measure F – Pascagoula - Moss Point Ring Levee Elevation 30.0-feet NAVD88

This measure includes a combination of a ring levee at 30-feet NAVD88 on an alternate footprint from measure B that would include the acquisition of structures and parcels in the Washington Avenue area.

- Measure G – Pascagoula - Moss Point Ring Levee at Elevation 20.0-feet NAVD88

This measure includes a combination of a ring levee at 20-feet NAVD88 on an alternate footprint from measure A that would include the acquisition of structures and parcels in the Moss Point and Washington Avenue areas.

- Measure H – Pascagoula - Moss Point Ring Levee Elevation 30.0-feet NAVD88

This measure includes a combination of a ring levee at 30-feet NAVD88 on an alternate footprint from measure B that would include the acquisition of structures and parcels in the Moss Point and Washington Avenue areas.

- Measure I – Pascagoula - Moss Point Nonstructural One

This measure includes the acquisition of 145 (0 in planning sub-unit 51 and 145 in planning sub-unit 52) parcels that include a structure and the flood proofing (raise structure in place) of 7,603 (781 in planning sub-unit 51 and 6,822 in planning sub-unit 52) structures to an elevation of 12.0-feet NAVD88 for planning sub-unit 51 and 14.95-feet for planning sub-unit 52. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was determined to be approximately the 100-year level of protection and is defined as still water elevation, plus wave run-up plus an estimate for waves (depth divided by two), and is the minimum elevation that a nonstructural plan could provide.

- Measure J – Pascagoula - Moss Point Nonstructural Two to elevation 20.0-feet NAVD88

This measure includes the acquisition of 2,333 (718 in planning sub-unit 51 and 1,615 in planning sub-unit 52) parcels that include a structure and the flood proofing (raise structure in place) of 5,427 (64 in planning sub-unit 51 and 5,363 in planning sub-unit 52) structures to an elevation of 20.0-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levees at elevation 20.0-feet NAVD88.

- Measure K – Pascagoula - Moss Point Nonstructural Three to elevation 30.0-feet NAVD88

This measure includes the acquisition of 7,760 (782 in planning sub-unit 51 and 6,978 in planning sub-unit 52) parcels that include a structure to an elevation of 30.0-feet NAVD88. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the Nonstructural Appendix. This elevation was chosen to show a direct comparison to the ring levees at elevation 30.0-feet NAVD88.

Residual damage is the equivalent annual damages that still remain even when a project is in place. Residual damage is calculated as the future without-project equivalent annual damages minus the damages reduced of the various measures. The purpose of residual damage is to calculate and communicate the portions of damages that will not be reduced by the implementation of a plan or "what damages are left on the table." Table 6.12-3 summarizes the equivalent annual without-project damages, damages reduced, and residual damages by measure and by future scenario.

Table 6.12-3.
Summary of Damages by Measure

Measures	Equivalent annual damages Future 3 ($)	Equivalent Annual Damage Reduction Future 3 ($)	Residual Damage Future 3 ($)	Equivalent annual damages Future 5 ($)	Equivalent Annual Damage Reduction Future 5 ($)	Residual Damage Future 5 ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A 20FT Ring Levee A	$26,078,000	$24,244,000	$1,834,000	$32,812,000	$30,616,000	$2,196,000
Measure B 30FT Ring Levee B	$26,078,000	$26,078,000	$0	$32,812,000	$32,733,000	$79,000
Measure C 20FT Ring Levee C	$26,078,000	$24,901,000	$1,177,000	$32,812,000	$29,504,000	$3,308,000
Measure D 30FT Ring Levee D	$26,078,000	$26,078,000	$0	$32,812,000	$31,212,000	$1,600,000
Measure E 20FT Ring Levee E	$26,078,000	$24,910,000	$1,168,000	$32,812,000	$29,518,000	$3,294,000
Measure F 30FT Ring Levee F	$26,078,000	$26,078,000	$0	$32,812,000	$31,211,000	$1,601,000
Measure G 20FT Ring Levee G	$26,078,000	$24,933,000	$1,145,000	$32,812,000	$29,545,000	$3,267,000
Measure H 30FT Ring Levee H	$26,078,000	$26,078,000	$0	$32,812,000	$31,212,000	$1,600,000
Measure I ABFE Nonstructural	$26,078,000	$17,199,000	$8,879,000	$32,812,000	$21,629,000	$11,183,000
Measure J 20FT Nonstructural	$26,078,000	$24,349,000	$1,729,000	$32,812,000	$28,815,000	$3,997,000
Measure K 30FT Nonstructural	$26,078,000	$25,454,000	$624,000	$32,812,000	$30,115,000	$2,697,000

Damages are rounded to the nearest thousand dollars.

6.12.6 Environmental Quality (EQ)

6.12.6.1 Impacts of Ring Levee Measures

The Engineering Research and Development Center Wetlands and Coastal Ecology Branch were asked to conduct an assessment of potential impacts to wetlands as a result of constructing various levees and seawalls along the Mississippi Gulf Coastal Plain. This report summarizes the results of the assessment. The analysis of impacts included two components:

1. A calculation of total acreage of all wetlands (by type and planning reach) that is directly under the levee footprints.

2. A modified Hydrogeomorphic (HGM) wetland rapid assessment of impacted Estuarine/Tidal Fringe wetlands, based on the Mississippi and Alabama Gulf Coast HGM guidebook (Shafer et al., 2007), with impacts reported as loss of functional units. Tables 6.12-4 and 6.12-5 show the impacts of the Pascagoula/Moss Point ring levees at elevations 20.0-feet NAVD88, and 30.0-feet NAVD88 respectively.

Table 6.12-4.
Wetland Acres Impacted by Elevation 20' Pascagoula/Moss Point Ring Levee A

Reach ID	Estuarine and Marine Deepwater	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Freshwater Pond	Total
51	0.5	2.8	0.1	3.2	0.5	7.0
52	0.0	2.4	0.0	14.3	0.1	16.8
53	0.3	3.2	0.0	3.8	0.0	7.2
54	0.6	5.2	0.5	19.6	0.1	25.9
Total	**1.4**	**13.6**	**0.5**	**40.8**	**0.7**	**57.0**

Table 6.12-5.
Wetland Acres Impacted by Elevation 30' Pascagoula/Moss Point Ring Levee B

Reach ID	Estuarine and Marine Deepwater	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Freshwater Pond	Total
51	0.5	3.5	0.1	4.8	0.8	9.7
52	0.0	3.2	0.0	22.7	0.1	26.0
53	1.5	4.8	0.0	5.8	0.0	12.1
54	1.2	7.9	0.6	26.3	0.2	36.2
Total	**3.2**	**19.3**	**0.7**	**59.7**	**1.1**	**84.1**

Nonstructural measures would have no construction activities other than demolition and disposal of building materials in an approved land fill occurs as a result of this measure. More detail on the impacts of the structural and nonstructural measures for the Pascagoula-Moss Point area can be found in the Environmental Appendix.

6.12.7 Summary of Costs

Table 6.12-6 summarizes the ROM costs by measure for the Pascagoula-Moss Point area.

Table 6.12-6.
Summary of Costs by Measure for the Pascagoula-Moss Point Area

Measures	Implement Costs (FY-08) ($)	Average Annual Implementation Cost ($)	Average Annual O&M ($)	IDC ($)	Total Average Annual Costs ($)
(No Action)	$0	$0	$0	$0	$0
Measure A 20FT Ring Levee A	$699,000,000	$34,371,000	$5,719,000	N/A	$40,090,000
Measure B 30FT Ring Levee B	$916,000,000	$45,041,000	$8,309,000	N/A	$53,350,000
Measure C 20FT Ring Levee C	$671,600,000	$33,023,000	$4,658,000	N/A	$37,681,000
Measure D 30FT Ring Levee D	$849,900,000	$41,791,000	$6,707,000	N/A	$48,498,000
Measure E 20FT Ring Levee E	$874,400,000	$42,995,000	$3,761,000	N/A	$46,756,000
Measure F 30FT Ring Levee F	$1,013,200,000	$49,820,000	$5,423,000	N/A	$55,243,000
Measure G 20FT Ring Levee G	$921,400,000	$45,306,000	$3,537,000	N/A	$48,843,000
Measure H 30FT Ring Levee H	$1,057,700,000	$52,008,000	$5,197,000	N/A	$57,205,000
Measure I ABFE Nonstructural	$2,272,975,000	$111,765,000	$20,000	N/A	$111,785,000
Measure J 20FT Nonstructural	$5,105,777,000	$251,057,000	$20,000	N/A	$251,077,000
Measure K 30FT Nonstructural	$5,105,777,000	$251,057,000	$20,000	N/A	$251,077,000

The implementation costs include 1/ supervision and administration (30 account), 2/ planning, engineering & design (31 account) and 3/ appropriate contingencies. See the Cost Appendix for more detail on the implementation cost breakdowns. Numbers are rounded to the nearest thousand.

6.12.8 Regional Economic Development (RED)

The purpose of this analysis is to determine the economic impact of the proposed project measures on business (sale volumes), income, employment, and population of the local area. Each of the measures would affect the local area of Jackson County, Mississippi. The expenditures, shown in Table 6.12-6, for the measures are estimated to be $699,000,000 for the 20.0-feet ring levee A measure, $916,000,000 for the 30.0-feet ring levee B measure, $671,600,000 for the 20.0-feet NAVD88 ring levee C measure, $849,900,000 for the 30.0-feet NAVD88 ring levee D measure, $874,400,000 for the 20.0-feet NAVD88 ring levee E measure, $1,013,200,000 for the 30.0-feet NAVD88 ring levee F measure, $921,400,000 for the 20.0-feet NAVD88 ring levee G measure, $1,057,700,000 for the 30.0-feet NAVD88 ring levee H measure, $2,272,975,000 for the ABFE nonstructural measure, $5,105,777,000 for the 20.0-feet NAVD88 nonstructural measure, and $5,105,777,000 for the 30.0-feet NAVD88 nonstructural measure. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $116,308,000 for the 20.0-feet NAVD88 ring levee A measure, $168,981,000 for the 30.0-feet NAVD88 ring levee B measure, $94,730,000 for the 20.0-feet NAVD88 ring levee C measure, $136,401,000 for the 30.0-feet NAVD88 ring levee D measure, $76,488,000 for the 20.0-feet NAVD88 ring levee E measure, $110,288,000 for the 30.0-feet NAVD88 ring levee F measure, $71,932,000 for the 20.0-feet NAVD88 ring levee G measure, $105,692,000 for the 30.0-feet NAVD88 ring levee H measure $406,000 for the ABFE nonstructural measure, $406,000 for the 20.0-feet NAVD88 nonstructural measure, and $406,000 for the 30.0-feet NAVD88 nonstructural measure respectively (assuming a 100- year period of analysis and an interest rate of 4.875-percent). The following tables, 6.12-7 through 6.12-14, summarize the EIFS model inputs and outputs for the Pascagoula-Moss Point Area measures.

Table 6.12-7.
EIFS Model Implementation Cost Inputs for the Pascagoula/Moss Point Area

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	20-foot Ring Levee E	30-foot Ring Levee F
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$699,000,000	$916,000,000	$671,600,000	$849,900,000	$874,400,000	$1,013,200,000

Table 6.12-8.
EIFS Model Implementation Cost Inputs for the Pascagoula/Moss Point Area

	20-foot Ring Levee G	30-foot Ring Levee H	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$921,400,000	$1,057,700,000	$2,272,975,000	$5,105,777,000	$5,105,777,000

Based of the given implementation cost inputs the outputs are as follows:

Table 6.12-9.
EIFS Model Implementation Cost Outputs for the Pascagoula/Moss Point Area

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	20-foot Ring Levee E	30-foot Ring Levee F
Direct Sales Volume	$699,000,000	$916,000,000	$671,600,000	$849,900,000	$874,400,000	$1,013,200,000
Induced Sales Volume	$782,880,000	$1,025,920,000	$752,192,000	$951,888,000	$979,328,000	$1,134,784,000
Total Sales Volume	$1,481,880,000	$1,941,920,000	$1,423,792,000	$1,801,788,000	$1,853,728,000	$2,147,984,000
Direct Income	$136,322,866	$178,643,413	$130,979,166	$165,752,223	$170,530,350	$197,599,897
Induced Income	$152,681,591	$200,080,598	$146,696,648	$185,642,467	$190,993,968	$221,311,858
Total Income	$289,004,458	$378,724,011	$277,675,814	$351,394,691	$361,524,318	$418,911,755
Direct Employment	3,956	5,185	3,801	4,810	4,949	5,735
Induced Employment	4,432	5,807	4,258	5,388	5,544	6,424
Total Employment	8,388	10,992	8,059	10,199	10,493	12,158
Local Population	0	0	0	0	0	0

Table 6.12-10.
EIFS Model Implementation Cost Outputs for the Pascagoula/Moss Point Area

	20-foot Ring Levee G	30-foot Ring Levee H	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Direct Sales Volume	$921,400,000	$1,057,700,000	$2,272,975,000	$5,105,777,000	$5,105,777,000
Induced Sales Volume	$1,031,968,000	$1,184,624,000	$2,545,732,000	$5,718,470,240	$5,718,470,240
Total Sales Volume	$1,953,368,000	$2,242,324,000	$4,818,707,000	$10,824,247,240	$10,824,247,240
Direct Income	$179,696,551	$206,278,535	$443,288,222	$995,757,019	$995,757,019
Induced Income	$201,260,112	$231,031,930	$496,482,747	$1,115,247,722	$1,115,247,722
Total Income	$380,956,663	$437,310,465	$939,770,969	$2,111,004,741	$2,111,004,741
Direct Employment	5,215	5,987	12,865	28,899	28,899
Induced Employment	5,842	6,706	14,411	32,371	32,371
Total Employment	11,057	12,692	27,276	61,269	61,269
Local Population	0	0	0	0	0

Table 6.12-11.
EIFS Model Operation and Maintenance Cost Inputs for the Pascagoula/Moss Point Area

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	20-foot Ring Levee E	30-foot Ring Levee F
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$116,308,000	$168,981,000	$94,730,000	$136,401,000	$76,488,000	$110,288,000

Table 6.12-12.
EIFS Model Operation and Maintenance Cost Inputs for the Pascagoula/Moss Point Area

	20-foot Ring Levee G	30-foot Ring Levee H	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$71,932,000	$105,692,000	$407,000	$407,000	$407,000

Based of the given implementation cost inputs the outputs are as follows:

Table 6.12-13.
EIFS Model Operation and Maintenance Cost Outputs for the Pascagoula/Moss Point Area

	20-foot Ring Levee A	30-foot Ring Levee B	20-foot Ring Levee C	30-foot Ring Levee D	20-foot Ring Levee E	30-foot Ring Levee F
Direct Sales Volume	$116,308,000	$168,981,000	$94,730,000	$136,401,000	$76,488,000	$110,288,000
Induced Sales Volume	$130,264,960	$189,258,720	$106,097,600	$152,769,120	$85,666,560	$123,522,560
Total Sales Volume	$246,572,960	$358,239,720	$200,827,600	$289,170,120	$162,154,560	$233,810,560
Direct Income	$22,683,033	$32,955,614	$18,474,771	$26,601,681	$14,917,115	$21,508,979
Induced Income	$25,404,994	$36,910,283	$20,691,741	$29,793,879	$16,707,167	$24,090,053
Total Income	$48,088,026	$69,865,897	$39,166,513	$56,395,561	$31,624,282	$45,599,032
Direct Employment	658	956	536	772	433	624
Induced Employment	737	1,071	601	865	485	699
Total Employment	1,396	2,028	1,137	1,637	918	1,323
Local Population	0	0	0	0	0	0

Table 6.12-14.
EIFS Model Operation and Maintenance Cost Outputs for the Pascagoula/Moss Point Area

	20-foot Ring Levee G	30-foot Ring Levee H	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural
Direct Sales Volume	$71,932,000	$105,692,000	$407,000	$407,000	$407,000
Induced Sales Volume	$80,563,840	$118,375,040	$455,840	$455,840	$455,840
Total Sales Volume	$152,495,840	$224,067,040	$862,840	$862,840	$862,840
Direct Income	$14,028,579	$20,612,641	$79,375	$79,375	$79,375
Induced Income	$15,712,006	$23,086,156	$88,900	$88,900	$88,900
Total Income	$29,740,585	$43,698,797	$168,276	$168,276	$168,276
Direct Employment	407	598	2	2	2
Induced Employment	456	670	3	3	3
Total Employment	863	1,268	5	5	5
Local Population	0	0	0	0	0

6.13 Evaluation of Bayou Cumbest Area Ecosystem Restoration Measures

This Section describes the evaluation of measures for the Bayou Cumbest area. Bayou Cumbest is approximately 373 acres in planning unit three, planning sub-unit fifty-three just west of the Mississippi and Alabama state line. This area experienced water elevations between 16.0 and 18.0 ft. NAVD88 from Hurricane Katrina storm surge. Figure 6.13-1 shows the location of the Bayou Cumbest area.

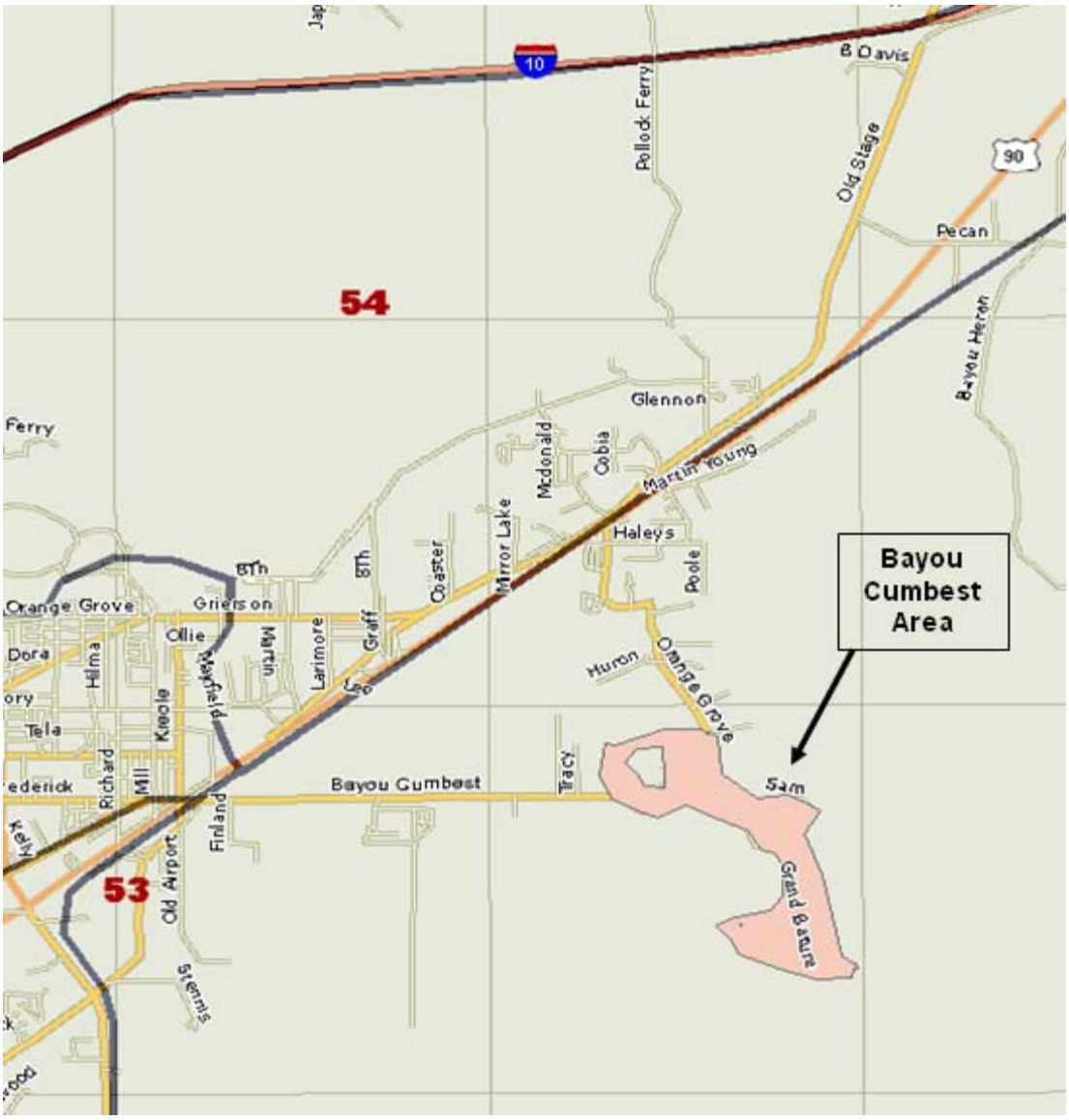


Figure 6.13-1 Bayou Cumbest Area, Planning Unit Three, Planning Sub-Unit fifty-three

This area was specifically identified for its ecosystem restoration potential using a Spatial Decision Support System (SDSS) tool, which was developed for the MsCIP Comprehensive Plan by the Engineer Research and Development Center (ERDC). The development of the GIS based SDSS tool allowed the Corps, Mobile District, working in cooperation with the USFWS and MDMR, to identify and prioritize potential wetland restoration areas throughout Coastal Mississippi. A subset of

potential restoration sites were identified by the SDSS tool and then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS. This interagency team allowed us to both confirm the accuracy of the SDSS results and to collect additional on-site information pertinent to restoration efforts.

There are some major benefits in using a GIS-based SDSS approach to wetland restoration. First, it allows for the relatively rapid assessment of the large number of restoration sites across the wide study area. Second, potential sites can be evaluated and restored in a watershed or landscape context, which allows us to comprehensively evaluate the overall natural system. This approach can maximize the benefits of wetland restoration, as opposed to simply restoring wetlands where convenient or where property is available. Essentially use of this SDSS tool allowed the MsCIP environmental team to assess the entire coastline as a holistic natural system; thus, the team was more effectively able to analyze needs in Coastal Mississippi.

The SDSS tool evaluated potential wetland restoration sites that had been initially selected based on having a non-natural land cover (i.e. urban, deforested, and agricultural land cover, based on MDMR 2001 land cover GIS layer) and were located in the 100-year floodplain. Numerous potential environmental restorations sites were initially identified. This initial group of sites was narrowed down based on the results of the SDSS. Sites with the following characteristics were screened out:

- < 5 acres in size
- Restorability class of Low or Medium Low
- Habitat class of Low or Medium Low
- Storm Surge/Flood Protection class of Low

6.13.1 Environmental Quality (EQ)

6.13.1.1 Ecosystem Restoration Assumptions

- In order for the Bayou Cumbest site to undergo ecosystem restoration, it is assumed that there will be buy-outs of properties within the area.
- A 50-year period of analysis was used to determine average annual outputs and costs.
- Construction implementation time is estimated to be twelve months.

6.13.1.2 Ecosystem Restoration Objectives

The following ecosystem restoration objectives were developed:

- Restore marsh to historical (pre-development ~1950's) conditions
- Provide storm surge protection
- Restore native tidal wetland plant community
- Provide fish and tidal wildlife habitat

6.13.1.3 Ecosystem Restoration Management Measures

Proposed restoration management measures are listed in table 6.13-1. Narrative descriptions of each management measure follow this table.

Table 6.13-1.
Ecosystem Restoration Management Measures

Management Measure	Description
No Action	No Action
1	Excavate Old Fill Material
2	Remove Exotic Species
3	Fill Existing Artificial Ditches
4 *a* *b* *c*	Plant Native Vegetation - 0.5 meter spacing - 1.0 meter spacing - 2.0 meter spacing

6.13.1.4 Excavate Old Fill Material (1)

This management measure must be included in all measures for the restoration to be successful. It includes 90-95 percent removal of existing exotic species in the excavated areas. This measure positively affects the hydrologic regime.

6.13.1.5 Remove Exotic Species from Non-Excavated Areas and Maintenance of Exotics in All Areas over the Project Life (2)

This management measure must be included in all measures for the restoration to be successful. It includes 100 percent removal of exotic species from non-excavated areas over the life of the project. The exotic species include Chinese Tallow, Phragmites, and Cogon Grass. This measure affects the percentage of the area covered by exotic species.

6.13.1.6 Fill Existing Artificial Ditches and Channels (3)

This management measure does not need to be included in all measures for the restoration to be successful. It includes 100 percent removal of existing artificial ditches and channels. This measure provides additional positive affects to the hydrologic regime.

6.13.1.7 Plant Native Vegetation (4)

This management measure must be included in all measures for the restoration to be successful. There are three different planting density options: (a) 0.5 meters spacing, (b) 1.0 meter spacing, and (c) 2.0 meter spacing. Planting emergent tidal marsh at varying densities will result in obtaining desired environmental output at varying years and costs. It is estimated that 2 re-planting efforts would be required for the two least dense plantings: 1.0 and 2.0 meter spacing. It is estimated that the 0.5 meter spacing will achieve full benefits in about 5 years while the 1.0 meter spacing and 2.0 meter spacing will achieve full benefits in about 7 and 10 years, respectively.

This measure affects the percent cover by woody plant species, wildlife habitat diversity, vegetation height, wetland indicator status and the mean percent cover emergent plant species.

6.13.1.8 Ecosystem Restoration Measures

These management measures were combined to create six measures. Each measure includes the mandatory management measures of excavating old fill material, removing exotic plant species from non-excavated areas, and planting native vegetation. Since there are three different planting densities, three measures are created with this combination of management measures. When the

management measure of filling existing artificial ditches is added to this combination, this creates another three measures.

All measures will restore 110 acres to tidal marsh. Measure 1 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas, filling existing artificial ditches, and planting native vegetation such as Spartina alterniflora (Smooth Cordgrass) at the seaward edge of marsh; Juncus roemerianus (Black Needle Rush) at a slightly higher elevation; and Spartina patens (Saltmeadow Cordgrass) at a slightly higher elevation at a density of 0.5 meter. Measure 2 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas, filling existing artificial ditches, and planting native vegetation at a density of 1.0 meter. Measure 3 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas, filling existing artificial ditches, and planting native vegetation at a density of 2.0 meter. Measure 4 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas, and planting native vegetation at a density of 0.5 meters. Measure 5 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas and planting native vegetation at a density of 1.0 meter. Measure 6 consists of restoring the study area by excavating old fill material, removing exotic plant species from non-excavated areas and planting native vegetation at a density of 2.0 meters. Figure 6.13-2 shows the location of the Bayou Cumbest restoration site. Table 6.13-2 displays a description of each ecosystem restoration measure.

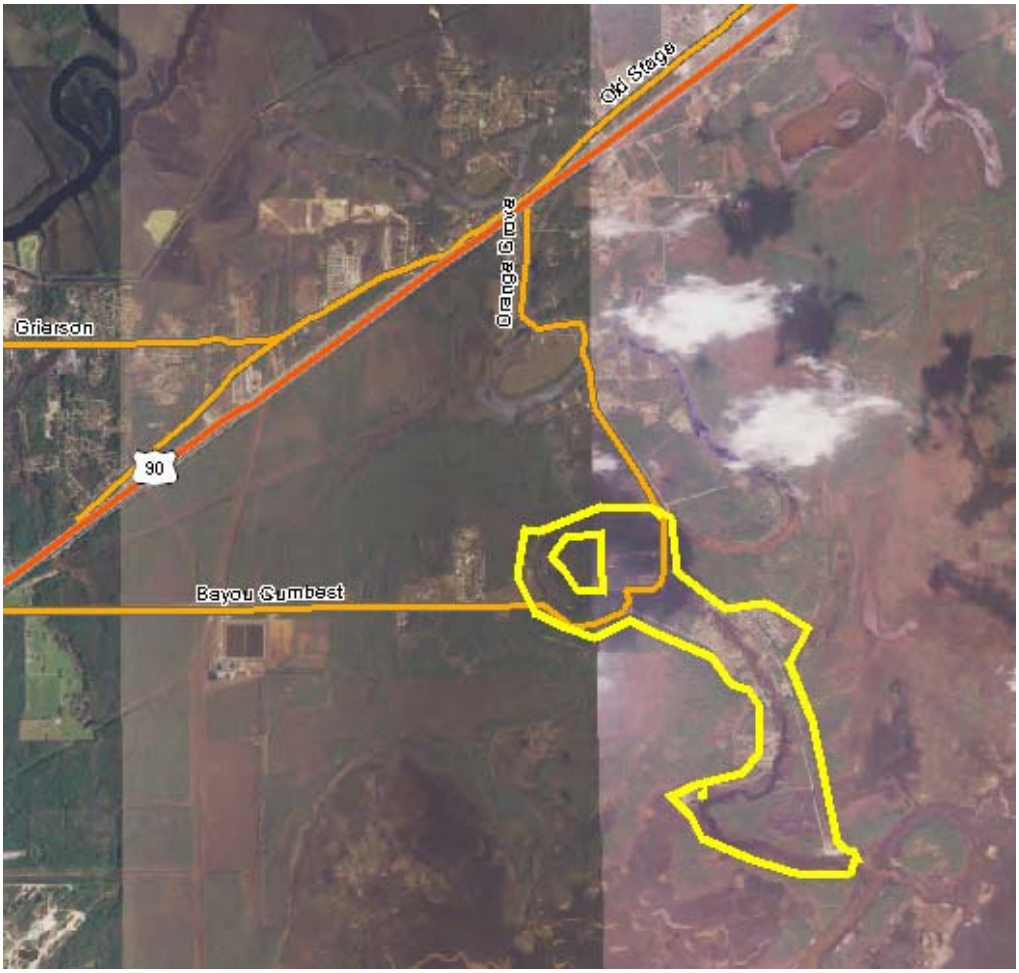


Figure 6.13-2 Bayou Cumbest restoration site

Table 6.13-2.
Ecosystem Restoration Measures

Measure	Management Measure	Description
0	No Action	No Action
1	1 + 2 + 3+ 4a	Excavate Fill Remove Exotics Fill Ditches Plant at Density 0.5m
2	1 + 2 + 3 + 4b	Excavate Fill Remove Exotics Fill Ditches Plant at Density 1.0m
3	1 + 2 + 3 + 4c	Excavate Fill Remove Exotics Fill Ditches Plant at Density 2.0m
4	1 + 2 + 4a	Excavate Fill Remove Exotics Plant at Density 0.5m
5	1 + 2 +4b	Excavate Fill Remove Exotics Plant at Density 1.0m
6	1 + 2 + 4c	Excavate Fill Remove Exotics Plant at Density 2.0m

6.13.3.9 Ecosystem Restoration Benefits and Costs

Benefits are measured in terms of Average Annual Functional Units (AAFU). The Hydrogeomorphic (HGM) approach was used to assess wetland function. A HGM assessment was performed in 2000 using the Regional Guidebook for Applying the HGM Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains. Results from this assessment were used to establish baseline (current) conditions and, ultimately, to measure the functional unit benefits resulting from different restoration measures. Table 6.13-3 shows the total functional units under each measure and the AAFU net benefit. It is assumed that functional units will remain the same under existing conditions and the no action measure. To calculate the AAFU net benefit, it is assumed all benefits are immediately accrued following measure implementation, and that the benefits are sustainable over the life of the project. Therefore, the AAFU net benefit was calculated as the difference between the total functional units for the ecosystem restoration measure and the total functional units for the no action measure. Table 6.13-4 summarizes the ROM costs at an FY-08 price level Bayou Cumbest ecosystem restoration measures.

Table 6.13-3.
Summary of Benefits

Measure	Measure Description	AAFU Units Benefits
No Action	No Action	0
Measure 1	Excavate Fill Remove Exotics Fill Ditches Plant at Density 0.5m	191
Measure 2	Excavate Fill Remove Exotics Fill Ditches Plant at Density 1.0m	188
Measure 3	Excavate Fill Remove Exotics Fill Ditches Plant at Density 2.0m	184
Measure 4	Excavate Fill Remove Exotics Plant at Density 0.5m	172
Measure 5	Excavate Fill Remove Exotics Plant at Density 1.0m	169
Measure 6	Excavate Fill Remove Exotics Plant at Density 2.0m	164

Table 6.13-4.
Summary of Costs by Measure for Bayou Cumbest

Measure	Measure Description	Implementation Cost (FY-08)	IDC	Investment Cost	AAIC[1]	AAO&M[2]	AAC[3]
0	No Action	$0	$0	$0	$0	$0	$0
1	Excavate Fill Remove Exotics Fill Ditches Plant at Density 0.5m	$28,000,000	$620,000	$28,600,000	$1,538,000	$2,000	$1,540,000
2	Excavate Fill Remove Exotics Fill Ditches Plant at Density 1.0m	$23,350,000	$520,000	$23,870,000	$1,282,000	$114,000	$1,396,000
3	Excavate Fill Remove Exotics Fill Ditches Plant at Density 2.0m	$21,030,000	$470,000	$21,500,000	$1,155,000	$112,000	$1,267,000
4	Excavate Fill Remove Exotics Plant at Density 0.5m	$27,990,000	$620,000	$28,610,000	$1,537,000	$2,000	$1,539,000
5	Excavate Fill Remove Exotics Plant at Density 1.0m	$23,340,000	$520,000	$23,860,000	$1,282,000	$114,000	$1,396,000
6	Excavate Fill Remove Exotics Plant at Density 2.0m	$21,020,000	$470,000	$21,480,000	$1,154,000	$112,000	$1,266,000

Note: Numbers are rounded to the nearest thousand.
1.Average Annual Investment Cost
2.Average Annual Operations and Maintenance Cost
3.Average Annual Cost (total)

6.13.3.10 Comparison of Measures

Table 6.13-5 display all measures with their respective AAC and AAFU in increasing order of AAFU.

Table 6.13-5.
All Measures: Average Annual Costs and Average Annual Functional Units

Measure	AAC	AAFU
No Action	$0	0
6	$1,266,000	164
5	$1,396,000	169
4	$1,539,000	172
3	$1,267,000	184
2	$1,396,000	188
1	$1,540,000	191

Note: The AAC values are rounded to the nearest thousand.

To determine if a measure is cost effective, economically inefficient measures must first be identified and eliminated. An economically inefficient measure is a measure that cost more for the same level of benefit. No measures are eliminated for the reason of economic inefficiency because each measure produces a different level of benefit.

Lastly, economically ineffective measures are identified and eliminated to determine which measures are cost effective. An economically ineffective measure is a measure that cost more or the same as a subsequent measure but produces less benefit than that subsequent measure. As shaded in table 6.13-6, the measures 4 and 5 were eliminated because they produced less benefit at greater cost than a subsequent measure. For example, Measure 4 produces 172 AAFU at an AAC of $1,539,000 while Measure 3 produces 184 AAFU at an AAC $1,267,000. Measure 4 produces less AAFU at a greater cost than Measure 3. Therefore, Measure 4 is eliminated. As shown in table 6.13-7 and plotted in figure 6.13-3, the cost effective measures are Measure 1, Measure 2, Measure 3, and Measure 6.

Table 6.13-6.
Elimination of Economically Ineffective Measures

Measure	Measure Description	AAC	AAFUs	Cost Effective?
No Action	No Action	$0	0	Yes
6	Excavate Fill Remove Exotics Plant at Density 2.0m	$1,266,000	164	Yes
5	Excavate Fill Remove Exotics Plant at Density 1.0m	$1,396,000	169	No
4	Excavate Fill Remove Exotics Plant at Density 0.5m	$1,539,000	172	No
3	Excavate Fill Remove Exotics Fill Ditches Plant at Density 2.0m	$1,267,000	184	Yes
2	Excavate Fill Remove Exotics Fill Ditches Plant at Density 1.0m	$1,396,000	188	Yes
1	Excavate Fill Remove Exotics Fill Ditches Plant at Density 0.5m	$1,540,000	191	Yes

Note: The AAC values are rounded to the nearest thousand.

Table 6.13-7.
Cost Effective Measures for Bayou Cumbest

Measure	Measure Description	AAC	AAFUs	Cost Effective?
No Action	No Action	$0	0	Yes
6	Excavate Fill Remove Exotics Plant at Density 2.0m	$1,266,000	164	Yes
3	Excavate Fill Remove Exotics Fill Ditches Plant at Density 2.0m	$1,267,000	184	Yes
2	Excavate Fill Remove Exotics Fill Ditches Plant at Density 1.0m	$1,396,000	188	Yes
1	Excavate Fill Remove Exotics Fill Ditches Plant at Density 0.5m	$1,540,000	191	Yes

Note: The AAC values are rounded to the nearest thousand.

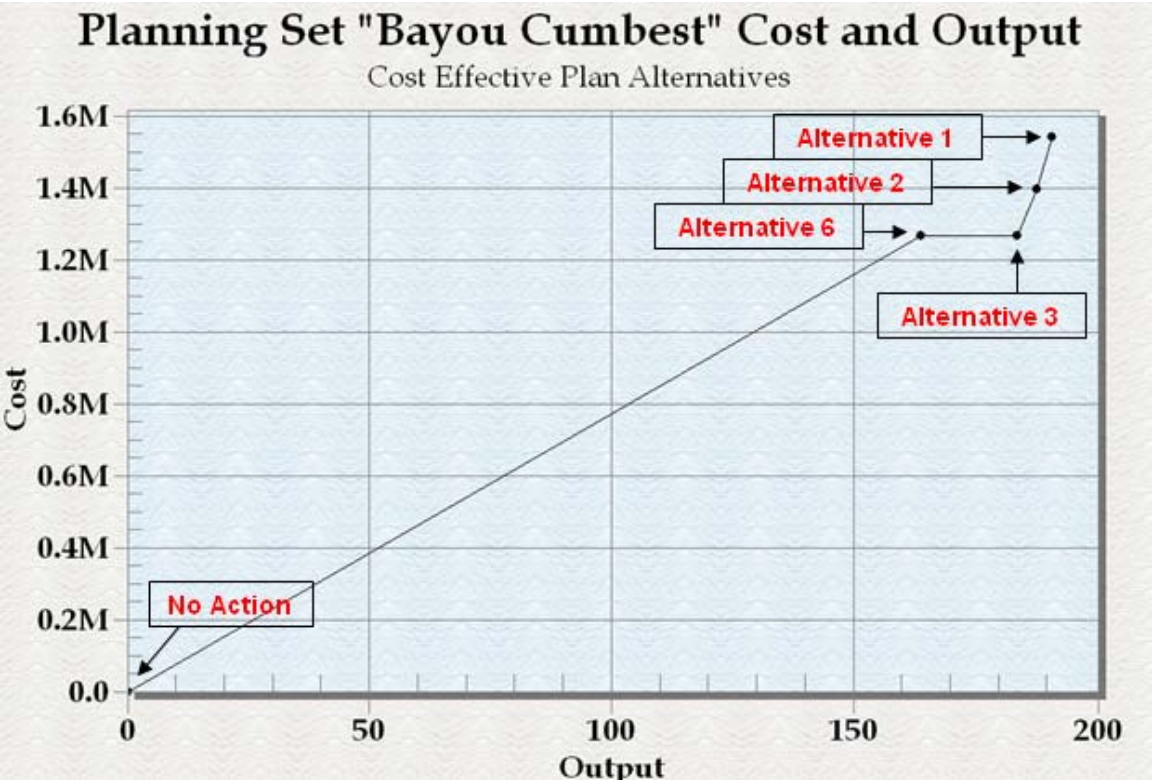


Figure 6.13-3 Cost Effective Measures for Bayou Cumbest Area

6.13.4 Regional Economic Development (RED)

The purpose of this section is to show the economic impact of the proposed project alternatives on business (sales volumes), income, employment, and population of the local area. Each of the alternatives would affect the local area of Jackson County, Mississippi. The expenditures for the alternatives are estimated to be $28,000,000 for Alternative 1, $23,400,000 for the Alternative 2, $21,000,000 for Alternative 3, and $21,000,000 for Alternative 6. Moreover, the present worth of the operation and maintenance (O&M) expenditures are estimated to be $43,000 for Alternative 1, $2,106,000 for Alternative 2, $2,071,000 for Alternative 3, and $2,071,000 for Alternative 6, (assuming a 50 year period of analysis and an interest rate of 4.875 percent). The following tables, 6.13-8 through 6.13-11 summarize the EIFS model inputs and outputs for the cost effective measures.

Table 6.13-8.
EIFS Model Implementation Cost Inputs for Bayou Cumbest Ecosystem

	No Action	Alternative 1	Alternative 2	Alternative 3	Alternative 6
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$0	$28,000,000	$23,400,000	$21,000,000	$21,000,000

Based of the given inputs the outputs are as follows:

Table 6.13-9.
EIFS Model Implementation Cost Outputs for Bayou Cumbest Ecosystem

	No Action	Alternative 1	Alternative 2	Alternative 3	Alternative 6
Direct Sales Volume	$0	$28,000,000	$23,400,000	$21,000,000	$21,000,000
Induced Sales Volume	$0	$31,360,000	$26,208,000	$23,520,000	$23,520,000
Total Sales Volume	$0	$59,360,000	$49,608,000	$44,520,000	$44,520,000
Direct Income	$0	$5,460,716	$4,563,598	$4,095,537	$4,095,537
Induced Income	$0	$6,116,001	$5,111,229	$4,587,001	$4,587,001
Total Income	$0	$11,576,716	$9,674,827	$8,682,537	$8,682,537
Direct Employment	0	158	132	119	119
Induced Employment	0	178	148	133	133
Total Employment	0	336	281	252	252
Local Population	0	0	0	0	0

Table 6.13-10.
EIFS Model O&M Cost Inputs for Bayou Cumbest Ecosystem

	No Action	Alternative 1	Alternative 2	Alternative 3	Alternative 6
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$0	$43,000	$2,106,000	$2,071,000	$2,071,000

Based of the given inputs the outputs are as followed:

Table 6.13-11.
EIFS Model O&M Cost Outputs for Bayou Cumbest Ecosystem

	No Action	Alternative 1	Alternative 2	Alternative 3	Alternative 6
Direct Sales Volume	$0	$43,000	$2,106,000	$2,071,000	$2,071,000
Induced Sales Volume	$0	$48,160	$2,358,720	$2,319,520	$2,319,520
Total Sales Volume	$0	$91,160	$4,464,720	$4,390,520	$4,390,520
Direct Income	$0	$8,386	$410,724	$403,898	$403,898
Induced Income	$0	$9,392	$460,011	$452,366	$452,366
Total Income	$0	$17,779	$870,734	$856,264	$856,264
Direct Employment	0	0	12	12	12
Induced Employment	0	0	13	13	13
Total Employment	0	0	25	25	25
Local Population	0	0	0	0	0

6.14 Dantzler Area Ecosystem Restoration Measures

This section describes the evaluation of ecosystem restoration measures at the Dantzler area that is located within planning sub-unit 53, which is part of planning unit three. The total area includes 385 acres of state owned land. This area was selected for ecosystem restoration using the Decision Support System, a GIS based model created by the Corps' Engineer Research and Development Center (ERDC). For more details on the selection process for ecosystem restoration sites see the Economic Appendix. Figure 6.14-1 shows the location of the Dantzler area.

6.14.1 Formulation of Measures

6.14.1.1 Assumptions

In order for the Dantzler site to undergo ecosystem restoration, it is assumed that all property and rights of way are owned by the State of Mississippi. Costs and benefits are based on a 50-year period of analysis and an FY-08 discount rate of 4.875-percent.

6.14.1.2 Objectives

The following objectives were developed for ecosystem restoration:

- Restore native wetland plant communities
- Restore natural fire regime
- Restore natural hydrology
- Restore fish and wildlife habitat
- Provide storm surge protection



Figure 6.14-1. Location of the Dantzler Ecosystem Restoration Area

6.14.1.3 Ecosystem Restoration Management Measures

Proposed restoration management measures are listed in table 6.14-1. Narrative descriptions of each management measure follow this table.

Table 6.14-1.
Ecosystem Restoration Management Measures

Management Measure	Description
No Action	No Action
1 *a* *b*	Maintain Native Savannah Vegetation *By Burning Every 3Years* *By Mowing Annually*
2	Remove Exotics and Plantation Pine
3	Fill Artificial Ditches

6.14.1.3.1 Maintain Native Savannah Vegetation (1)

This management measure must be included in all measures for the restoration to be successful. There are two methods that will be analyzed for maintaining vegetation: (a) burning and (b) mowing. Fire benefits this ecosystem in many different ways. It creates a bare seedbed for pine seedlings and other fire dependent plants, reduces fuel loads and recycles nutrients. Periodic burning promotes early successional plants that are important to many species of wildlife indigenous to this ecosystem. Many of the plant species found in this ecosystem are fire dependent; for example, the federally endangered American Chaff seed flowers almost exclusively after a fire. It has been reduced to a fraction of its original range due to fire suppression and habitat destruction. Fire suppression is mainly due to liability issues and fear of litigation.

Mowing is a mechanical alternative that many land managers use to maintain early successional habitats. Although it is successful to some extent, it fails to provide all the necessary components that come from prescribed fire. This method also has a negative effect. Mowing requires the use of heavy equipment in sensitive areas. Tractors can create ruts in saturated soils, creating hydrologic problems and micro site conditions. Mowing can also introduce non-native species through the use of contaminated equipment. Another disadvantage of mowing is that the duff or litter layer remains on the ground, preventing seeds from reaching the bare ground needed for germination. This thick litter layer can also provide heavy fuel loads increasing the risk of wildfires during dry periods. Although mowing provides some level of habitat management in pine savannahs, it is not a substitute for prescribed fire. Mowing can maintain succession, but may inhibit other functions of the system.

6.14.1.3.2 Removal of Exotics and Plantation Pines (2)

This management measure must be included in all measures for the restoration to be successful. This measure positively affects the percent cover by invasive or exotic species.

6.14.1.3.3 Fill Ditches (3)

This management measure must be included in all measures for the restoration to be successful. This measure positively affects the outflow of water. It measures the removal of water by ditches or drains.

6.14.1.3.4 Ecosystem Restoration Measures

These management measures were combined to create six measures. Each measure requires burning and mowing the project area in the initial year on construction and maintaining native savanna vegetation by either burning every three years or mowing every year, removing all exotics and plantation pine and maintaining their elimination over the project life, and filling all artificial ditches. The difference between each measure includes the number of acres restored and the method of maintaining vegetation over the life of the project.

Measures 1 and 2 consist of restoring the project areas north and south of the road: 385 acres. Measure 1 maintains vegetation by burning once every three years. Measure 2 maintains vegetation by mowing every year. Measures 3 and 4 consist of restoring only the project area north of the road: 151 acres. Measure 3 maintains vegetation by burning once every three years. Measure 4 maintains vegetation by mowing every year. Measures 5 and 6 consist of restoring only the project area south of the railroad: 234 acres. Measure 5 maintains vegetation by burning once every three years. Measure 6 maintains vegetation by mowing every year. Table 6.14-2 displays a description of each ecosystem restoration measure. Figure 6.14-2 shows the Dantzler restoration site.

Table 6.14-2.
Ecosystem Restoration Measures

Measure	Management Measures	Measure Description
0	No Action	No Action
1	1a + 2 +3	385 Acre Restoration Maintain by Burning
2	1b + 2 + 3	385 Acre Restoration Maintain by Mowing
3	1a + 2 +3	151 Acre Restoration Maintain by Burning
4	1b + 2 + 3	151 Acre Restoration Maintain by Mowing
5	1a + 2 +3	234 Acre Restoration Maintain by Burning
6	1b + 2 + 3	234 Acre Restoration Maintain by Mowing



Figure 6.14-2. Dantzler Restoration Site

6.14.1.4 Benefits

In order to restore this area to a Wet Pine Savannah habitat, the higher areas will be designated as Wet Pine Savannah. These areas have depression areas within them which will enable water to flow down to the depression areas; thus, holding water. The Wet Pine Savannah habitat will be restored with Wet Pine Flatwoods, such as Pinus elliotti, Morella cerifera, Llex glabra, Spartina patens and Panicum virgatum.

Many species of wildlife are indigenous to the Wet Pine Savannah habitat. Understory plant communities may contain wiregrass, sedges, orchids, American Chaff seed and rough-leaved loosestrife. Insectivorous plants that may be found include pitcher plants, bladderworts, venus flytrap, and sundews. Rare, threatened or endangered birds that may occur in these areas include Henslowe's sparrow, Bachman's sparrow, red-cockaded woodpecker, and Mississippi Sandhill Crane. This ecosystem may also benefit the Mississippi Gopher frog and in drier areas along ridges, the black pine snake and the gopher tortoise.

Benefits are measured in terms of Average Annual Functional Units (AAFU). The Hydrogeomorphic (HGM) approach was used to assess wetland function. A HGM assessment was performed in 2000 using the Regional Guidebook for Applying the HGM Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains. Results from this assessment were used to establish baseline (current) conditions and, ultimately, to measure the functional unit benefits resulting from different restoration measures. Table 6.14-3 shows the AAFU net benefit

under each measure. The AAFU net benefit was calculated as the difference between the total functional units for the ecosystem restoration measure and the total functional units for the no action measure.

Table 6.14-3.
Summary of Benefits

Measure	Measure Description	AAFU Net Benefit
No Action	No Action	0
Measure 1	385 Acre Restoration Maintain by Burning	1,244
Measure 2	385 Acre Restoration Maintain by Mowing	943
Measure 3	151 Acre Restoration Maintain by Burning	488
Measure 4	151 Acre Restoration Maintain by Mowing	370
Measure 5	234 Acre Restoration Maintain by Burning	756
Measure 6	234 Acre Restoration Maintain by Mowing	573

6.14.1.5 Costs

A rough order magnitude (ROM) cost estimate was developed for the 385, 151, and 234 acres of restoration. It included the cost of filling ditches with 65,560, 30,560, and 36,000 cubic yards of material for $798,720, $366,720, and $432,000, respectively; burning 385, 151, and 234 acres of vegetation for $57,750, $22,650, and $35,100, respectively; mowing 385, 151, and 234 acres for $32,725, $12,835, and $19,890, respectively; removing roads and utilities for $275,000, $121,000, and $154,000; mobilizing and demobilizing for $40,000, $20,000, and $20,000, respectively; and miscellaneous site items for $90,000, $45,000, and $45,000, respectively. Total construction costs for the 385, 151, and 234 acres of restoration equaled $1,294,195, $588,205, and $882,488. A contingency cost of 25 percent and lands and damages costs of $25,000 were added to the construction cost. Then, Planning, Engineering and Design (PED) costs of 8 percent and a Construction Management cost of 6 percent were added for a total first cost of construction of $1,881,000, $870,000, and $1,039,000.

For each measure, these first costs of construction are presented in Table 6.14-4 at October 2007 price levels along with the Interest During Construction (IDC), investment cost (first cost plus IDC), Average Annual Investment Cost (AAIC), Average Annual Operations and Maintenance (AAO&M) cost and, ultimately, the Average Annual Costs (AAC).

Investment cost, O&M cost and AAC for Measure 1 are $1,922,000, $1,328,000, and $129,000, respectively. The investment cost, O&M cost and AAC for Measure 2 are $1,922,000, $2,303,000, and $150,000, respectively. The investment cost, O&M cost and AAC for Measure 3 are $889,000, $528,000, and $58,000, respectively. The investment cost, O&M cost and AAC for Measure 4 are $889,000, $931,000, and $67,000, respectively. The investment cost, O&M cost and AAC for Measure 5 are $1,039,000, $816,000, and $73,000, respectively. The investment cost, O&M cost and AAC for Measure 6 are $1,039,000, $1,421,000, and $86,000, respectively.

Table 6.14-4.
Summary of Costs by Measure for Dantzler Area

Measure	Measure Description	Implement-ation Cost (FY-08)	IDC	Investment Cost	AAIC	AAO&M	AAC
0	No Action	$0	$0	$0	$0	$0	$0
1	879 Acre Restoration Maintain by Burning	$1,880,000	$41,000	$1,922,000	$103,000	$26,000	$129,000
2	879 Acre Restoration Maintain by Mowing	$1,880,000	$41,000	$1,922,000	$103,000	$47,000	$150,000
3	689 Acre Restoration Maintain by Burning	$870,000	$19,000	$889,000	$48,000	$10,000	$58,000
4	689 Acre Restoration Maintain by Mowing	$870,000	$19,000	$889,000	$48,000	$19,000	$67,000
5	190 Acre Restoration Maintain by Burning	$1,040,000	$23,000	$1,062,000	$57,000	$16,000	$73,000
6	190 Acre Restoration Maintain by Mowing	$1,040,000	$23,000	$1,062,000	$57,000	$29,000	$86,000

Note: Numbers are rounded to the nearest thousand dollars.

First cost of construction is used along with the duration of 12 months of construction and a discount rate of 4.875 percent to calculate Interest During Construction (IDC). The sum of the first cost of construction and IDC cost equals the investment cost. This cost is amortized at the FY 2007 federal discount rate of 4.875 percent over a 50-year economic period of analysis to calculate the Average Annual Investment Cost (AAIC). Average Annual O&M (AAO&M) costs for burning once every three years or mowing every year were present valued and amortized at an interest rate of 4.875 percent over a 50-year economic period of analysis. The sum of the AAIC and AAO&M cost equals the Average Annual Costs (AAC).

6.14.2 Comparison of Measures

Table 6.14-5 displays all measures with their respective AAC and AAFU.

Table 6.14-5.
All Measures: AAC and AAFU

Measure	AAC	AAFU
No Action	$0	0
1	$129,000	1,244
2	$150,000	943
3	$20,000	488
4	$29,000	370
5	$60,000	756
6	$73,000	573

Note: The AAC values are rounded to the nearest thousand dollars.

In order to determine the cost effectiveness of each measure, the list of measures is reordered so that they are listed in increasing order of their outputs (AAFU). This list is shown in Table 6.14-6.

Table 6.14-6.
All Measures Arrayed by Increasing Output

Measure	AAC	AAFU
No Action	$0	0
4	$29,000	370
3	$20,000	488
6	$73,000	573
5	$60,000	756
2	$150,000	943
1	$129,000	1,244

Note: The AAC values are rounded to the nearest thousand dollars.

To determine if a measure is cost effective, economically inefficient measures must first be identified and eliminated. An economically inefficient measure is a measure that cost more for the same level of benefit. No measures are eliminated for the reason of economic inefficiency because each measure produces a different level of benefit.

Lastly, economically ineffective measures are identified and eliminated to determine which measures are cost effective. An economically ineffective measure is a measure that cost more or the same as a subsequent measure but produces less benefit than that subsequent measure. As shown in Table 6.14-7, the three shaded measures, 2, 4, and 6 were eliminated because they produced less benefit at greater cost than a subsequent measure. For example, Measure 4 produces 370 AAFU at an AAC of $29,000 while Measure 3 produces 488 AAFU at an AAC $20,000. Measure 4 produces less AAFU at a greater cost than Measure 3. Therefore, Measure 4 is eliminated. As shown in table 6.14-8 and plotted in figure 6.14-3, the cost effective measures are Measure 1 (385 acres of restoration maintained by burning), Measure 3 (151 acres of restoration maintained by burning) and Measure 5 (234 acres of restoration maintained by burning).

Table 6.14-7.
Elimination of Economically Ineffective Measures

Measure	Measure Description	AAC	AAFUs	Cost Effective?
No Action	No Action	$0	0	Yes
4	151 Acre Restoration Maintain by Mowing	$29,000	370	No
3	151 Acre Restoration Maintain by Burning	$20,000	488	Yes
6	234 Acre Restoration Maintain by Mowing	$73,000	573	No
5	234 Acre Restoration Maintain by Burning	$60,000	756	Yes
2	385 Acre Restoration Maintain by Mowing	$150,000	943	No
1	385 Acre Restoration Maintain by Burning	$129,000	1,244	Yes

Note: The AAC values are rounded to the nearest thousand dollars.

Table 6.14-8.
Cost Effective Measures for Dantzler Area

Measure	Measure Description	AAC	AAFUs	Cost Effective?
No Action	No Action	$0	0	Yes
3	151 Acre Restoration Maintain by Burning	$20,000	488	Yes
5	234 Acre Restoration Maintain by Burning	$60,000	756	Yes
1	385 Acre Restoration Maintain by Burning	$129,000	1,244	Yes

Note: The AAC values are rounded to the nearest thousand dollars.

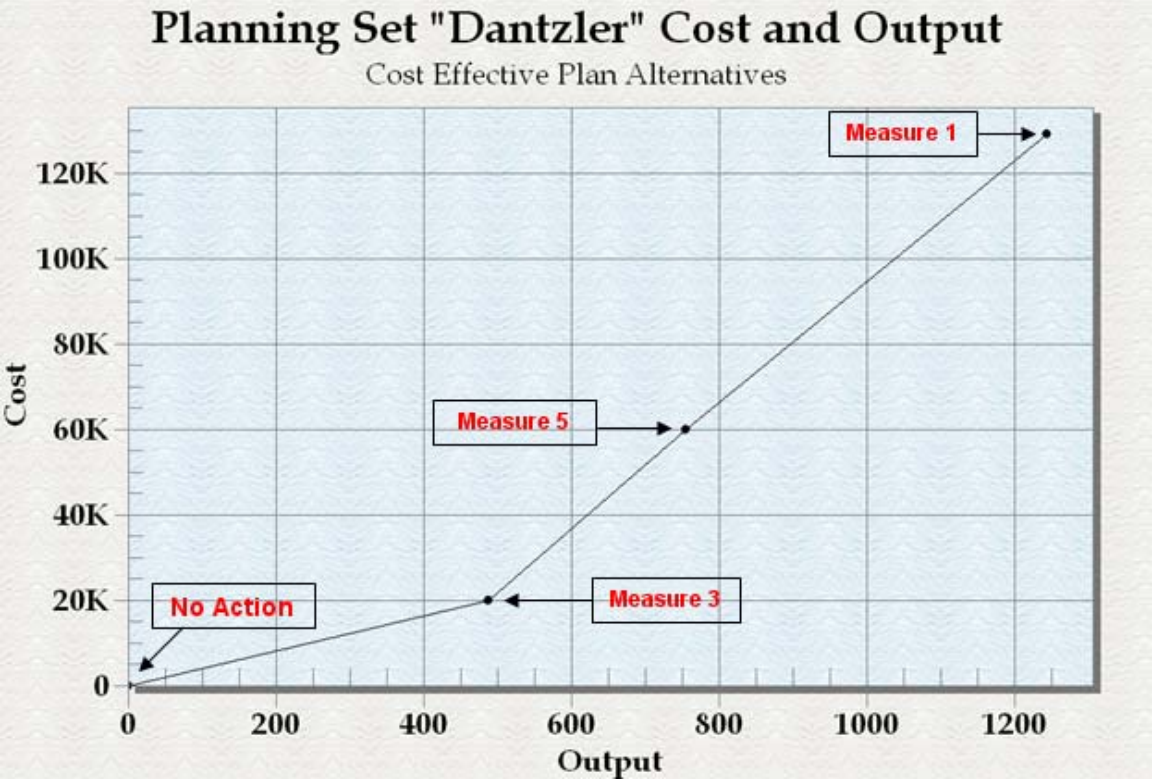


Figure 6.14-3. Display of Cost Effective Alternatives for the Dantzler Area

6.14.3 Regional Economic Development (RED) Benefits

6.14.3.1 Socioeconomic Impacts using the Economic Impact Forecast System

The purpose of this section is to show the economic impact of the cost effective alternatives on business (sale volumes), income, employment, and population of the local area. Each of the alternatives would affect the local area of Jackson County, Mississippi. The expenditures for the alternatives are estimated to be $1,900,000 for Alternative 1, $1,040,000 for Alternative 3, $870,000 for Alternative 5. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $484,000 for Alternative 1, $186,000 for Alternative 3, and

$298,000 for Alternative 5 (assuming a 50 year period of analysis and an interest rate of 4.875 percent).

6.14.4 Summary Explanation of the EIFS Model Output

The outputs shown in this section are based on the following input from the proposed project alternatives. EIFS model inputs and outputs are shown in tables 6.14-9 through 6.14-12. The inputs are as follows:

Table 6.14-9.
EIFS Model Implementation Inputs for the Dantzler Ecosystem

	No Action	Alternative 1	Alternative 3	Alternative 5
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$0	$1,900,000	$1,040,000	$870,000

Based of the given inputs the outputs are as follows:

Table 6.14-10.
EIFS Model Implementation Outputs for the Dantzler Ecosystem

	No Action	Alternative 1	Alternative 3	Alternative 5
Direct Sales Volume	$0	$1,900,000	$1,040,000	$870,000
Induced Sales Volume	$0	$2,128,000	$1,164,800	$974,400
Total Sales Volume	$0	$4,028,000	$2,204,800	$1,844,400
Direct Income	$0	$370,549	$202,827	$169,672
Induced Income	$0	$415,014	$227,166	$190,033
Total Income	$0	$785,563	$429,992	$359,705
Direct Employment	0	11	6	5
Induced Employment	0	12	7	6
Total Employment	0	23	12	10
Local Population	0	0	0	0

Table 6.14-11.
EIFS Model O&M Inputs for the Dantzler Ecosystem

	No Action	Alternative 1	Alternative 3	Alternative 5
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$0	$484,000	$186,000	$298,000

Based of the given inputs the outputs are as follows:

Table 6.14-12.
EIFS Model O&M Outputs for the Dantzler Ecosystem

	No Action	Alternative 1	Alternative 3	Alternative 5
Direct Sales Volume	$0	$484,000	$186,000	$298,000
Induced Sales Volume	$0	$542,080	$208,320	$333,760
Total Sales Volume	$0	$1,026,080	$394,320	$631,760
Direct Income	$0	$94,392	$36,275	$58,118
Induced Income	$0	$105,719	$40,628	$65,092
Total Income	$0	$200,112	$76,902	$123,209
Direct Employment	0	3	1	2
Induced Employment	0	3	1	2
Total Employment	0	6	2	4
Local Population	0	0	0	0

6.15 Franklin Ecosystem Restoration Measures

This section describes the evaluation of ecosystem restoration measures at the Franklin Creek area that is located within planning sub-unit 53, which is part of planning unit three. The total area includes 149 acres of land that was acquired during the interim phase of the MsCIP. This area was selected for ecosystem restoration using the Decision Support System, a GIS based model created by the Corps' Engineer Research and Development Center (ERDC). For more details on the selection process for ecosystem restoration sites see the Economic Appendix. Figure 6.15-1 shows the location of the Franklin Creek area.

6.15.1 Formulation of Alternatives

6.15.1.1 Assumptions

In order for the Franklin Creek site to undergo ecosystem restoration, it is assumed that all of the property is being acquired under the Mississippi Coastal Improvements Program Interim Projects.

6.15.1.2 Objectives

The following objectives were developed for ecosystem restoration:

- Restore native vegetation
- Restore natural fire regime
- Restore natural hydrology
- Restore fish and wildlife habitat
- Provide storm water storage protection

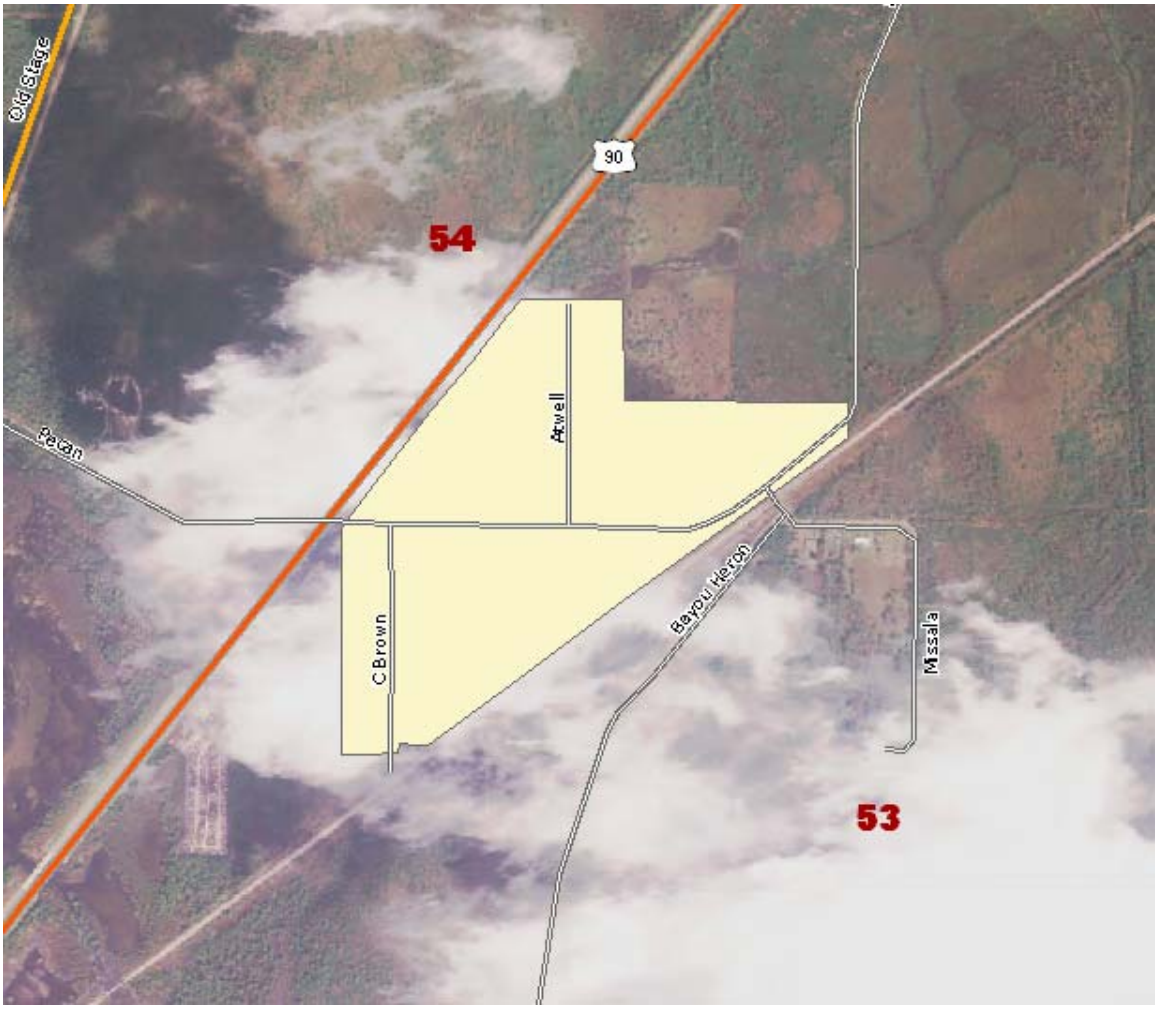


Figure 6.15-1. Franklin Creek Restoration Area.

6.15.1.3 Ecosystem Restoration Management Measures

Proposed restoration management measures are listed in table 6.15-1. Narrative descriptions of each management measure follow this table.

Table 6.15-1
Ecosystem Restoration Management Measures

Management Measure	Description
No Action	No Action
1	Fill Artificial Ditches
2 *a* *b*	Maintain Native Savannah Vegetation *By Burning Every 3Years* *By Mowing Annually*
3	Excavate & Remove Roadbeds & Fill
4	Add Culverts

6.15.1.4 Fill Ditches (1)

This management measure must be included in all alternatives for the restoration to be successful. This measure positively affects the outflow of water. It measures the removal of water by ditches or drains.

6.15.1.5 Maintain Native Savannah Vegetation (2)

This management measure must be included in all alternatives for the restoration to be successful. There are two methods that will be analyzed for maintaining vegetation: (a) burning and (b) mowing. Fire benefits this ecosystem in many different ways. It creates a bare seedbed for pine seedlings and other fire dependent plants, reduces fuel loads and recycles nutrients. Periodic burning promotes early successional plants that are important to many species of wildlife indigenous to this ecosystem. Many of the plant species found in this ecosystem are fire dependent; for example, the federally endangered American Chaff seed flowers almost exclusively after a fire. It has been reduced to a fraction of its original range due to fire suppression and habitat destruction. Fire suppression is mainly due to liability issues and fear of litigation.

Mowing is a mechanical alternative that many land managers use to maintain early successional habitats. Although it is successful to some extent, it fails to provide all the necessary components that come from prescribed fire. This method also has a negative effect. Mowing requires the use of heavy equipment in sensitive areas. Tractors can create ruts in saturated soils, creating hydrologic problems and micro site conditions. Mowing can also introduce non-native species through the use of contaminated equipment. Another disadvantage of mowing is that the duff or litter layer remains on the ground, preventing seeds from reaching the bare ground needed for germination. This thick litter layer can also provide heavy fuel loads increasing the risk of wildfires during dry periods. Although mowing provides some level of habitat management in pine savannahs, it is not a substitute for prescribed fire. Mowing can maintain succession, but may inhibit other functions of the system.

6.15.1.6 Excavate and Remove Existing Roadbeds and Fill (3)

This management measure must be included in all alternatives for the restoration to be successful. This measure affects the surface water storage. An ecological improvement would occur where existing roadbeds and fill are removed.

6.15.1.7 Add Culverts (4)

This measure increases the hydrologic connection between the two existing wetland areas separated by the elevated railway. The wetlands are primarily precipitation driven resulting in sheet flow drainage. Additional culverts will result in increased sheet flow drainage reducing standing surface water in the northern wetland area.

6.15.1.8 Ecosystem Restoration Alternatives

These management measures were combined to create four alternatives. Each alternative requires filling in ditches, maintaining native savannah vegetation by burning and mowing the project area in the initial year of construction with followed-up maintenance throughout the life of the project with either burning every 3 years or mowing every year, and excavating and removing existing roadbeds and any additional fill. Restoring the north and south acres together also includes adding culverts to increase hydrologic connectivity whereas restoring only the south portion does not include the culvert measure. Otherwise, the difference between each alternative includes the number of acres restored and/or the method of maintaining vegetation over the life of the project. Restoring only the north portion was not considered as an alternative since it would make the ecology worse off.

Alternatives 1 and 2 consist of restoring the project areas north and south of the railway: 149 acres. Alternative 1 maintains vegetation by burning once every three years. Alternative 2 maintains vegetation by mowing every year. Alternatives 3 and 4 consist of restoring only the project area south of the railway: 56 acres. Alternative 3 maintains vegetation by burning once every three years. Alternative 4 maintains vegetation by mowing every year. Table 6.15-2 displays a description of each ecosystem restoration alternative. Figure 6.15-2 shows the Franklin Creek restoration site divided by the railroad into the north (A) and south (B) acreages.

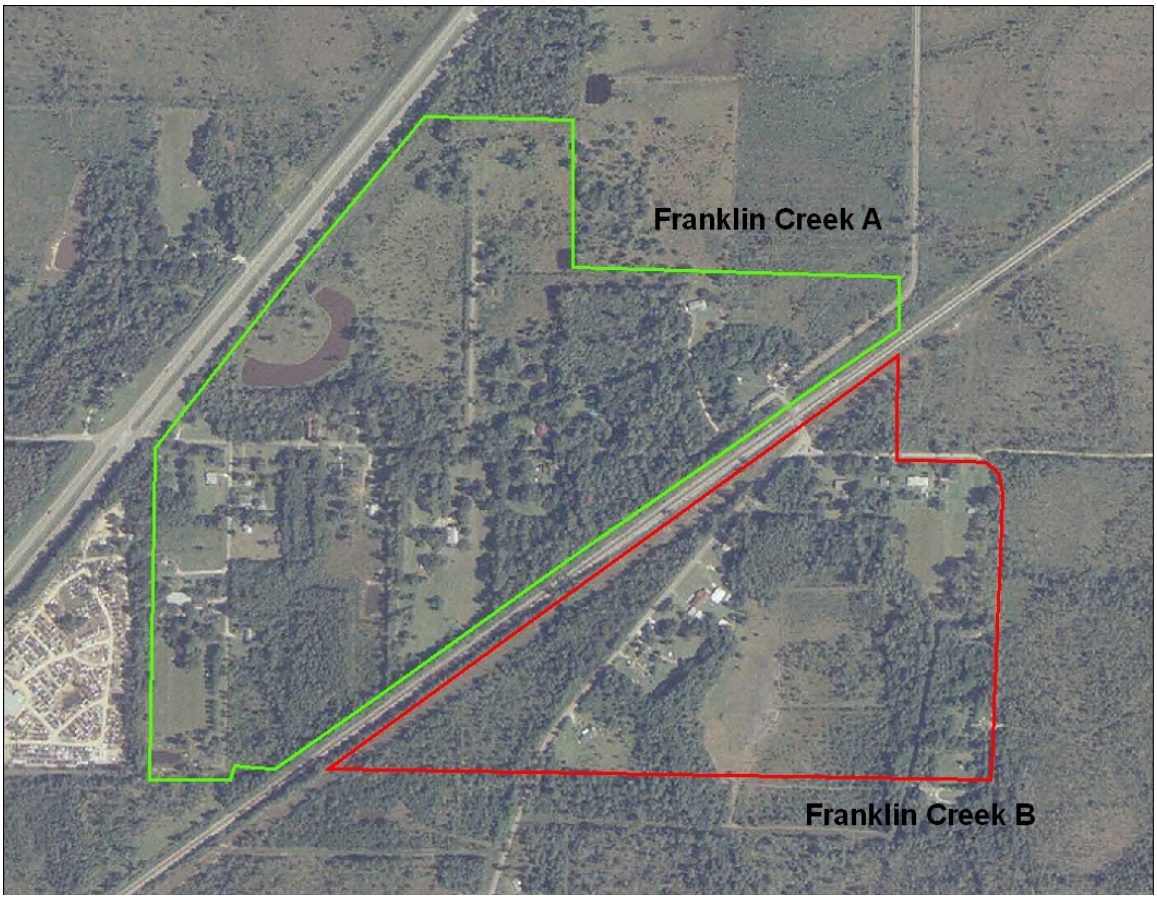


Figure 6.15-2. Franklin Creek Restoration Site

Table 6.15-2.
Ecosystem Restoration Alternatives

Alternative	Management Measures	Alternative Description
0	No Action	No Action
1	1 + 2a + 3 + 4	149 Acre Restoration Maintain by Burning
2	1 + 2b + 3 + 4	149 Acre Restoration Maintain by Mowing
3	1 + 2a +3	56 Acre Restoration Maintain by Burning
4	1 + 2b + 3	56 Acre Restoration Maintain by Mowing

6.15.1.9 Benefits

In order to restore this area to a Wet Pine Savannah habitat, the higher areas will be designated as Wet Pine Savannah. These areas have depression areas within them which will enable water to flow down to the depression areas; thus, holding water. The Wet Pine Savannah habitat will be restored with Wet Pine Flatwoods, such as Pinus elliotti, Morella cerifera, Ilex glabra, Spartina patens and Panicum virgatum.

Many species of wildlife are indigenous to the Wet Pine Savannah habitat. Understory plant communities may contain wiregrass, sedges, orchids, American Chaff seed and rough-leaved loosestrife. Insectivorous plants that may be found include pitcher plants, bladderworts, venus flytrap, and sundews. Rare, threatened or endangered birds that may occur in these areas include Henslowe's sparrow, Bachman's sparrow, red-cockaded woodpecker, and Mississippi Sandhill Crane. This ecosystem may also benefit the Mississippi Gopher frog and in drier areas along ridges, the black pine snake and the gopher tortoise.

Benefits are measured in terms of Average Annual Functional Units (AAFU). The Hydrogeomorphic (HGM) approach was used to assess wetland function. A HGM assessment was performed in 2000 using the Regional Guidebook for Applying the HGM Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains. Results from this assessment were used to establish baseline (current) conditions and, ultimately, to measure the functional unit benefits resulting from different restoration alternatives. Table 6.15-3 shows the AAFU net benefit under each alternative. The AAFU net benefit was calculated as the difference between the total functional units for the ecosystem restoration alternative and the total functional units for the no action alternative.

Table 6.15-3.
Summary of Benefits

Alternative	Alternative Description	AAFU Net Benefit
No Action (alternatives 1-2)	No Action (149 acres)	0
No Action (alternatives 3-4)	No Action (56 acres)	0
Alternative 1	149 Acre Restoration Maintain by Burning	516
Alternative 2	149 Acre Restoration Maintain by Mowing	399
Alternative 3	56 Acre Restoration Maintain by Burning	194
Alternative 4	56 Acre Restoration Maintain by Mowing	150

6.15.1.10 Costs

A rough order magnitude (ROM) cost estimate was developed for the 149 acres of restoration represented in Alternatives 1 and 2. The first costs for Alternatives 1 and 2 are estimated at $1,634,000. First costs include construction, contingency, lands and damages, PED, and construction management costs. Investment cost (first cost plus IDC) for Alternatives 1 and 2 are estimated at $1,670,000. The equivalent average annual cost (AAC), which includes AAC of investment of $90,000 and O&M of $11,000 and $19,000, for Alternatives 1 and 2 are $101,000 and $109,000, respectively. The first costs for Alternatives 3 and 4 representing 56 acres of restoration south of the railway are estimated at $548,000. Investment cost (first cost plus IDC) for Alternatives 1 and 2 are estimated at $560,000. The AAC, which includes AAC of investment of $30,000 and

O&M of $4,000 and $7,000, respectively, for Alternatives 3 and 4 are $34,000 and $37,000, respectively.

For each alternative, first costs of construction, Interest During Construction (IDC), total investment cost, Average Annual Investment Cost (AAIC), Average Annual Operations and Maintenance (AAO&M) cost and, ultimately, the Average Annual Costs (AAC) are presented in table 6.15-4 at October 2007 price levels.

Table 6.15-4.
Summary of Costs by Measure for Franklin Creek

Alternative	Alternative Description	Implement-ation Cost (FY-08)	IDC	Investment Cost	AAIC	AAO&M	AAC
0	No Action	$0	$0	$0	$0	$0	$0
1	149 Acre Restoration Maintain by Burning	$1,630,000	$36,000	$1,670,000	$90,000	$11,000	$101,000
2	149 Acre Restoration Maintain by Mowing	$1,630,000	$36,000	$1,670,000	$90,000	$19,000	$109,000
3	56 Acre Restoration Maintain by Burning	$550,000	$12,000	$560,000	$30,000	$4,000	$34,000
4	56 Acre Restoration Maintain by Mowing	$550,000	$12,000	$560,000	$30,000	$7,000	$37,000

Note: Values are rounded to the nearest thousand dollars.

First cost of construction is used along with the duration of 12 months of construction and a discount rate of 4.875 percent to calculate Interest During Construction (IDC). The sum of the first cost of construction and IDC cost equals the investment cost. This cost is amortized at the FY 2007 federal discount rate of 4.875 percent over a 50-year economic period of analysis to calculate the Average Annual Investment Cost (AAIC). Average Annual O&M (AAO&M) costs for burning once every three years or mowing every year were present valued and amortized at an interest rate of 4.875 percent over a 50-year economic period of analysis. The sum of the AAIC and AAO&M cost equals the Average Annual Costs (AAC).

6.15.2 Comparison of Alternatives

Table 6.15-5 displays all alternatives with their respective AAC and AAFU.

Table 6.15-5.
All Alternatives: AAC and AAFU

Alternative	AAC	AAFU
No Action	$0	0
1	$101,000	516
2	$109,000	399
3	$34,000	194
4	$37,000	150

Note: The AAC values are rounded to the nearest thousand dollars.

In order to determine the cost effectiveness of each alternative, the list of alternatives is reordered so that they are listed in increasing order of their outputs (AAFU). This list is shown in table 6.15-6.

Table 6.15-6.
All Alternatives Arrayed by Increasing Output

Alternative	AAC	AAFU
No Action	$0	0
4	$37,000	150
3	$34,000	194
2	$109,000	399
1	$101,000	516

Note: The AAC values are rounded to the nearest thousand dollars.

To determine if an alternative is cost effective, economically inefficient alternatives must first be identified and eliminated. An economically inefficient alternative is an alternative that cost more for the same level of benefit. No alternatives are eliminated for the reason of economic inefficiency because each alternative produces a different level of benefit.

Lastly, economically ineffective alternatives are identified and eliminated to determine which alternatives are cost effective. An economically ineffective alternative is an alternative that costs more or the same as a subsequent alternative but produces less benefit than that subsequent alternative. As shown in table 6.15-7, the two shaded alternatives 4 and 2 were eliminated because they produced less benefit at greater cost than a subsequent alternative. For example, Alternative 4 produces 150 AAFU at an AAC of $37,000 while Alternative 3 produces 194 AAFU at an AAC $34,000. Alternative 4 produces less AAFU at a greater cost than Alternative 3. Therefore, Alternative 4 is eliminated. As shown in table 6.15-8 and plotted in figure 6.15-3, the cost effective alternatives are Alternative 3 (56 acres of restoration maintained by burning) and Alternative 1 (149 acres of restoration maintained by burning).

Table 6.15-7.
Elimination of Economically Ineffective Alternatives

Alternative	Alternative Description	AAC	AAFUs	Cost Effective?
No Action	No Action	$0	0	Yes
4	56 Acre Restoration Maintain by Mowing	$37,000	150	No
3	56 Acre Restoration Maintain by Burning	$34,000	194	Yes
2	149 Acre Restoration Maintain by Mowing	$109,000	399	No
1	149 Acre Restoration Maintain by Burning	$101,000	516	Yes

Note: The AAC values are rounded to the nearest thousand dollars.

Table 6.15-8.
Cost Effective Alternatives for Franklin Creek Area

Alternative	Alternative Description	AAC	AAFUs	Cost Effective?
No Action	No Action	$0	0	Yes
3	56 Acre Restoration Maintain by Burning	$34,000	194	Yes
1	149 Acre Restoration Maintain by Burning	$101,000	516	Yes

Note: The AAC values are rounded to the nearest thousand dollars.

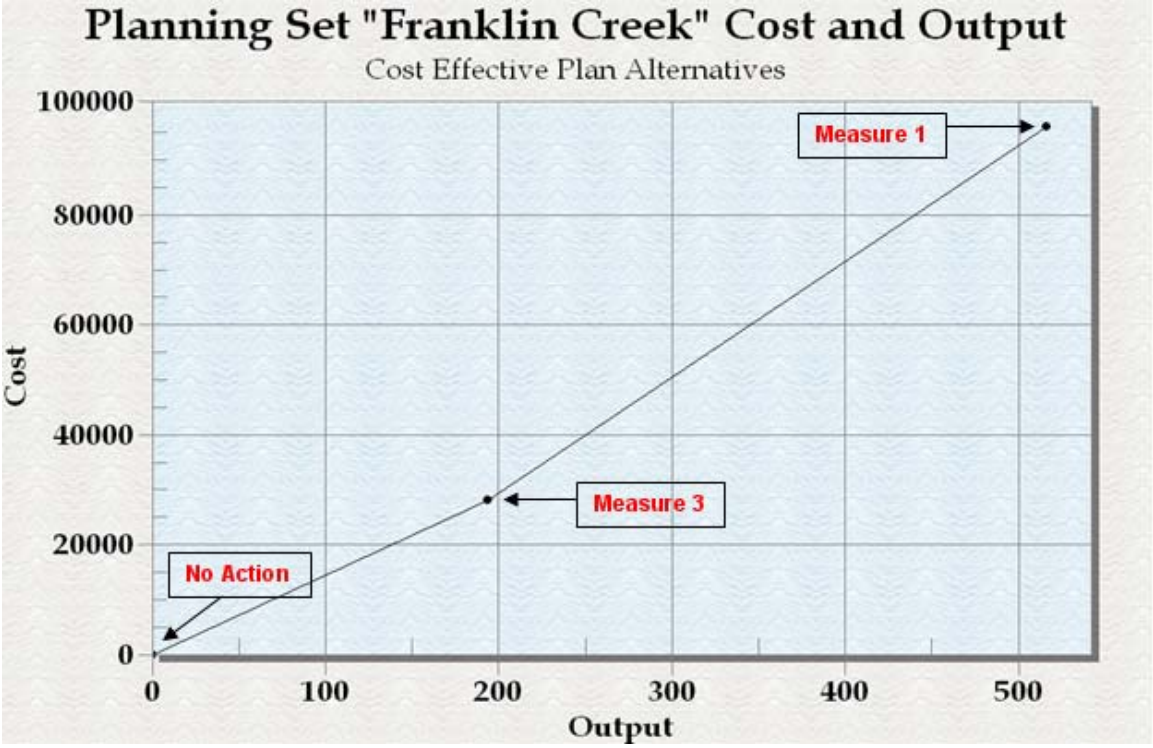


Figure 6.15-3. Display of Cost Effective Alternatives for the Franklin Creek Area

6.15.3 Regional Economic Development (RED) Benefits

6.15.3.1 Summary of Socioeconomic Impacts using the Economic Impact Forecast System

The purpose of this analysis is to show the economic impact of the cost effective alternatives on business (sale volumes), income, employment, and population of the local area. Each of the alternatives would affect the local area of Jackson County, Mississippi. The expenditures for the alternatives are estimated to be $960,000 for Alternative 1, $1,530,000 for Alternative 3. Moreover, the total present worth of the operation and maintenance (O&M) expenditures are estimated to be $205,000 for Alternative 1 and $74,000 for Alternative 3 (assuming a 50 year period of analysis and an interest rate of 4.875 percent).

The outputs shown in this section are based on the following input from the proposed project measures. The inputs and outputs are shown in tables 6.15-9 through 6.15-12. The inputs are as follows:

Table 6.15-9.
EIFS Model Implementation Inputs for Franklin Creek Ecosystem

	No Action	Alternative 1	Alternative 3
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$0	$1,630,000	$550,000

Based of the given inputs the outputs are as follows:

Table 6.15-10.
EIFS Model Implementation Outputs for Franklin Creek Ecosystem

	No Action	Alternative 1	Alternative 3
Direct Sales Volume	$0	$1,630,000	$550,000
Induced Sales Volume	$0	$1,825,600	$616,000
Total Sales Volume	$0	$3,455,600	$1,166,000
Direct Income	$0	$317,892	$107,264
Induced Income	$0	$356,039	$120,136
Total Income	$0	$673,930	$227,400
Direct Employment	0	9	3
Induced Employment	0	10	3
Total Employment	0	19	6
Local Population	0	0	0

Table 6.15-11.
EIFS Model O&M Inputs for Franklin Creek Ecosystem

	No Action	Alternative 1	Alternative 3
Region of Influence (ROI)	Jackson County	Jackson County	Jackson County
Change in Local Expenditures	$0	$205,000	$74,000

Based of the given inputs the outputs are as follows:

Table 6.15-12.
EIFS Model O&M Outputs for Franklin Creek Ecosystem

	No Action	Alternative 1	Alternative 3
Direct Sales Volume	$0	$205,000	$74,000
Induced Sales Volume	$0	$229,600	$82,880
Total Sales Volume	$0	$434,600	$156,880
Direct Income	$0	$39,980	$14,432
Induced Income	$0	$44,778	$16,164
Total Income	$0	$84,758	$30,596
Direct Employment	0	1	1
Induced Employment	0	1	0
Total Employment	0	2	1
Local Population	0	0	0

6.16 Evaluation of Inland Barrier and Surge Barrier Flood Damage Reduction Measures

6.16.1 General

The Inland barrier and surge barrier area is located in all three planning units just north of the roadways that run parallel to the beach. These areas are denoted by the inland zone planning area. In planning unit one, the inland barrier area includes planning sub-units one, two, seven, thirty-seven, and thirty-eight; in planning unit two, planning sub-units eight, eleven, twelve, fourteen, sixteen, seventeen, twenty, thirty-nine, forty, forty-seven, forty-eight, and fifty; and in planning unit three the planning sub-units are twenty-one, twenty-three, forty-one, forty-six, and forty-nine.

6.16.2 Historic (Pre-Hurricane Katrina) Conditions

The pre-Hurricane Katrina conditions for planning sub-units three and four in planning unit one represented a mostly residential community as shown in Table 6.16-1. The areas in planning unit one included 35,770 tax parcels, of which 17,914 contained an asset with some economic value and 17,856, were vacant land. Of the 17,914 parcels that contain assets, 13,961 were residential one-story, 763 were residential two-story, 463 were mobile homes, 2,236 were commercial, and 491 were municipal. The areas in planning unit two included 76,487 tax parcels, of which 48,962 contained an asset with some economic value and 27,525 were vacant land. Of the 48,962 parcels that contain assets, 40,456 were residential one-story, 1,594 were residential two-story, 2,487 were mobile homes, 4,136 were commercial, and 289 were municipal. The areas in planning unit three included 21,353 tax parcels, of which 14,575 contained an asset with some economic value and 6,778 were vacant land. Of the 14,575 parcels that contain assets, 12,551 were residential one-story, 311 were residential two-story, 828 were mobile homes, 789 were commercial, and 96 were municipal.

Table 6.16-1.
Pre-Hurricane Katrina Estimate of Structures for Inland Zone Area

	Planning Unit One	Planning Unit Two	Planning Unit Three	
Asset Categories	**Assets by Category**	**Assets by Category**	**Assets by Category**	**Total**
Residential	14,724	42,050	12,862	**69,636**
Mobile Homes	463	2,487	828	**3,778**
Commercial	2,236	4,136	789	**7,161**
Municipal	491	289	96	**876**
Vacant Land	17,856	27,525	6,778	**52,159**
Total	**35,770**	**76,487**	**21,353**	**133,610**

Figure 6.16-1 denotes the various zones and shows the inland zone in green. Figures 6.16-2 shows the planning sub-units of the area by planning unit.

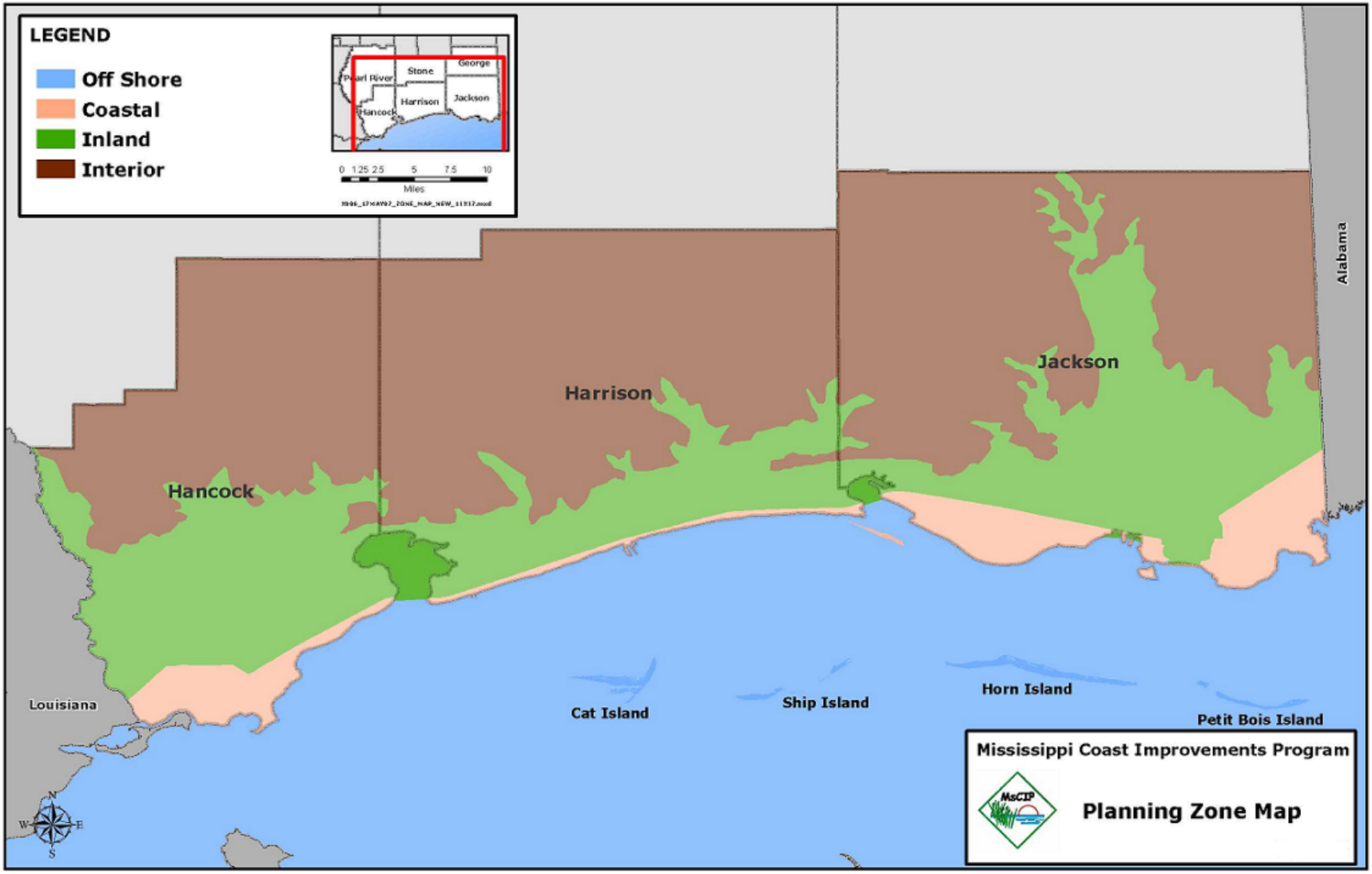


Figure 6.16-1. Planning Zones – Impacted area is the inland zone

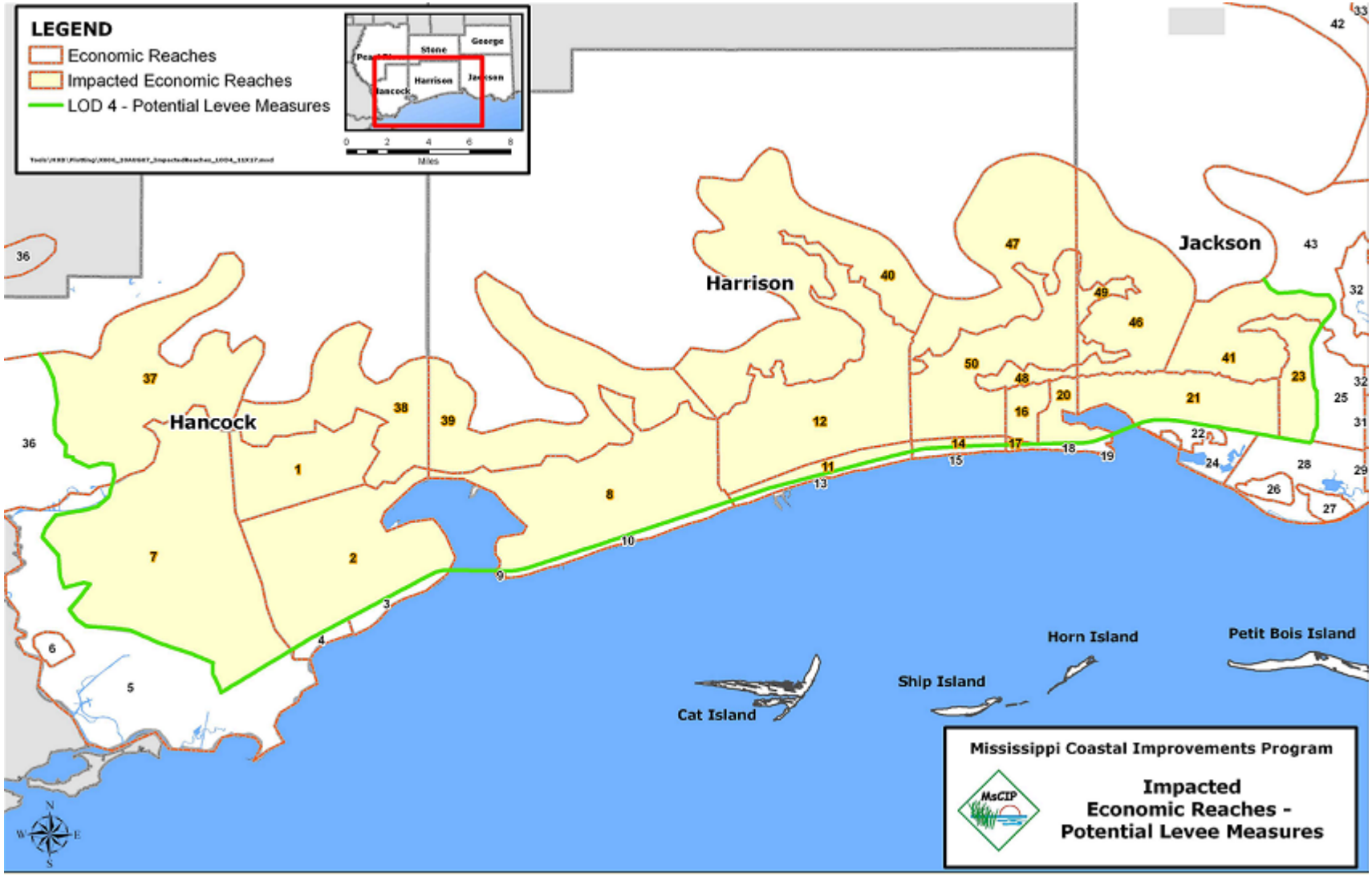


Figure 6.16-2 Planning sub-units in Inland Area for Planning Units One, Two, and Three

6.16.2.1 Existing (Post-Hurricane Katrina) Conditions

Hurricane Katrina made its Mississippi landfall just west of planning sub-units three and four. Damage from the surge was devastating across the three planning units. In the inland barrier impact area, it is estimated that 12,857 structures sustained significant damage (50-percent or more). Of those, 5,610 were destroyed in planning unit one, 6,850 in planning unit two, and 397 were destroyed in planning unit three. Table 6.16-2 displays the destroyed structures by category and by planning unit for these areas.

Table 6.16-2.
Destroyed Structures by Category and Planning Unit

	Planning Unit One	Planning Unit Two	Planning Unit Three	
Asset Categories	**Assets by Category**	**Assets by Category**	**Assets by Category**	**Total**
Residential	5,213	6,115	349	**11,677**
Mobile Homes	33	60	10	**103**
Commercial	311	648	38	**997**
Municipal	53	27	0	**80**
Total	**5,610**	**6,850**	**397**	**12,857**

6.16.3 Opportunities

The following opportunities were identified for this area:

- Hurricane storm damage reduction or remediation.

6.16.4 Assumptions

The following assumptions were used in this analysis.

- The FY 2008 discount rate of 4-7/8 percent was used in estimating average annual benefits and costs.
- Price levels are FY-08, unless otherwise stated.
- A 100-year period of analysis (2012 to 2111) was used to calculate average annual benefits and costs for initial screening.
- Full redevelopment of the area will take place by the base year 2012.

6.16.5 Measures

Initially, a comprehensive list of measures was identified for flood damage reduction purposes for planning unit one. This list was screened and vetted for engineering and environmental feasibility and for policy compliance. The MsCIP Comprehensive Main Report and the Engineering and Environmental Appendices contain a detailed description of the measures that were initially screened.

Several potential measures were carried forward for this area for the purpose of flood damage reduction. These measures include both structural features and nonstructural actions. The measures evaluated for economic benefits include:

- Measure A - LOD-4, Inland Barrier and Surge Barrier at 20.0-feet NAVD88 Elevation

This measure will consist of an elevation 20.0-feet NAVD88 earthen levee construction in planning unit one along an alignment that extends southward from the same ground surface elevation as the levee along the last watershed divide before entering the Pearl River basin and then turn eastward and extend along the south side of the CSX railroad track to the Bay St. Louis Surge Barrier. An elevation 20.0-feet NAVD88 surge barrier will extend across the mouth of St. Louis Bay from the western shore in Hancock County to the eastern shore in Harrison County. The structure will be located just south of the railway bridge. The barrier will consist of abutments extending from each shore with rising sector gates spanning most of the distance. The abutments will include gated culverts to provide proper circulation and tidal exchange. The earthen levee will then continue in planning unit two along an alignment that extends eastward from the Bay St. Louis Surge Barrier along the south side of the CSX railroad track to the Biloxi Bay Surge Barrier.

A second elevation 20.0-feet NAVD88 surge barrier will extend across the mouth of Biloxi Bay from the western shore in Harrison County to the eastern shore in Jackson County. The structure will be located just south of the existing railway bridge. The barrier will consist of abutments extending from each shore with rising sector gates spanning most of the distance. The abutments will include gated culverts to provide proper circulation and tidal exchange. In planning unit three, the earthen levee construction will continue along an alignment that extends eastward from the Biloxi Bay Surge Barrier along the south side of the CSX railroad track to the last watershed divide before entering the Pascagoula River basin. At the watershed divide, the alignment will follow the divide northward until it intersects the same ground surface elevation as the levee. This system will include interior drainage, pumping stations, and required road crossings. All required maintenance for the surge barrier facilities will be included.

- Measure B – LOD-4, Inland Barrier and Surge Barrier at 30.0-feet NAVD88 Elevation

This measure will consist of an elevation 30.0-feet NAVD88 earthen levee construction in planning unit one along an alignment that extends southward from the same ground surface elevation as the levee along the last watershed divide before entering the Pearl River basin and then turn eastward and extend along the south side of the CSX railroad track to the Bay St. Louis Surge Barrier. An elevation 30.0-feet NAVD88 surge barrier will extend across the mouth of St. Louis Bay from the western shore in Hancock County to the eastern shore in Harrison County. The structure will be located just south of the railway bridge. The barrier will consist of abutments extending from each shore with rising sector gates spanning most of the distance. The abutments will include gated culverts to provide proper circulation and tidal exchange. The earthen levee will then continue in planning unit two along an alignment that extends eastward from the Bay St. Louis Surge Barrier along the south side of the CSX railroad track to the Biloxi Bay Surge Barrier.

A second elevation 30.0-feet NAVD88 surge barrier will extend across the mouth of Biloxi Bay from the western shore in Harrison County to the eastern shore in Jackson County. The structure will be located just south of the existing railway bridge. The barrier will consist of abutments extending from each shore with rising sector gates spanning most of the distance. The abutments will include gated culverts to provide proper circulation and tidal exchange. In planning unit three, the earthen levee construction will continue along an alignment that extends eastward from the Biloxi Bay Surge Barrier along the south side of the CSX railroad track to the last watershed divide before entering the Pascagoula River basin. At the watershed divide, the alignment will follow the divide northward until it intersects the same ground surface elevation as the levee. This system will include interior drainage, pumping stations, and required road crossings. All required maintenance for the surge barrier facilities will be included.

- Measure C - LOD-4, Inland Barrier and Surge Barrier at 40.0-feet NAVD88 Elevation

This measure will consist of an elevation 40.0-feet NAVD88 earthen levee construction in planning unit one along an alignment that extends southward from the same ground surface elevation as the levee along the last watershed divide before entering the Pearl River basin and then turn eastward and extend along the south side of the CSX railroad track to the Bay St. Louis Surge Barrier. An elevation 40.0-feet NAVD88 surge barrier will extend across the mouth of St. Louis Bay from the western shore in Hancock County to the eastern shore in Harrison County. The structure will be located just south of the railway bridge. The barrier will consist of abutments extending from each shore with rising sector gates spanning most of the distance. The abutments will include gated culverts to provide proper circulation and tidal exchange. The earthen levee will then continue in planning unit two along an alignment that extends eastward from the Bay St. Louis Surge Barrier along the south side of the CSX railroad track to the Biloxi Bay Surge Barrier.

A second elevation 40.0-feet NAVD88 surge barrier will extend across the mouth of Biloxi Bay from the western shore in Harrison County to the eastern shore in Jackson County. The structure will be located just south of the existing railway bridge. The barrier will consist of abutments extending from each shore with rising sector gates spanning most of the distance. The abutments will include gated culverts to provide proper circulation and tidal exchange. In planning unit three, the earthen levee construction will continue along an alignment that extends eastward from the Biloxi Bay Surge Barrier along the south side of the CSX railroad track to the last watershed divide before entering the Pascagoula River basin. At the watershed divide, the alignment will follow the divide northward until it intersects the same ground surface elevation as the levee. This system will include interior drainage, pumping stations, and required road crossings. All required maintenance for the surge barrier facilities will be included.

- Measure D – Levee for Roadway - Elevation 20.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure E – Levee for Roadway - Elevation 30.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure F - Menge Ave. - Elevation 20.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure G - Menge Ave. - Elevation 30.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure H – Menge Ave. - Elevation 40.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure I – Levee for Roadway with Menge Ave. Alt - Elevation 20.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure J - Levee for Roadway with Menge Ave. Alt - Elevation 30.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure K - Non-structural One

This measure includes the acquisition and flood proofing (elevate in place) of structures to a 100-year level of protection. See the Non-structural Appendix for more detail on this measure.

- Measure L – Non-structural Two

REQUIRES FUTHER STUDY

- Measure M – Non-structural Three

REQUIRES FUTHER STUDY

- Measure N – Non-structural Four

REQUIRES FUTHER STUDY

Figure 6.16-3 shows the footprints for measures A through J. The alignment running from Hancock County to Jackson County is the footprint for measures A, through E, and the alignment going from Harrison County east to Jackson County is the footprint for measures F through J. The highlighted areas in figure 6.16-2 above represent the footprint of the nonstructural measures K through N.

6.16.6 National Economic Development (NED)

The purpose of this section is to document investigations conducted to identify the National Economic Development (NED) benefits of each of the potential measures previously listed. For this analysis, NED benefits are the reduced inundation damages of assets and their contents when one of the potential measures is in place. Typically, NED benefits are annualized over the period of the analysis (average annual benefits) and then compared to annualized costs over the period of analysis (average annual costs). This comparison is commonly known as the benefit-to-cost ratio (BCR). For purposes of this analysis, no benefit-to-cost ratios will be calculated as per the legislative Congressional language authorizing this study. The Coastal Mississippi Comprehensive Plan Report was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states: "…***that the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project plan features based upon maximizing net national economic development benefits…"*** More detail on the authorizing language can be found in the MsCIP Comprehensive Plan Main Report.

6.16.6.1 Future Without-Project Conditions

Equivalent annual surge damages for several future without-project scenarios were evaluated using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. Each of the measures were evaluated and compared to the without-project conditions in order to calculate equivalent annual damage reduction. Future without-project scenarios three, four, five, and six were applicable for the inland barrier area.

Future scenario one is the full redevelopment of structures within the study area by the year 2012 with no relative sea level rise over the 100-year period of analysis. Structures will be rebuilt to what they were pre-Hurricane Katrina; residential back to residential, commercial back to commercial, etc. This future scenario, as previously noted in section 5.3, is for sensitivity purposes only and will not be evaluated against all of the potential measures for the Inland Barrier area.

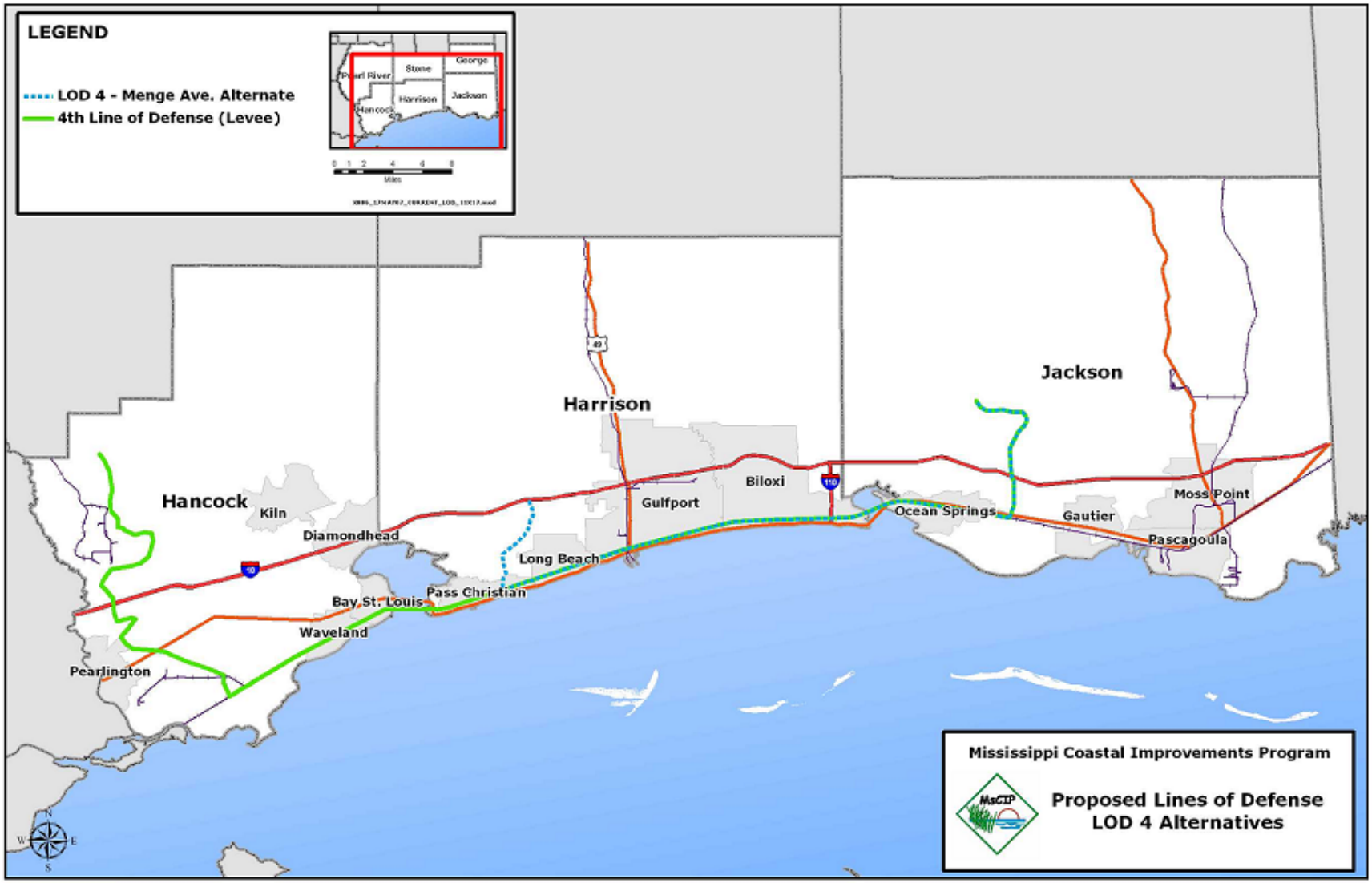


Figure 6.16-3. Footprints for the Inland Barrier Levees Alignments

Future scenario two is the full redevelopment of structures within the study area by the year 2012 with no relative sea level rise over the 100-year period of analysis. Structures will be rebuilt to what they were pre-Hurricane Katrina; residential back to residential, commercial back to commercial, etc, with the exception of the water front areas for planning units one and two. In these planning units, the scenario will address what if commercial and casino redevelopment would occur along the water front and Back Bay areas. This future scenario, as previously noted in section 5.3, is for sensitivity purposes only and will not be evaluated against all of the potential measures for the Inland Barrier area.

Future scenario three has the same redevelopment as future scenario one with a maximum relative sea level rise of 2.0-feet NAVD88. Equivalent annual damages that could occur under this scenario are $426,040,000 (rounded to the nearest thousand). These damages are the damages expected for this scenario that are attributed to all fifty-four planning units without a project in place.

Future scenario four has the same redevelopment as future scenario two with a maximum relative sea level rise of 2.0-feet NAVD88. Equivalent annual damages that could occur under this scenario are $434,040,000 (rounded to the nearest thousand). These damages are the damages expected for this scenario that are attributed to all fifty-four planning units without a project in place.

Future scenario five has the same redevelopment as future scenario one with a maximum relative sea level rise of 3.4-feet NAVD88 over the period of analysis. Equivalent annual damages that could occur under this scenario are $475,200,000 (rounded to the nearest thousand). These damages are the damages expected for this scenario that are attributed to all fifty-four planning units without a project in place.

Future scenario six has the same redevelopment as future scenario two with a maximum relative sea level rise of 3.4-feet NAVD88 over the period of analysis. Equivalent annual damages that could occur under this scenario are $483,700,000 (rounded to the nearest thousand). These damages are the damages expected for this scenario that are attributed to all fifty-four planning units without a project in place.

6.16.6.2 Equivalent annual damages Reduced

Equivalent annual damages reduced are calculated as the difference between the damages under the future without-project scenarios and the damages incurred with the measure in place. The HEC-FDA model was run for each measure to determine the damages reduced as compared to the without-project scenario.

In order to provide the HEC-FDA model with accurate information about the economic characteristics of each measure, separate inventories were created for each measure. The inventories are the same as the without-project inventory except that footprints of inland barrier and surge barrier and the acquisitions were deleted from the inventory and flood proofed (structure to be raised in place) structures were given a specific first floor elevation. The structure inventories for each of the HEC-FDA with-measure runs are as follows:

- Measure A – Inland Barrier and Surge Barrier at Elevation 20.0-feet NAVD88

This measure includes the without-project inventory less 2,426 parcels that were deleted out of the inventory. Of those, 506 parcels were estimated to be impacted in planning unit one, 1,580 in planning unit two, and 340 in planning unit three. These parcels represent the footprint of the inland barrier and surge barrier across the three planning units and some portion of the total would have to be purchase for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted

from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure B – Inland Barrier and Surge Barrier at Elevation 30.0-feet NAVD88

This measure includes the without-project inventory less 2,746 parcels that were deleted out of the inventory. Of those, 576 parcels were estimated to be impacted in planning unit one, 1,784 in planning unit two, and 386 in planning unit three. These parcels represent the footprint of the inland barrier and surge barrier across the three planning units and some portion of the total would have to be purchase for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure C – Inland Barrier and Surge Barrier at Elevation 40.0-feet NAVD88

This measure includes the without-project inventory less 3,087 parcels that were deleted out of the inventory. Of those, 634 parcels were estimated to be impacted in planning unit one, 2,025 in planning unit two, and 428 in planning unit three. These parcels represent the footprint of the inland barrier and surge barrier across the three planning units and some portion of the total would have to be purchase for its construction. At this level of analysis, it is assumed that all of the structures identified to be touched in any way by the ring levee would be purchased; therefore all were deleted from the without-project structure inventory. Some of the parcels are wetland impacts and are discussed below in the Environmental Quality section.

- Measure D – Levee for Roadway - Elevation 20.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure E – Levee for Roadway - Elevation 30.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure F - Menge Ave. - Elevation 20.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure G - Menge Ave. - Elevation 30.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure H – Menge Ave. - Elevation 40.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure I – Levee for Roadway with Menge Ave Alt - Elevation 20.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure J - Levee for Roadway with Menge Ave Alt - Elevation 30.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure K - Non-structural One

This measure includes the acquisition of 20,308 parcels with structures and vacant land, and the flood proofing (elevate in place) of 10,524 structures to a range of elevations from 11.0-feet to 22.35-feet NAVD88 depending on the planning sub-unit. The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is

detailed in the Non-structural Appendix. This elevation was determined to be approximately the ABFE level of protection is defined as still water elevation, plus wave run-up plus and estimate for waves (depth divided by two), and is the minimum elevation that a non-structural plan could provide.

- Measure L – Non-structural Two to Elevation 20.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure M – Non-structural Three to Elevation 30.0-feet NAVD88

REQUIRES FUTHER STUDY

- Measure N – Non-structural Three to Elevation 30.0-feet NAVD88

REQUIRES FUTHER STUDY

The equivalent annual damage reduction by measure for the Inland barrier and surge barrier is shown in table 6.16-3.

Table 6.16-3.
Equivalent Annual Damage Reduction by Future Scenario

Measures	Equivalent Annual Damage Reduction Future 3 ($)	Equivalent Annual Damage Reduction Future 4 ($)	Equivalent Annual Damage Reduction Future 5 ($)	Equivalent Annual Damage Reduction Future 6 ($)
(No Action)	$0	$0	$0	$0
Measure A	$46,818,000	$38,660,000	$51,650,000	$41,400,000
Measure B	$75,548,000	$84,460,000	$81,980,000	$77,840,000
Measure C	$77,066,000	$74,230,000	$84,520,000	$79,750,000
Measure D	RFS	RFS	RFS	RFS
Measure E	RFS	RFS	RFS	RFS
Measure F	RFS	RFS	RFS	RFS
Measure G	RFS	RFS	RFS	RFS
Measure H	RFS	RFS	RFS	RFS
Measure I	RFS	RFS	RFS	RFS
Measure J	RFS	RFS	RFS	RFS
Measure K	$207,760,000	$211,820,000	$303,000,000	$231,340,000
Measure L	RFS	RFS	RFS	RFS
Measure M	RFS	RFS	RFS	RFS
Measure N	RFS	RFS	RFS	RFS

Damages are rounded to the nearest thousand
RFS – Requires Further Study.

6.16.6.3 Residual Damage

Residual damage is the equivalent annual damages that still remain even when a project is in place. Residual damage is calculated as the future without-project equivalent annual damages minus the damages reduced of the various measures. The purpose of residual damage is to calculate and communicate the portions of damages that will not be reduced by the implementation of a plan or "what damages are left on the table". Residual damage by measure is shown in table 6.16-4.

Table 6.16-4.
Residual Damage by Measure and by Future Scenario

Measures	Residual Damage Future 3 ($)	Residual Damage Future 4 ($)	Residual Damage Future 5 ($)	Residual Damage Future 6 ($)
(No Action)	$0	$0	$0	$0
Measure A	$199,082,000	$395,380,000	$423,550,000	$442,300,000
Measure B	$170,352,000	$349,580,000	$393,220,000	$405,860,000
Measure C	$168,834,000	$359,810,000	$390,680,000	$403,950,000
Measure D	RFS	RFS	RFS	RFS
Measure E	RFS	RFS	RFS	RFS
Measure F	RFS	RFS	RFS	RFS
Measure G	RFS	RFS	RFS	RFS
Measure H	RFS	RFS	RFS	RFS
Measure I	RFS	RFS	RFS	RFS
Measure J	RFS	RFS	RFS	RFS
Measure K	$38,140,000	$222,220,000	$172,200,000	$252,360,000
Measure L	RFS	RFS	RFS	RFS
Measure M	RFS	RFS	RFS	RFS
Measure N	RFS	RFS	RFS	RFS

Damages are rounded to the nearest thousand.
RFS – Requires Further Study

6.16.7 Environmental Quality (EQ)

6.16.7.1 Impacts of Inland Barrier Area Measure

The Engineering Research and Development Center Wetlands and Coastal Ecology Branch were asked to conduct an assessment of potential impacts to wetlands as a result of constructing various levees and seawalls along the Mississippi Gulf Coastal Plain. This report summarizes the results of the assessment. The analysis of impacts included two components:

1. A calculation of total acreage of all wetlands (by type and planning reach) that is directly under the levee footprints.

2. A modified Hydrogeomorphic (HGM) wetland rapid assessment of impacted Estuarine/Tidal Fringe wetlands, based on the Mississippi and Alabama Gulf Coast HGM guidebook (Shafer et al., 2007), with impacts reported as loss of functional units. Tables 6.16-5, and 6.16-6, and 6.16-7 show the impacts of the inland barrier and surge barrier at elevations 20.0, 30.0, and 40.0-feet NAVD88 respectively.

Nonstructural measures would have no construction activities other than demolition and disposal of building materials in an approved land fill occurs as a result of this measure. More detail on the impacts of the structural and nonstructural measures for the Inland Barrier area can be found in the Environmental Appendix.

Table 6.16-5.
Wetland Acres Impacted by Inland Barrier A, elevation 20.0-feet NAVD88

Reach ID	Estuarine and Marine Deepwater	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Freshwater Pond	Total
3	0	0	0	2.9	0	2.9
4	4.1	11.9	0	0	0	16.0
5	0.5	36.3	0	12.3	0	49.0
7	0	0	0	3.9	0	3.9
10	0	1.6	0.1	13.3	0	15.0
13	0	0	0	0.2	0	0.2
23	0	0	0.2	4.1	0	4.3
24	0	0	0	2.5	0	2.5
25	0	0	0.3	2.3	0.1	2.6
28	0	0.7	0	4.3	0	4.9
Total	**4.6**	**50.5**	**0.6**	**45.6**	**0.1**	**101.4**

Table 6.16-6.
Wetland Acres Impacted by Inland Barrier B, elevation 30.0-feet NAVD88

Reach ID	Estuarine and Marine Deepwater	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Freshwater Pond	Total
3	0	0	0.2	6.1	0	6.3
4	8.0	25.0	0	0	0	33.0
5	0.9	75.2	0	40.7	0	116.8
7	0	0	0	16.9	0	16.9
10	0	3.4	0.5	34.7	0	38.5
13	0	0	0	0.9	0	0.9
23	0	0	1.9	14.2	0	16.0
24	0	0	0	11.6	0	11.6
25	0	0	2.6	10.8	0.3	13.6
28	0	1.3	0	17.1	0	18.4
36	0	0	0.2	19.3	0	19.5
37	0	0	0.1	9.6	0	9.8
41	0	0	0	0.5	0	0.5
43	0	0	0	0.3	0	0.3
Total	**8.9**	**104.8**	**5.5**	**182.8**	**0.3**	**302.4**

Table 6.16-7.
Wetland Acres Impacted by Inland Barrier C, elevation 40.0-feet NAVD88

Reach ID	Estuarine and Marine Deepwater	Estuarine and Marine Wetland	Freshwater Emergent Wetland	Freshwater Forested/Shrub Wetland	Freshwater Pond	Total
3	0	0	0.1	8.1	0	8.3
4	9.2	30.8	0	0.2	0	40.3
5	1.1	91.3	0	52.0	0	144.4
7	0	0	0	23.3	0	23.3
10	0	4.1	0.7	41.5	0	46.2
13	0	0	0	1.2	0	1.2
23	0	0	2.3	18.1	0	20.4
24	0	0	0	14.8	0	14.8
25	0	0	3.6	15.5	0.3	19.5
28	0	1.5	0	21.5	0	23.0
36	0	0	3.6	44.4	0	48.0
37	0	0	3.5	31.5	0	35.0
41	0	0	0	0.8	0	0.8
43	0	0	0	0.5	0	0.5
Total	**10.4**	**127.7**	**13.9**	**273.2**	**0.3**	**425.5**

6.16.8 Summary of Costs

Table 6.16-8 summarizes the ROM costs at an FY-08 price level by measure.

Table 6.16-8.
Summary of Costs by Measure for the Inland Barrier Area

Measures	Implement Cost (FY-08) ($)	Average Annual Implementation Cost ($)	Average Annual O&M ($)	IDC ($)	Total Average Annual Costs ($)
(No Action)	$0	$0	$0	N/A	$0
Measure A	$3,559,900,000	$175,045,000	$42,660,000	N/A	$217,705,000
Measure B	$5,039,300,000	$247,789,000	$61,777,000	N/A	$309,566,000
Measure C	$6,176,800,000	$303,721,000	$76,522,000	N/A	$380,243,000
Measure D	$ 3,329,500,000	$163,716,000	$42,521,000	N/A	$206,237,000
Measure E	$ 5,076,000,000	$249,593,000	$61,843,000	N/A	$311,436,000
Measure F	$ 1,257,100,000	$61,813,000	$16,389,000	N/A	$78,202,000
Measure G	$ 1,809,000,000	$88,951,000	$23,726,000	N/A	$112,677,000
Measure H	$ 2,583,000,000	$127,009,000	$34,245,000	N/A	$161,254,000
Measure I	$ 1,295,300,000	$63,691,000	$16,662,000	N/A	$80,353,000
Measure J	$ 1,954,800,000	$96,120,000	$25,690,000	N/A	$121,810,000
Measure K	$7,395,182,000	$363,630,000	$210,000	N/A	$363,840,000
Measure L	RFS	RFS	RFS	N/A	RFS
Measure M	RFS	RFS	RFS	N/A	RFS
Measure N	RFS	RFS	RFS	N/A	RFS

6.16.9 Regional Economic Development (RED)

The purpose of this analysis is to show the economic impact of the proposed project measures on business (sale volumes), income, employment, and population of the local area. Each of the measures would affect the local areas of Jackson County, Harrison County and Hancock County, Mississippi. The expenditures for the measures are estimated to be $3,559,900,000 for the Inland Barrier A measure, $5,039,300,000 for the Inland Barrier B measure, $6,176,800,000 for the Inland Barrier C measure, $3,329,500,000 for the Inland Barrier D measure, $5,076,000,000 for the Inland Barrier E measure, $1,257,100,000 for the Inland Barrier F measure, $1,809,000,000 for the Inland Barrier G measure, $2,583,000,000 for the Inland Barrier H measure, $1,295,300,000 for the Inland Barrier I measure, $1,954,800,000 for the Inland Barrier J measure. Moreover, the total Operation and Maintenance (O&M) expenditures, which are based on the total present worth O&M costs over the period of analysis, are estimated to be $867,581,000 for the Inland Barrier A measure, $1,256,365,000 for the Inland Barrier B measure, $1,5556,235,000 for the Inland Barrier C measure, $864,754,000 for the Inland Barrier D measure, $1,257,707,000 for the Inland Barrier E measure, $333,305,000 for the Inland Barrier F measure, $482,518,000 for the Inland Barrier G measure, $696,444,000 for the Inland Barrier H measure, $338,857,000 for the Inland Barrier I measure, $522,460,000 for the Inland Barrier J measure. The following tables, 6.16-9 through 6.16-16, summarize the EIFS model inputs and outputs for the various measures.

6.17 Evaluation of Coast Wide Nonstructural Flood Damage Reduction Measures

6.17.1 General

This section describes the evaluation of nonstructural measures for the entire fifty-four planning sub-units that compose the MsCIP study area. Formulation of potential measures evaluated in this section was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC). There are a number of measures that can be classified as “nonstructural”. In some cases such as dry flood proofing by the use of ring walls, a nonstructural measure can approximate a structural solution when expanded to protect a large contiguous complex (college campus, industry, or commercial area). When judiciously applied, nonstructural measures can result in reductions in inundation damages and losses of life to structure occupants.

6.17.2 Opportunities

The following opportunities were identified for the area:

- Hurricane storm damage reduction or remediation.
- Preservation of Fish and Wildlife.

Table 6.16-9.
EIFS Model Implementation Cost Inputs for the Inland Barrier Area

	Inland Barrier A	Inland Barrier B	Inland Barrier C	Inland Barrier D	Inland Barrier E	Inland Barrier F	Inland Barrier G	Inland Barrier H
Region of Influence (ROI)	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County
Change in Local Expenditures	$3,559,900,000	$5,039,300,000	$6,176,800,000	$3,329,500,000	$5,076,000,000	$1,257,100,000	$1,809,000,000	$2,583,000,000

Table 6.16-10.
EIFS Model Implementation Cost Inputs for the Inland Barrier Area

	Inland Barrier I	Inland Barrier J	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural	40-foot Nonstructural
Region of Influence (ROI)	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County
Change in Local Expenditures	$1,295,300,000	$1,954,800,000	$7,478,172,000	RFS	RFS	RFS

Based of the given implementation cost inputs the outputs are as followed:

Table 6.16-11.
EIFS Model Implementation Cost Outputs for the Inland Barrier Area

	Inland Barrier A	Inland Barrier B	Inland Barrier C	Inland Barrier D	Inland Barrier E	Inland Barrier F	Inland Barrier G
Direct Sales Volume	$3,559,900,000	$5,039,300,000	$6,176,800,000	$3,329,500,000	$5,076,000,000	$1,257,100,000	$1,809,000,000
Induced Sales Volume	$3,931,528,000	$5,565,951,000	$6,898,170,000	$3,643,528,000	$5,611,826,000	$1,554,878,000	$2,232,026,000
Total Sales Volume	$7,491,428,000	$10,605,251,000	$13,074,970,000	$6,973,028,000	$10,687,826,000	$2,811,978,000	$4,041,026,000
Direct Income	$810,567,613	$1,145,905,330	$1,395,933,868	$761,797,617	$1,153,673,815	$263,984,202	$379,177,804
Induced Income	$888,978,600	$1,256,935,279	$1,548,098,737	$828,016,097	$1,266,645,886	$326,762,954	$468,272,881
Total Income	$1,699,546,214	$2,402,840,609	$2,944,032,605	$1,589,813,714	$2,420,319,700	$590,747,156	$847,450,685
Direct Employment	21,916	31,000	38,093	20,453	31,233	7,895	11,332
Induced Employment	24,269	34,331	42,659	22,439	34,622	9,778	14,004
Total Employment	46,184	65,330	80,752	42,892	65,855	17,673	25,336
Local Population	0	0	0	0	0	0	0

Table 6.16-12.
EIFS Model Implementation Cost Outputs for the Inland Barrier Area

	Inland Barrier H	Inland Barrier I	Inland Barrier J	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural	40-foot Nonstructural
Direct Sales Volume	$2,583,000,000	$1,295,300,000	$1,954,800,000	$7,478,172,000	RFS	RFS	RFS
Induced Sales Volume	$3,194,170,000	$1,602,628,000	$2,414,276,000	$8,149,059,000	RFS	RFS	RFS
Total Sales Volume	$5,777,170,000	$2,897,928,000	$4,369,076,000	$15,627,232,000	RFS	RFS	RFS
Direct Income	$542,328,539	$272,070,199	$410,040,067	$1,711,127,000	RFS	RFS	RFS
Induced Income	$671,166,769	$336,870,453	$506,850,715	$1,852,321,000	RFS	RFS	RFS
Total Income	$1,213,495,308	$608,940,652	$916,890,782	$3,563,448,000	RFS	RFS	RFS
Direct Employment	16,219	8,138	12,258	45,830	RFS	RFS	RFS
Induced Employment	20,083	10,082	15,161	50,063	RFS	RFS	RFS
Total Employment	36,302	18,219	27,419	95,892	RFS	RFS	RFS
Local Population	0	0	0	0	RFS	RFS	RFS

Table 6.16-13.
EIFS Model Operation and Maintenance Cost Inputs for the Inland Barrier Area

	Inland Barrier A	Inland Barrier B	Inland Barrier C	Inland Barrier D	Inland Barrier E	Inland Barrier F	Inland Barrier G	Inland Barrier H
Region of Influence (ROI)	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County
Change in Local Expenditures	$867,581,000	$1,256,365,000	$1,556,235,000	$864,754,000	$1,257,707,000	$333,305,000	$482,518,000	$696,444,000

Table 6.16-14.
EIFS Model Operation and Maintenance Cost Inputs for the Inland Barrier Area

	Inland Barrier I	Inland Barrier J	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural	40-foot Nonstructural
Region of Influence (ROI)	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County	Jackson, Harrison & Hancock County
Change in Local Expenditures	$338,857,000	$522,460,000	$4,474,000	RFS	RFS	RFS

Based of the given implementation cost inputs the outputs are as followed:

Table 6.16-15.
EIFS Model Operation and Maintenance Cost Outputs for the Inland Barrier Area

	Inland Barrier A	Inland Barrier B	Inland Barrier C	Inland Barrier D	Inland Barrier E	Inland Barrier F	Inland Barrier G
Direct Sales Volume	$867,581,000	$1,256,365,000	$1,556,235,000	$864,754,000	$1,257,707,000	$333,305,000	$482,518,000
Induced Sales Volume	$949,794,000	$1,380,545,000	$1,732,946,000	$946,260,000	$1,382,223,000	$414,466,000	$597,786,000
Total Sales Volume	$1,817,375,000	$2,636,910,000	$3,289,181,000	$1,811,014,000	$2,639,930,000	$747,770,000	$1,080,304,000
Direct Income	$198,984,000	$287,002,000	$352,854,000	$198,385,000	$287,286,000	$70,275,000	$101,450,000
Induced Income	$216,353,000	$313,205,000	$390,161,000	$215,605,000	$313,561,000	$87,422,000	$125,767,000
Total Income	$415,337,000	$600,207,000	$743,015,000	$413,990,000	$600,846,000	$157,697,000	$227,218,000
Direct Employment	5,339	7,728	9,601	5,321	7,737	2,105	3,036
Induced Employment	5,860	8,514	10,721	5,838	8,525	2,620	3,765
Total Employment	11,199	16,242	20,321	11,158	16,262	4,725	6,801
Local Population	0	0	0	0	0	0	0

Table 6.16-16.
EIFS Model Operation and Maintenance Cost Outputs for the Inland Barrier Area

	Inland Barrier H	Inland Barrier I	Inland Barrier J	ABFE Nonstructural	20-foot Nonstructural	30-foot Nonstructural	40-foot Nonstructural
Direct Sales Volume	$696,444,000	$338,857,000	$522,460,000	$4,474,000	RFS	RFS	RFS
Induced Sales Volume	$864,109,000	$421,406,000	$647,713,000	$5,206,000	RFS	RFS	RFS
Total Sales Volume	$1,560,553,000	$760,262,000	$1,170,173,000	$9,680,000	RFS	RFS	RFS
Direct Income	$146,594,000	$71,450,000	$109,905,000	$960,000	RFS	RFS	RFS
Induced Income	$181,986,000	$88,891,000	$136,336,000	$1,113,000	RFS	RFS	RFS
Total Income	$328,581,000	$160,341,000	$246,241,000	$2,073,000	RFS	RFS	RFS
Direct Employment	4,388	2,140	3,289	27	RFS	RFS	RFS
Induced Employment	5,450	2,664	4,082	32	RFS	RFS	RFS
Total Employment	9,839	4,804	7,371	59	RFS	RFS	RFS
Local Population	0	0	0	0	RFS	RFS	RFS

6.17.3 Assumptions

The following assumptions were used in this analysis.

- The FY 2008 discount rate of 4-7/8 percent was used in estimating average annual benefits and costs.
- Price levels are FY-08, unless otherwise stated.
- A 100-year period of analysis (2012 to 2111) was used to calculate average annual benefits and costs.

6.17.4 Types of Nonstructural Measures

The nonstructural measures described below can be grouped into several general categories including:

- Flood Preparedness
- Floodplain Management, Floodplain Zoning and Flood Insurance
- Building codes
- Land Use Regulation and Zoning
- Development Impact Fees, TDR, TPR, and Redirection
- Land Taxation policies and development
- Flood proofing (elevation of structure in place, wet/dry proof, etc.)
- Permanent evacuations (acquisitions)
- Relocations of public buildings

Corps of Engineers documents and regulations as well as the technical papers and bulletins of other Federal and state agencies that address flooding from storms and hurricanes contain lists of possible nonstructural measures. Generally speaking, each of these identified measures can be applied either singly or in combination with other nonstructural or structural measures to attain project goals and planning objectives. In an effort to simplify the formulation of nonstructural plans, the NSFPC went through an initial screening process to determine which plans were feasible for detailed evaluation. The screening process used by the NSFPC for each of these types of measures can be found in the Nonstructural Appendix.

6.17.5 Historic Conditions

The Mississippi Gulf Coast is no stranger to large storm surge events. On August 17, 1969, Hurricane Camille impacted the area in a similar fashion to Hurricane Katrina. Hurricane Camille made landfall at Bay St. Louis, Mississippi only a few miles way from Hurricane Katrina's landfall path. The total surge area ranged from lower Plaquemines Parish in Louisiana to Perdido Pass, Alabama. Maximum surge from Hurricane Camille on the Mississippi coast ranged from 21.7-feet above m.s.l. in planning unit one, to 24.2-feet above m.s.l. in planning unit two, and 15.8-feet above m.s.l. in planning unit 3.

Damage to the Mississippi Coast from Hurricane Camille was extensive. Federal relief expenditures topped 100 million dollars at 1970 prices, over 600 million dollars at today's prices after accounting

for inflation. The magnitude of this number is astounding considering that many of the relief programs that exist today did not exist for Hurricane Camille. Chapter IV of this appendix describes in detail damage statics caused by Hurricane Camille surge inundation.

6.17.6 Existing Conditions

On August 29, 2005, Hurricane Katrina made land fall in Hancock County, Mississippi just east of the Pearl River. By virtually all accounts, it was the single largest disaster in U.S. history. Storm surge from Hurricane Katrina was the largest that has ever hit the continental United States. The surge inundated approximately 484 square miles of southern Mississippi. The relief expenditures in Mississippi alone have totaled in the billions of dollars. Figure 6.17-1 shows the inundation footprint of Hurricane Katrina.



Figure 6.17-1. Hurricane Katrina Path and Extent of Hurricane Katrina Surge in Planning Units One, Two, and Three

The three planning units suffered tremendous devastation from Hurricane Katrina's surge. The PDT estimates that 32,446 structures were significantly destroyed (at least fifty-percent or more), with another 15,000 to 25,000 suffering moderate to minimal inundation damage. Of the structures sustaining significant destruction, 9,555 were in planning unit one, 16,528, in planning unit two, and 6,363 in planning unit three. Of those significant loss structures, approximately 19,000 claims were paid out by the Federal Emergency Management Agency's (FEMA's) National Flood Insurance Program (NFIP) totally over $2.3 Billion dollars, with the average claim around $137,000. Currently, no accurate data exists for uninsured losses, but estimates range in the billions of dollars. Table 6.17-1 displays the significantly damaged structures by planning unit and by structure category. Chapter IV of this appendix describes in greater detail the coast wide damage caused by Hurricane Katrina surge inundation.

Table 6.17-1.
Structures Damaged 50% or More by Planning Unit and by Category

	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Commercial	1,267	1,794	378	**3,439**
Residential	8,099	14,500	5,780	**28,379**
Municipal	127	89	136	**352**
Mobile Home	62	145	69	**276**
Total	**9,555**	**16,528**	**6,363**	**32,446**

Source: Field inventory conducted by the Corps PDT.

6.17.7 Without-Project Conditions

This section summarizes the coast wide future without-project conditions used as the basis for the evaluation of nonstructural measures. Future without-project conditions are defined as the characteristics of the area over the period of analysis should no federal project be implemented. The coast wide future without-project conditions are described in greater detail in Chapter IV of this appendix.

Given the vast devastation caused by hurricane Katrina, the projection of the future without-project conditions contains significant uncertainty. In an attempt to reduce this uncertainty, scenario testing was implemented. Scenario testing is where multiple future scenarios are created in order to evaluate what would happen if observed variables or assumptions do not happen as projected, and attempts to answer the 'what if' questions that arise when making forecasting assumptions and predictions. Table 6.17-2 summarizes the six future-without project scenarios created for the MsCIP Comprehensive Plan. As described in chapter IV, Future without-project scenarios one and two are for testing the sensitivity of effects of the increment between a no relative sea level rise scenario and the expected relative sea level rise scenario. Therefore, only future without-project scenarios three, four, five, and six were used to evaluate the nonstructural measures.

Table 6.17-2.
Overview of Future Scenarios

Future Scenario	Redevelopment Type	Relative Sea Level Rise	Description
Future Scenario 1	Residential	None	Rebuild structures as existed pre-Hurricane Katrina with no relative sea level rise over the period of analysis. This future scenario applies to all three planning units.
Future Scenario 2	Mixed Residential & Commercial	None	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, no relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.
Future Scenario 3	Residential	Expected (up to 2.4-feet depending on location)	Rebuild structures as existed pre-Hurricane Katrina with up to 2.4-feet relative sea level rise over the period of analysis. This future scenario applies to all three planning units.
Future Scenario 4	Mixed Residential & Commercial	Expected (up to 2.4-feet depending on location)	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, a up to 2.4-feet relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.
Future Scenario 5	Residential	High Rate (up to 3.4-feet depending on location)	Rebuild structures as existed pre-Hurricane Katrina with up to 3.4-feet of relative sea level rise over the period of analysis. This future scenario applies to all three planning units.
Future Scenario 6	Mixed Residential & Commercial	High Rate (Up to 3.4-feet depending on location)	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, up to 3.4-feet of relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.

Future Scenarios One and Two are included only to evaluate the effects of relative sea level rise. These Future scenarios will not be used in the evaluation of potential measures. Futures Three, Four, Five, and Six will be the future scenarios by which potential measures will be evaluated depending on the planning unit.

Tables 6.17-3, 6.17-4, and 6.17-5 summarize the structure inventory for future without-project scenarios three and five.

Table 6.17-3.
Futures Without-Project Scenarios Three and Five Inventory Parcels by Planning Unit and by Structure Category

Structure Categories	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Residential	17,907	49,121	49,688	**116,716**
Mobile Homes	498	2,497	3,553	**6,548**
Commercial	3,255	5,618	4,266	**13,139**
Municipal	653	351	763	**1,767**
Vacant Land	22,843	29,984	29,779	**82,606**
Total	**45,156**	**87,571**	**88,049**	**220,776**

Table 6.17-4.
Futures Without Project Scenarios Three and Five Inventory Cumulative Structures for All Three Planning Units by Structure Category and One-foot Elevation

Estimated First Floor Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
1-foot	19	1	2	1	**23**
2-foot	115	1	16	4	**136**
3-foot	411	2	42	18	**473**
4-foot	1,015	2	88	34	**1,139**
5-foot	2,566	20	143	52	**2,781**
6-foot	3,117	77	196	68	**3,458**
7-foot	3,975	129	270	87	**4,461**
8-foot	5,111	183	350	108	**5,752**
9-foot	6,475	226	463	130	**7,294**
10-foot	8,012	270	576	163	**9,021**
11-foot	10,381	321	730	194	**11,626**
12-foot	14,068	396	1,064	256	**15,784**
13-foot	18,411	507	1,537	352	**20,807**
14-foot	22,416	617	2,128	465	**25,626**
15-foot	31,139	779	3,424	629	**35,971**
16-foot	34,210	878	3,829	692	**39,609**
17-foot	37,925	1,006	4,125	774	**43,830**
18-foot	42,793	1,144	4,771	865	**49,573**
19-foot	47,914	1,368	5,650	942	**55,874**
20-foot	56,895	1,606	7,244	1,089	**66,834**
21-foot	60,673	1,784	7,809	1,154	**71,420**
22-foot	64,417	1,960	8,158	1,221	**75,756**
23-foot	71,143	2,174	8,893	1,293	**83,503**
24-foot	75,711	2,331	9,295	1,345	**88,682**
25-foot	79,957	2,473	9,633	1,392	**93,455**
26-foot	83,944	2,648	9,901	1,428	**97,921**
27-foot	86,948	2,788	10,144	1,463	**101,343**
28-foot	89,743	2,887	10,405	1,487	**104,522**
29-foot	92,130	2,986	10,634	1,502	**107,252**

Table 6.17-4.
Futures Without Project Scenarios Three and Five Inventory Cumulative Structures for All Three Planning Units by Structure Category and One-foot Elevation (continued)

Estimated First Floor Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
30-foot	94,042	3,057	10,873	1,521	**109,493**
31-foot	95,586	3,158	11,114	1,535	**111,393**
32-foot	96,621	3,242	11,324	1,545	**112,732**
33-foot	97,531	3,300	11,450	1,555	**113,836**
34-foot	98,165	3,364	11,559	1,572	**114,660**
35-foot	98,669	3,429	11,623	1,584	**115,305**
36-foot	99,075	3,481	11,651	1,590	**115,797**
37-foot	99,498	3,532	11,682	1,598	**116,310**
38-foot	99,952	3,589	11,711	1,600	**116,852**
39-foot	100,478	3,644	11,747	1,605	**117,474**
40-foot	116,716	6,548	13,139	1,767	**138,170**

Table 6.17-5.
Futures Without-Project Scenarios Three and Five Inventory Structure and Content Values by Category and Planning Unit

	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Structure Values				
Residential	$2,415,885,807	$4,449,184,443	$3,200,940,955	**$10,066,011,205**
Mobile Homes	$8,518,174	$48,312,941	$52,053,731	**$108,884,846**
Commercial	$611,355,705	$4,526,104,161	$2,048,940,654	**$7,186,400,520**
Municipal	$335,220,287	$261,009,884	$303,986,556	**$900,216,727**
Structure Value Subtotal	**$3,370,979,973**	**$9,284,611,429**	**$5,605,921,896**	**$18,261,513,298**
Content Values				
Residential	$2,415,885,807	$4,449,184,443	$3,200,940,955	**$10,066,011,205**
Mobile Homes	$12,606,898	71503152.68	77039521.88	**$161,149,573**
Commercial	$1,213,472.28	$2,388,618,644	$428,362,111	**$2,818,194,227**
Municipal	$135,597,922	$102,609,763	$102,022,049	**$340,229,734**
Content Value Subtotal	**$2,565,304,099**	**$7,011,916,003**	**$3,808,364,637**	**$13,385,584,739**
Total	**$5,936,284,072**	**$16,296,527,432**	**$9,414,286,533**	**$31,647,098,037**

Tables 6.17-6, 6.17-7, and 6.17-8 summarize the structure inventory for future without-project scenarios four and six.

Table 6.17-6.
Futures Without-Project Scenarios Four and Six
Inventory Parcels by Planning Unit and by Structure Category

Structure Categories	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Residential	17,757	2,497	49,688	**69,942**
Mobile Homes	498	48,636	3,553	**52,687**
Commercial	3,408	6,101	4,266	**13,775**
Municipal	651	381	763	**1,795**
Vacant Land	22,842	29,956	29,779	**82,577**
Total	**45,156**	**87,571**	**88,049**	**220,776**

Table 6.17-7.
Futures Without-Project Scenarios Four and Six Inventory Cumulative Structures
for All Three Planning Units by Structure Category and One-foot Elevation

Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
1-foot	19	1	3	1	**24**
2-foot	111	1	17	4	**133**
3-foot	403	2	43	18	**466**
4-foot	1,003	2	89	34	**1,128**
5-foot	2,543	20	144	52	**2,759**
6-foot	3,080	77	197	68	**3,422**
7-foot	3,932	129	271	87	**4,419**
8-foot	5,055	183	351	108	**5,697**
9-foot	6,408	226	464	130	**7,228**
10-foot	7,934	270	577	163	**8,944**
11-foot	10,291	321	730	194	**11,536**
12-foot	13,954	396	1,069	256	**15,675**
13-foot	18,266	507	1,546	352	**20,671**
14-foot	22,220	617	2,147	465	**25,449**
15-foot	30,880	779	3,468	630	**35,757**
16-foot	33,923	878	3,930	692	**39,423**
17-foot	37,611	1,006	4,272	775	**43,664**
18-foot	42,439	1,144	4,949	866	**49,398**
19-foot	47,513	1,368	5,840	943	**55,664**
20-foot	56,412	1,606	7,398	1,089	**66,505**
21-foot	60,178	1,784	7,975	1,153	**71,090**
22-foot	63,910	1,960	8,365	1,220	**75,455**
23-foot	70,535	2,174	9,137	1,292	**83,138**
24-foot	75,091	2,331	9,590	1,344	**88,356**
25-foot	79,328	2,473	9,986	1,391	**93,178**
26-foot	83,308	2,648	10,301	1,427	**97,684**

Table 6.17-7.
Futures Without-Project Scenarios Four and Six Inventory Cumulative Structures for All Three Planning Units by Structure Category and One-foot Elevation (continued)

Elevation (NAVD88)	Residential	Mobile Homes	Commercial	Municipal	Total
27-foot	86,314	2,788	10,584	1,462	**101,148**
28-foot	89,112	2,887	10,878	1,486	**104,363**
29-foot	91,498	2,986	11,147	1,501	**107,132**
30-foot	93,409	3,057	11,406	1,520	**109,392**
31-foot	94,952	3,158	11,677	1,534	**111,321**
32-foot	95,986	3,242	11,902	1,544	**112,674**
33-foot	96,897	3,300	12,053	1,554	**113,804**
34-foot	97,531	3,364	12,178	1,571	**114,644**
35-foot	98,035	3,429	12,247	1,583	**115,294**
36-foot	98,441	3,481	12,278	1,589	**115,789**
37-foot	98,864	3,532	12,315	1,597	**116,308**
38-foot	99,318	3,589	12,345	1,599	**116,851**
39-foot	99,844	3,644	12,381	1,604	**117,473**
40-foot	116,081	6,548	13,775	1,795	**138,199**

Table 6.17-8.
Future Without-Project Scenarios Four and Six Inventory Structure and Content Values by Category and Planning Unit

	Planning Unit One	Planning Unit Two	Planning Unit Three	Total
Structure Values				
Residential	$2,390,977,748	$4,402,477,082	$3,200,940,955	**$9,994,395,785**
Mobile Homes	$8,518,168	$48,312,740	$52,053,731	**$108,884,639**
Commercial	$1,500,399,292	$4,233,140,761	$2,048,940,654	**$7,782,480,707**
Municipal	$334,734,608	$261,025,195	$303,986,556	**$899,746,359**
Structure Value Subtotal	**$4,234,629,816**	**$8,944,955,778**	**$5,605,921,896**	**$18,785,507,490**
Content Values				
Residential	$2,390,977,748	$4,402,477,082	$3,200,940,955	**$9,994,395,785**
Mobile Homes	$12,606,888.64	$71,502,855.20	$77,039,521.88	**$161,149,266**
Commercial	$1,473,899,310	$2,498,045,931	$428,362,111	**$4,400,307,352**
Municipal	$135,240,760	$102,280,080	$102,022,049	**$339,542,889**
Content Value Subtotal	$4,012,724,707	$7,074,305,948	$3,808,364,637	**$14,895,395,292**
Total	**$8,247,354,523**	**$16,019,261,726**	**$9,414,286,533**	**$33,680,902,782**

Equivalent annual damages for future without-project scenarios three, four, five, and six were estimated using the HEC-FDA program and based on the structure inventories described in the previous tables. Table 6.17-9 summarizes the equivalent annual damages for those scenarios. More detail can be found in chapter IV.

Table 6.17-9.
Equivalent Annual Without-Project Damages by Planning Unit and Future Scenario

Without-Project Damages	Future 3 Damages	Future 4 Damages	Future 5 Damages	Future 6 Damages
Planning Unit One	$218,050,000	$222,220,000	$237,310,000	$241,520,000
Planning Unit Two	$103,280,000	$107,120,000	$115,470,000	$119,760,000
Planning Unit Three	$104,700,000	$104,700,000	$122,420,000	$122,420,000
Total	**$426,040,000**	**$434,040,000**	**$475,200,000**	**$483,700,000**

1/ Damages are rounded to the nearest thousand.
2/ Futures Two, Four, and Six do not apply to planning unit three, therefore total damages are the same as future scenarios one, three, and five.

6.17.8 Equivalent Annual Damages Reduced and Residual Damages

Equivalent annual damages reduced are calculated as the difference between the damages under the future without-project scenarios three and five and the damages incurred with the measure in place. The HEC-FDA model was run for each measure to determine the damages reduced as compared to the without-project scenario.

In order to provide the HEC-FDA model with accurate information about the economic characteristics of each measure, separate inventories were created for each of the nonstructural measures. The inventories are the same as the without project inventory except that footprints of the acquisitions were deleted from the inventory and floodproofed structures (structures to be elevated in place) were given a higher elevation. The structure inventories for each of the HEC-FDA measure runs are as follows:

- NS-Measure A Acquisition and Floodproofing to Advisory Base Flood Elevation (ABFE) Level

This measure includes the acquisition of 33,198 structures and vacant parcels and the flood proofing (raise structure in place) of 25,419 structures to the ABFE elevation that is applicable for the planning sub-unit. This elevation was determined to be approximately the ABFE level of protection and is defined as still water elevation, plus wave run-up, plus an estimate for waves (depth divided by two), and is the minimum implementation elevation that a nonstructural measure do to the requirements of the National Flood Insurance Program (NFIP).The formulation process for this measure was conducted by the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and is detailed in the nonstructural appendix. Figure 6.17-2 shows the areas included in this plan. Figures 6.17-3, 6.17-4, and 6.17-5 show the same areas by planning unit.

- NS Measure B: Acquisition and Floodproofing to elevation 20.0-feet NAVD88

Requires Further Study

- NS Measure C: Acquisition and Floodproofing to elevation 30.0-feet NAVD88

Requires Further Study

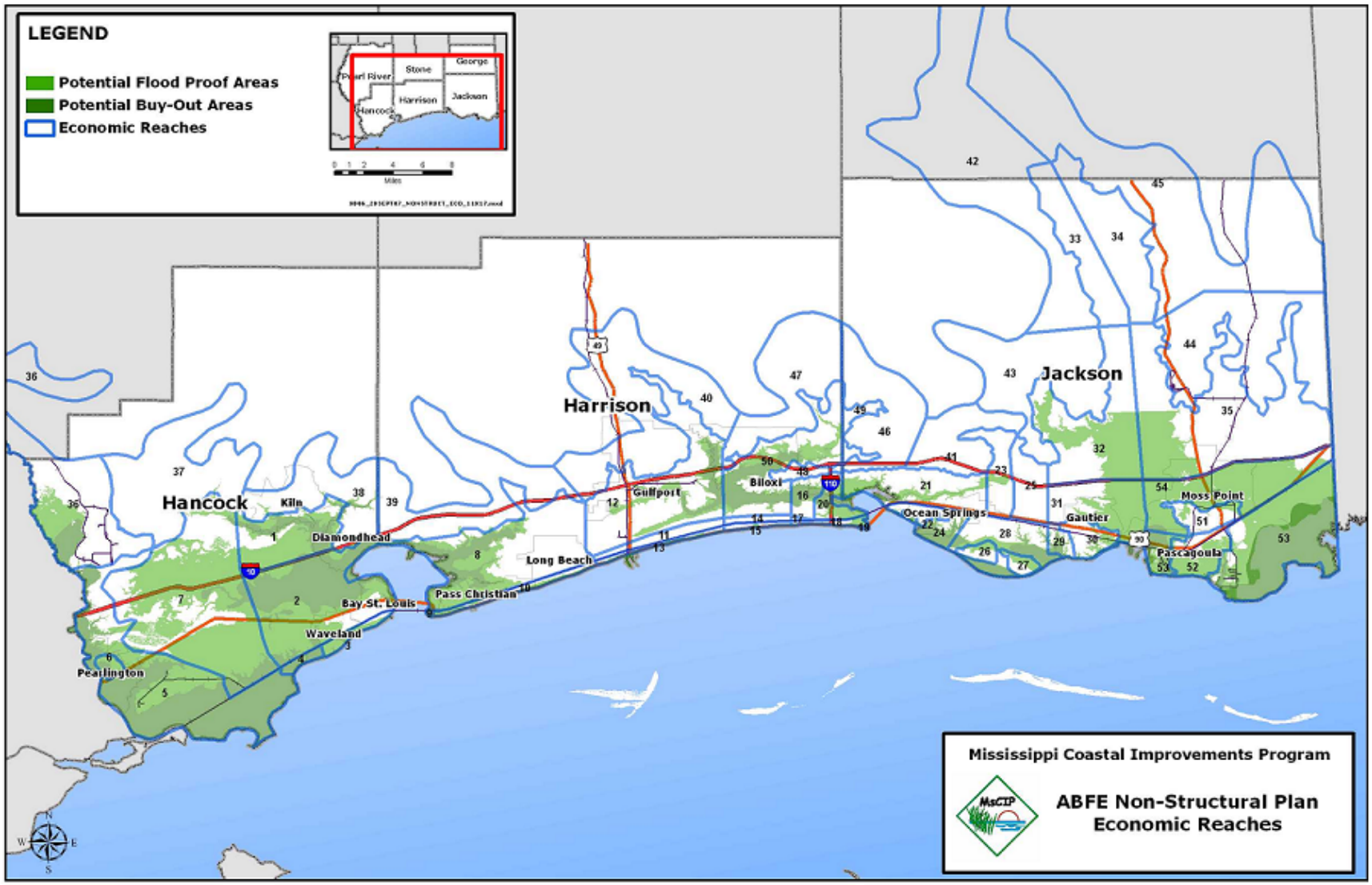


Figure 6.17-2. Nonstructural ABFE measure footprint

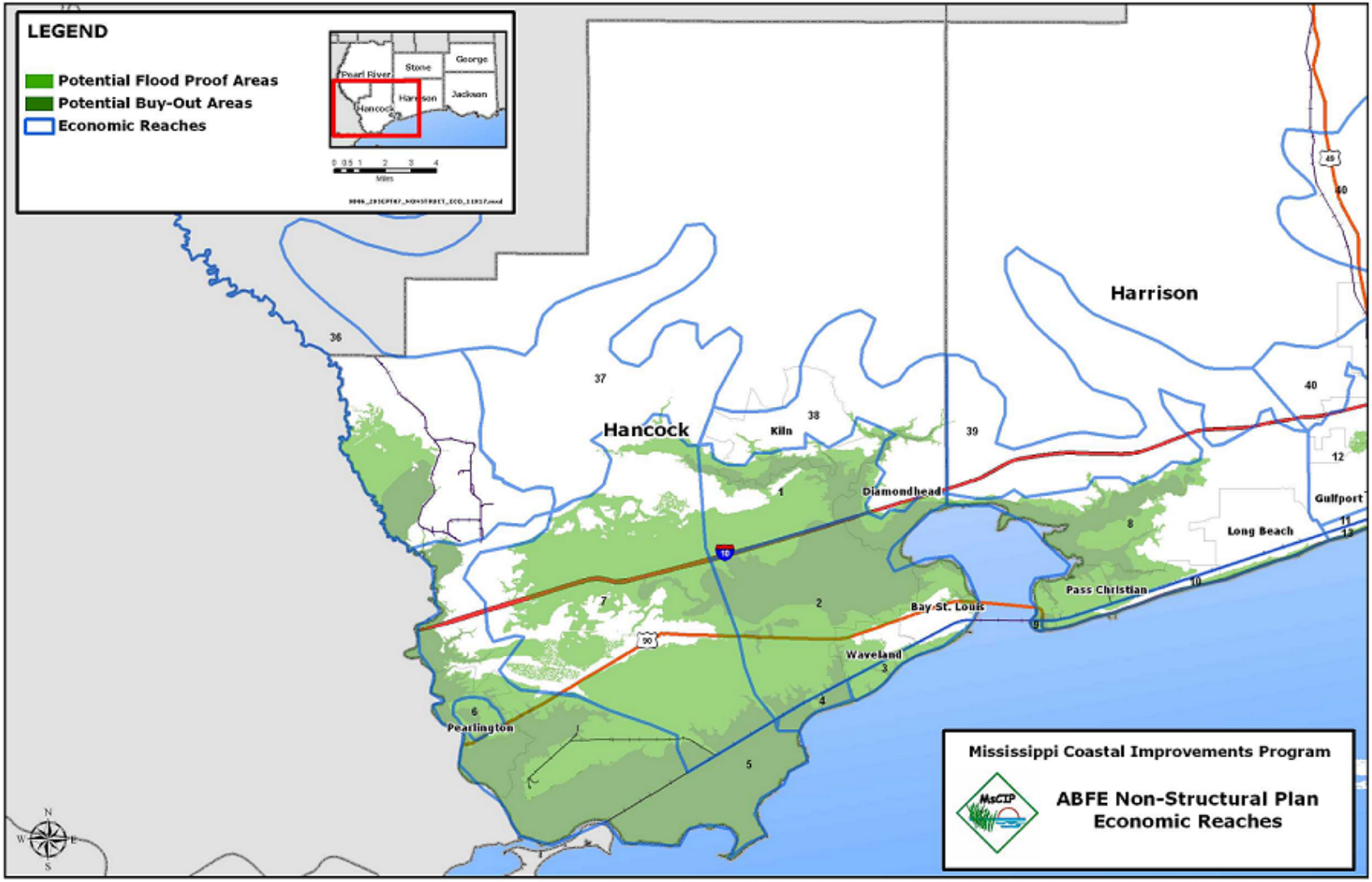


Figure 6.17-3. Nonstructural ABFE measure for planning unit one – Hancock County

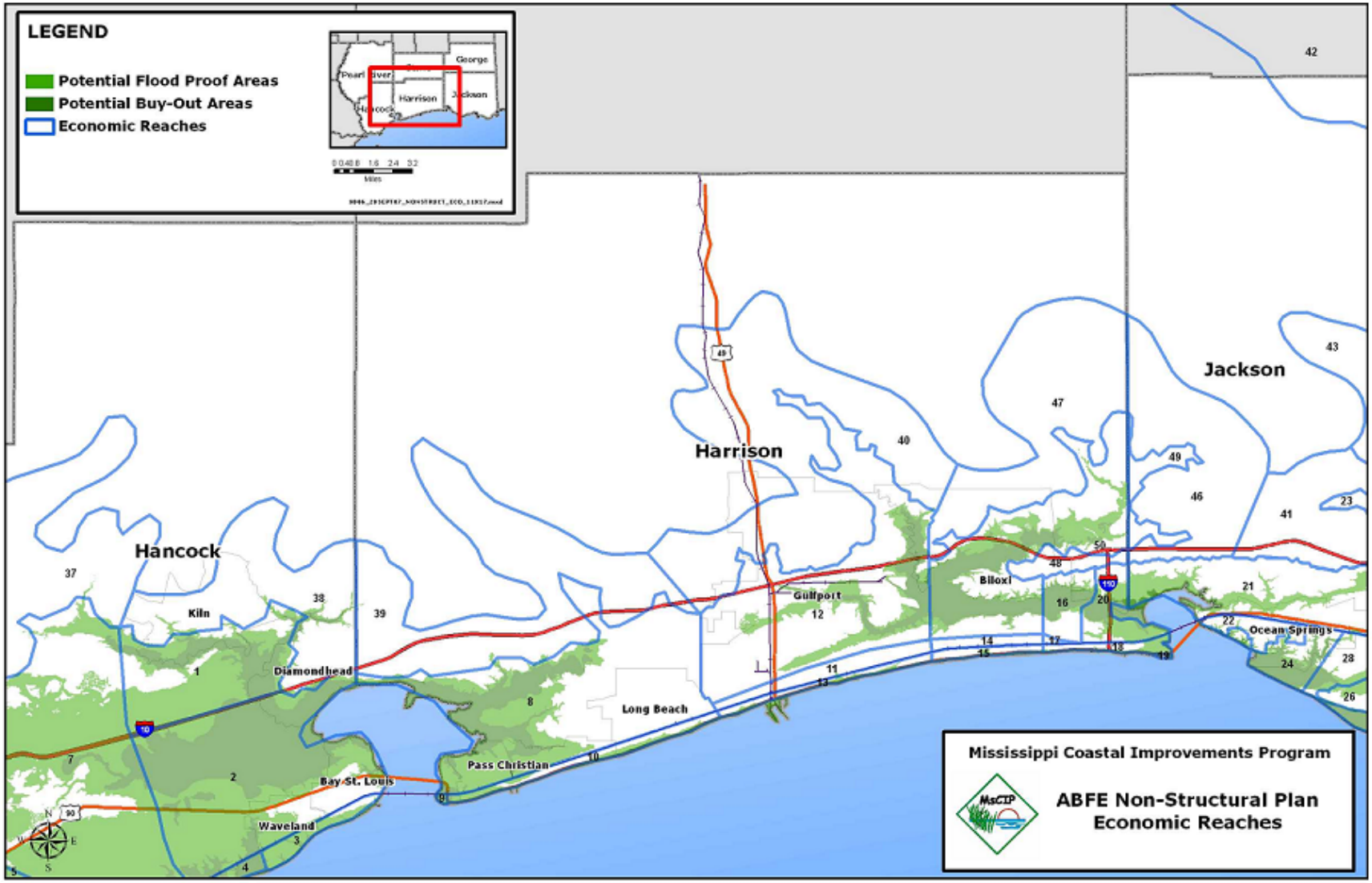


Figure 6.17-4. Nonstructural ABFE measure for Planning Unit Two – Harrison County

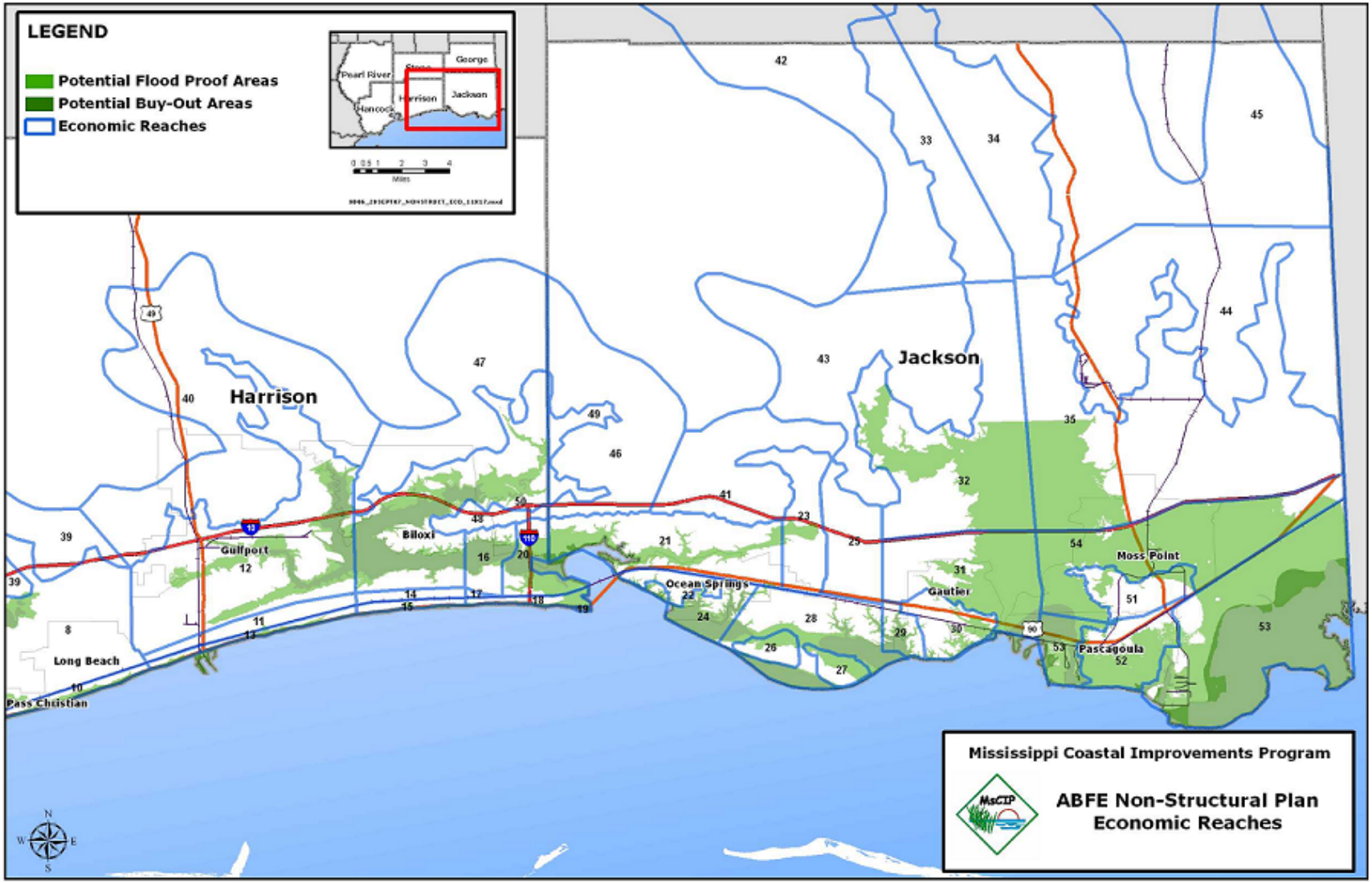


Figure 6.17-5. Nonstructural ABFE Measure for Planning Unit Three – Jackson County

- NS Measure D: Acquisition and Floodproofing to elevation 40.0-feet NAVD88

Requires Further Study

Residual damage is the equivalent annual damages that still remain even when a project is in place. Residual damage is calculated as the future without-project equivalent annual damages minus the damages reduced of the various measures. The purpose of residual damage is to calculate and communicate the portions of damages that will not be reduced by the implementation of a plan or "what damages are left on the table."

6.17.9. Summary of Damages

Table 6.17-10 summarizes the without-project damages, damages reduced, and residual damages by measure for scenarios three and five.

Table 6.17-10.
Summary of Damages by Potential Measure for Future Scenarios Three and Five

Measures	Equivalent Annual Damages Future 3 ($)	Equivalent Annual Damage Reduction Future 3 ($)	Residual Damage Future 3 ($)	Equivalent Annual Damages Future 5 ($)	Equivalent Annual Damage Reduction Future 5 ($)	Residual Damage Future 5 ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A ABFE Nonstructural	$426,040,000	$280,705,000	$145,335,000	$475,200,000	$307,305,000	$167,895,000
Measure B 20FT Nonstructural	RFS	RFS	RFS	RFS	RFS	RFS
Measure C 30FT Nonstructural	RFS	RFS	RFS	RFS	RFS	RFS
Measure D 40FT Nonstructural	RFS	RFS	RFS	RFS	RFS	RFS

Damages are rounded to the nearest thousand dollars.
RFS – Requires Further Study

Table 6.17-11 summarizes the without-project damages, damages reduced, and residual damages by measure for scenarios four and six.

Table 6.17-11.
Summary of Damages by Potential Measure for Future Scenarios Four and Six

Measures	Equivalent Annual Damages Future 4 ($)	Equivalent Annual Damage Reduction Future 4 ($)	Residual Damage Future 4 ($)	Equivalent Annual Damages Future 6 ($)	Equivalent Annual Damage Reduction Future 6 ($)	Residual Damage Future 6 ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A ABFE Nonstructural	$434,040,000	$286,706,000	$147,334,000	$483,700,000	$311,333,000	$172,367,000
Measure B 20FT Nonstructural	RFS	RFS	RFS	RFS	RFS	RFS
Measure C 30FT Nonstructural	RFS	RFS	RFS	RFS	RFS	RFS
Measure D 40FT Nonstructural	RFS	RFS	RFS	RFS	RFS	RFS

Damages are rounded to the nearest thousand dollars.
RFS – Requires Further Study

6.17.10 Summary of Costs

Table 6.17-12 summarizes the costs by measure.

Table 6.17-12.
Summary of Costs by Nonstructural Measure

Measures	Total Cost to Implement (First Cost) ($)	Average Annual Implementation Cost ($)	Average Annual O&M ($)	IDC[1] ($)	Total Average Annual Costs ($)
(No Action)	$0	$0	$0	$0	$0
Measure A ABFE Nonstructural	$16,782,494	$825,216,000	$400,000	N/A	$825,616,000
Measure B 20FT Nonstructural	RFS[2]	RFS	RFS	N/A	RFS
Measure C 30FT Nonstructural	RFS	RFS	RFS	N/A	RFS
Measure D 40FT Nonstructural	RFS	RFS	RFS	N/A	RFS

1/ Due to the massive scale and extended time frame of implementation of the coast wide nonstructural plans, IDC is not able to be calculated at this time. 2/ RFS – Requires Further Study.

6.17.11 Alternative Land Use

Each of the nonstructural measures contains some portion of the plan that consists of the acquisition of structures and parcels. Should any of the plans be implemented, the land contained in the footprint could never be used again for habitable use. However, there are alternative uses of land for these areas such as recreational areas, ecotourism areas, or environmental restoration. Each of these alternative uses of the acquisition area land would have associated benefits and costs. Further study would be required to determine the most cost effective use of the acquisition lands.

6.17.12 Other Social and Economic Benefits

In addition to the direct structure damage reduction benefits and the alternative use of land, acquisition of structures would have other social and economic benefits. These benefits include the reduction of risk to health and human safety, reduction of evacuation and subsistence costs (travel and stay to evacuate, non-profit assistance such as food, etc.), reduction of emergency costs following storm events (debris removal, temporary housing, etc.), reduction of residential reoccupation costs, reduction of commercial clean-up costs, and future infrastructure savings to the tax base for roads and utilities. For example, the bullets below are from the Louisiana Coastal Master Plan[4] estimates for damages in these categories. These numbers are based on Louisiana data and do not apply for Coastal Mississippi, but provide a sense of the potential costs savings that could be reduced.

- Combined federal, state, parish and municipality spending average of $1,450 for inundated residential structures and $3,850 for inundated non-residential structures,
- Evacuation and subsistence costs of up to $21,284 per household at risk,
- Reoccupation costs of up to $7,133 per inundated residential structure,
- Commercial clean-up and restoration costs of up to $16, 245 per inundated commercial structure.

Although these benefits can be shown on a per structure basis, significant economies of scale can be achieved with the acquisition of clusters of structures including streets, neighborhoods, and communities. Due to timing constraints of the study, quantifiable dollar amounts for these benefit categories could not be identified, but would be estimated as part of implementation or further study. Careful coordination between the Corps and local stakeholders would be required prior to implementation in order to optimize the economic efficiencies that could be gained from acquisition of parcels.

6.17.13 Summary of Regional Economic Development Benefits

The purpose of this section is to show the economic impact of the proposed measure on business (sale volumes), income, employment, and population of the local area. Each of the measures would affect the local area of the three coastal counties of Mississippi. The first cost expenditures for the ABFE nonstructural measure are estimated to be $15,394,143,000, with an additional $8,134,000 for the total present worth of the operation and maintenance (O&M) expenditures assuming a 100-year period of analysis and an FY 08 discount rate of 4.875-percent. The 20FT elevation, 30FT elevation, and 40FT elevation coast wide nonstructural plans require further study to determine regional impacts. The following tables, 6.17-13 through 6.17-16, summarize the EIFS model inputs and outputs for the coast wide nonstructural plan.

[4] Louisiana Coastal Master Plan Appendix F: Economic Analysis.

Table 6.17-13.
EIFS Model Construction Costs Inputs for the Nonstructural Measures

	ABFE Nonstructural	20-Foot Nonstructural	30-Foot Nonstructural	40-Foot Nonstructural
Region of Influence (ROI)	Hancock, Harrison, and Jackson Counties	Hancock, Harrison, and Jackson Counties	Hancock, Harrison, and Jackson Counties	Hancock, Harrison, and Jackson Counties
Change in Local Expenditures	$16,782,494,000	RFS	RFS	RFS

RFS – Requires Further Study

Based of the given inputs the outputs are as followed:

Table 6.17-14.
EIFS Model Construction Costs Outputs for the Nonstructural Measures

	ABFE Nonstructural	20-Foot Nonstructural	30-Foot Nonstructural	40-Foot Nonstructural
Direct Sales Volume	$16,782,494,204	RFS	RFS	RFS
Induced Sales Volume	$18,593,365,860	RFS	RFS	RFS
Total Sales Volume	$35,375,860,065	RFS	RFS	RFS
Direct Income	$3,668,506,993	RFS	RFS	RFS
Induced Income	$4,041,514,947	RFS	RFS	RFS
Total Income	$7,710,021,941	RFS	RFS	RFS
Direct Employment	100,952	RFS	RFS	RFS
Induced Employment	112,040	RFS	RFS	RFS
Total Employment	212,992	RFS	RFS	RFS
Local Population	0	RFS	RFS	RFS

RFS – Requires Further Study

Table 6.17-15.
EIFS Model O&M Costs Inputs for the Nonstructural Measures

	ABFE Nonstructural	20-Foot Nonstructural	30-Foot Nonstructural	40-Foot Nonstructural
Region of Influence (ROI)	Hancock, Harrison, and Jackson Counties	Hancock, Harrison, and Jackson Counties	Hancock, Harrison, and Jackson Counties	Hancock, Harrison, and Jackson Counties
Change in Local Expenditures	$8,134,000	RFS	RFS	RFS

RFS – Requires Further Study

Based of the given inputs the outputs are as followed:

Table 6.17-16.
EIFS Model O&M Costs Outputs for the Nonstructural Measures

	ABFE Nonstructural	20-Foot Nonstructural	30-Foot Nonstructural	40-Foot Nonstructural
Direct Sales Volume	$8,134,000	RFS	RFS	RFS
Induced Sales Volume	$9,261,000	RFS	RFS	RFS
Total Sales Volume	$17,395,000	RFS	RFS	RFS
Direct Income	$1,718,000	RFS	RFS	RFS
Induced Income	$1,950,000	RFS	RFS	RFS
Total Income	$3,668,000	RFS	RFS	RFS
Direct Employment	49	RFS	RFS	RFS
Induced Employment	56	RFS	RFS	RFS
Total Employment	105	RFS	RFS	RFS
Local Population	0	RFS	RFS	RFS

RFS – Requires Further Study

6.18 Forrest Heights Levee, City of Gulfport, Harrison County

6.18.1 General

The culturally historical Forest Heights residential community in the City of Gulfport, Harrison County, Mississippi, has frequently been inundated by flood waters due to storm surges from the Mississippi Sound and from inland flooding along the lower Turkey Creek. Water reached a depth of 2-8 ft over the entire community during Hurricane Katrina inundation. The Forest Heights levee is proposed to be constructed as a pilot project for the MsCIP comprehensive plan. The levee will address the combination of storm surge protection, inland flooding protection, and evacuation. The levee is intended to be constructed to a height such that the levee might be certified under the National Flood Insurance Program. A preliminary engineering analysis suggests a levee built to approximately elevation 21 feet NAVD ’88 would satisfy or exceed certification elevation criteria.

Engineering performance and economic evaluations of protection options were done using the Hydrologic Engineering Center’s (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA. HEC-FDA modeling was done using variations in with-project conditions compared to the future without-project conditions for the Turkey Creek study. Details regarding the methodology are presented in the Economic Appendix. Additional evaluation to determine the precise levee height will be performed during final engineering and design based upon analyzing the risk and uncertainty associated with the coincident occurrence of inland flooding and storm surge impacts.

6.18.2 Location

The Forrest Heights community is located in an area known as North Gulfport within the City of Gulfport on the Mississippi Gulf Coast. The location of the levee at Forrest Heights is shown below in Figures 6.18-1. The community lies along the lower Turkey Creek floodplain, which has a tendency to frequently exceed its stream channel capacity and flood adjacent low-lying areas.

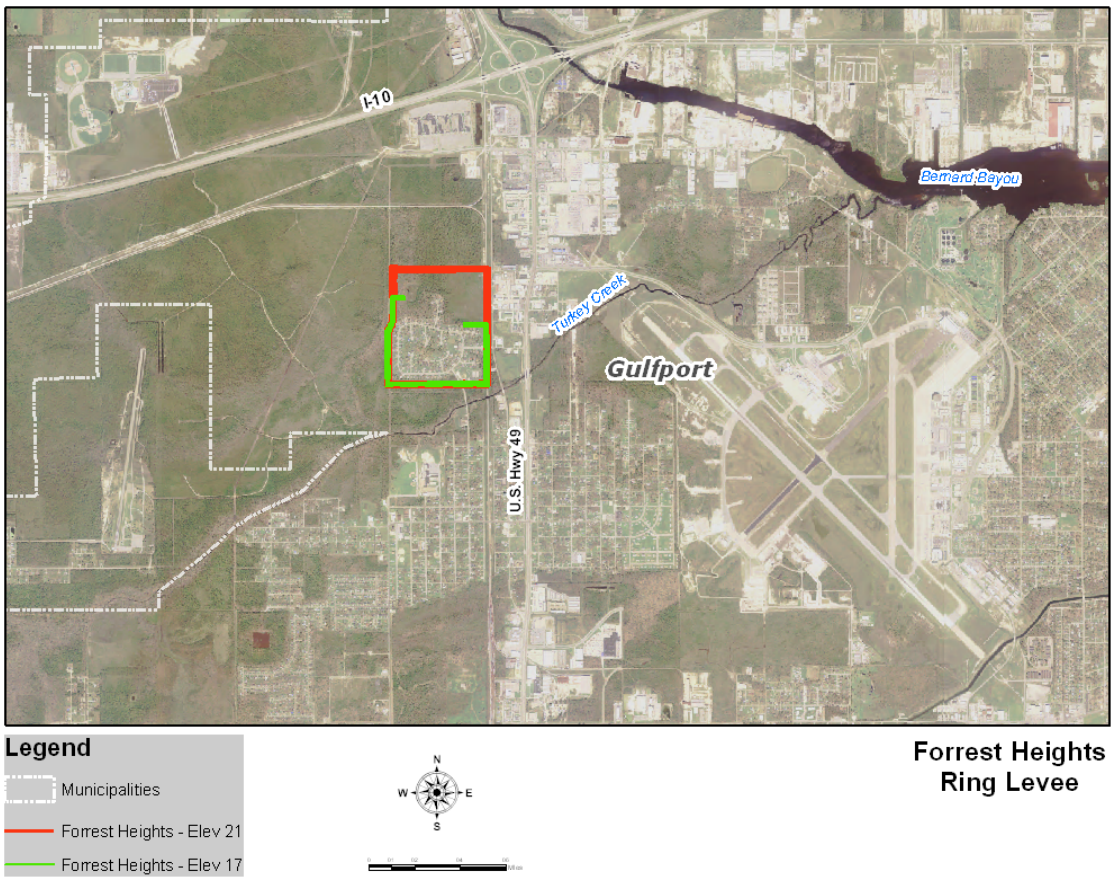


Figure 6.18-1. Forrest Heights Ring Levee Location

6.18.3 Assumptions

- The New Orleans District Corps of Engineers fresh water depth-damage relationships for residential and non-residential property were considered appropriate and accurate for the properties in this area,
- 50-year period of analysis,
- FY 2008 Federal discount rate of 4.875-percent,
- All values are equivalent to October 2007 dollars.

6.18.4 Existing Conditions

The community of Forrest Heights lies on the bank of Turkey Creek about 2.6 miles from the mouth at Bernard Bayou. Ground elevations over most of the residential area are between elevations 10-14 ft NAVD88. Drainage is mostly along streets and through natural drainage ways to the Turkey Creek. Impacts from flooding and hurricanes have been devastating. Hurricane Katrina in August, 2005 resulted in significant flood damages to residences in the Forrest Heights community. A levee with top width of 6 ft was constructed around the community to elevation 16.5 ft NGVD with side slopes of 1 vertical to 1.5 horizontal in 1969, prior to Hurricane Camille. It has not had adequate maintenance and is a state of disrepair. It is scheduled to be restored to as-built condition by January of 2009. However, the restored levee will not be sufficient to meet the present day standard for certification

according to the existing FEMA flood profiles in the vicinity. It is assumed that the as-built condition of this restored levee will be the existing condition for this report.

6.18.5 Without-Project Conditions

The without-project condition is the most likely case to occur during the 50-year period when a project could be in place. Because the Forrest Heights area has been developed since the 1800's, all of the usable land within the community is presently developed and rebuilt since Hurricane Katrina. Damages considered in the analysis were inundation damages and emergency cost damages that would occur from future storm events. Inundation damages and damages reduced were estimated using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) computer software program. Three future without-project scenarios were identified for the Forrest Heights area: existing relative sea level rise, moderate relative sea level rise and high relative sea level rise.

6.18.5.1 Coastal Hydraulic Data

This section describes the development of the existing relative sea level rise scenario. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), 20-ft(orange), and 20-ft(pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 6.18-2. The data indicates the water was as high as 18-20 ft NAVD88 near the site, totally inundating the entire area.

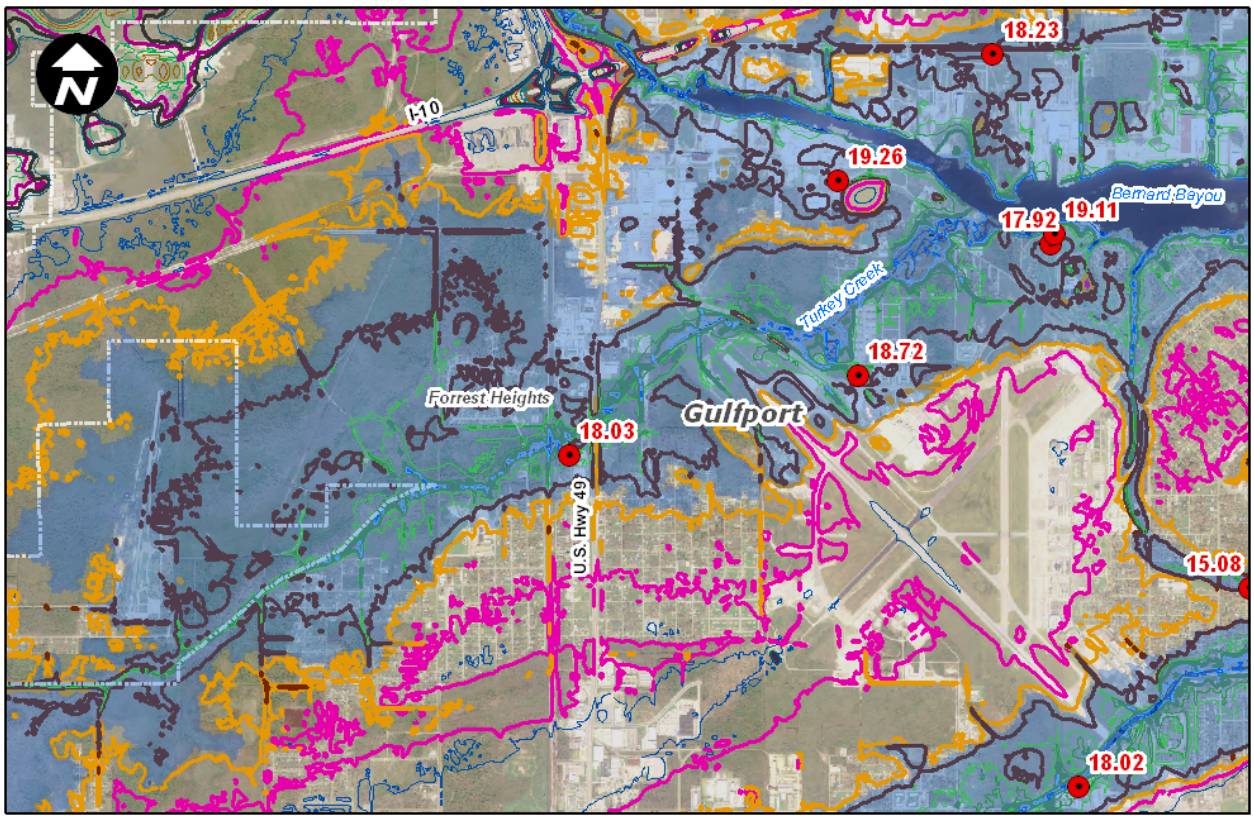


Figure 6.18-2. Hurricane Katrina Inundation and High Water, Forrest Heights

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical coastal tide gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area. An expanded description of the procedure is presented in Section 2.13 of the Engineering Appendix. Points near Forrest Heights, at which data from hydrodynamic modeling was saved, are displayed in Table 6.18-1.

Table 6.18-1.
Surge Stage-Probability and Uncertainty

Annual Probability	Stage (Ft. NAVD88)	Standard Deviation (Feet)
0.04	8.8	0.6
0.02	11.6	1
0.01	13.7	1.5
0.002	17.2	2.5
0.001	18.3	2.9

It should be noted that the frequency curve reflects only that flooding resulting from storm surge in the gulf. The Forrest Heights community is also subject to riverine flooding by Turkey Creek. The preliminary FEMA Harrison County Flood Insurance Study (FIS) dated November 2007 provides computed Turkey Creek flood profiles which appear to have been adjusted for the effects of coincident surge in Back Bay of Biloxi. Table 6.18-2 shows relevant discharge and stage information from the FIS for Turkey Creek at Ohio Avenue, the southern entrance to the Forrest Heights community. In comparison to the preliminary FEMA Flood Insurance Study dated November 2007, which is based on contemporary (post-Katrina) FEMA contractor hydrodynamic modeling, the ERDC frequency curve, which is based on surge alone, suggests a lower stage associated with the annual one in one hundred chance (0.01 exceedance probability) event.

Table 6.18-2.
Turkey Creek Flood Stages At Ohio Avenue, Harrison County FIS.

Exceedance Probability	Discharge (cfs)	Stage (ft. NAVD '88)
0.1	2600	12
0.02	3650	14.2
0.01	5500	15.5
0.002	7950	18.3

Hydraulic data was developed for use in the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) program. The HEC-FDA program uses risk-based analysis methods for evaluating flood damage and flood damage reduction alternatives. The program relies on hydrologic, hydraulic, and economic data input. Uncertainties in these data are input and used by the model for computing annual damages. Version 1.2.3b dated August 2007 was used. As described in chapter 2 of this appendix, this is a customized version of the current official release version 1.2 dated March 2000. This section describes the model's hydrologic and hydraulic input as applied to the Forrest Heights community.

Forrest Heights is subject to both riverine and surge flooding. For this reason, a discharge-frequency curve and a stage-discharge relationship (also known as a 'rating curve') were developed for input

into the HEC-FDA model. The discharge-frequency curve was computed in FDA using synthetic statistics using the 0.5-, 0.1-, and 0.01 annual exceedance probability discharges from the preliminary Harrison County FIS (see Table 3.3.6-2). The version of FDA used extends the stage frequency curve to the 0.999 and 0.0001 annual exceedance values. Uncertainty about the discharge-frequency curve was computed by the FDA program assuming an equivalent period of record. Sensitivity analysis of discharge uncertainty with respect to the equivalent period of record was conducted. Interpretation of the standard error and apparent period of record of the underlying hydrologic information used to develop the FIS discharge values versus discharge uncertainty computed by the FDA program suggested that an equivalent period of record of 20 years provided a reasonable preliminary estimate of uncertainty of discharge in the un-gaged stream. The resultant discharge-frequency curve and curves at the 5% and 95% confidence limits are shown below in Figure 6.18-3 and the values are shown in Table 6.18-3. These relationships are representative in the vicinity of Ohio Avenue.

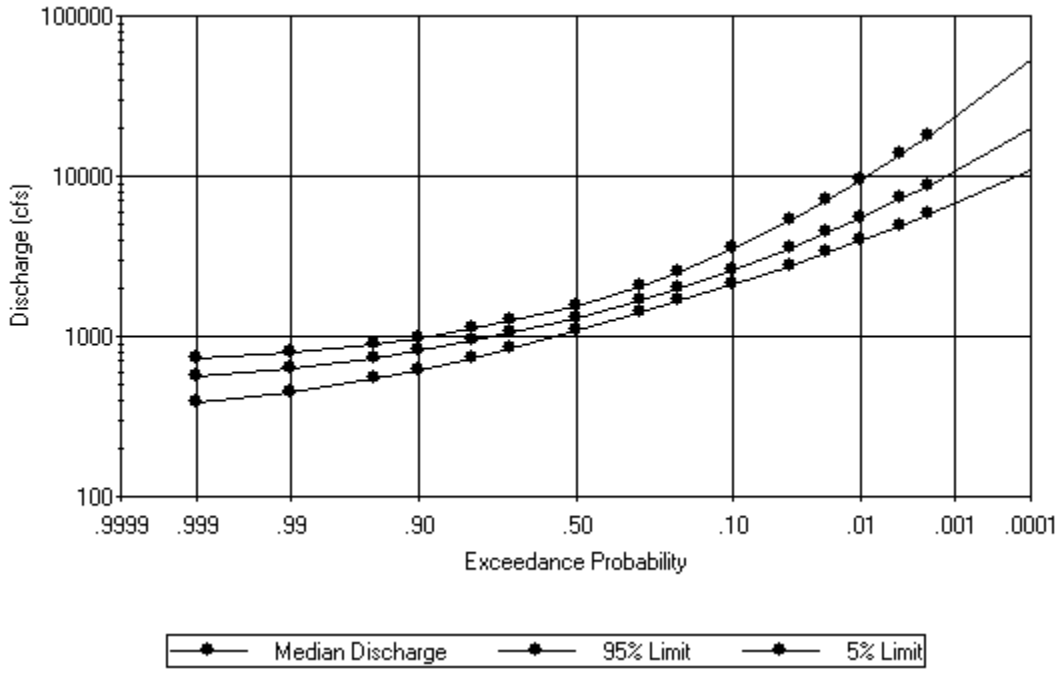


Figure 6.18-3. Computed Discharge-Frequency Curve, Turkey Creek at Ohio Avenue

Table 6.18-3.
Discharge-Frequency, Turkey Creek at Ohio Avenue

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) 95%	75%	25%	5%
0.9990	563	383	458	660	720
0.9900	634	447	525	733	795
0.9500	735	542	622	839	904
0.9000	811	614	696	918	986
0.8000	932	731	814	1,044	1,118
0.7000	1,045	840	924	1,165	1,245
0.5000	1,300	1,081	1,167	1,443	1,548
0.3000	1,678	1,412	1,511	1,882	2,051
0.2000	1,995	1,669	1,785	2,274	2,522
0.1000	2,601	2,118	2,281	3,066	3,515
0.0400	3,563	2,770	3,027	4,411	5,296
0.0200	4,449	3,330	3,684	5,716	7,104
0.0100	5,500	3,961	4,439	7,334	9,428
0.0040	7,211	4,935	5,625	10,093	13,561
0.0020	8,771	5,778	6,671	12,723	17,655
0.0001	19,704	11,042	13,464	33,224	52,792

The stage-discharge curve was developed by fitting an equation of the form $H = CQ^a$ (H = water surface elevation; Q is discharge; C and a determined by regression) through the Turkey Creek stage at cross section F as shown on the Turkey Creek Flood Profile, Plate 83P, of the preliminary FIS. The profile plate shows this location to have been adjusted for coincident probability of surge. The equation thus developed was used to extend the rating curve through a broader range of discharges than represented on the flood profiles. Uncertainty about the rating curve was assumed to be 1.5 feet at the 10-year and higher discharges based on FIS hydraulic modeling techniques and assuming a poor historic hydrologic data record (Turkey Creek is ungaged). The rating curve is shown in Figure 6.18-4.

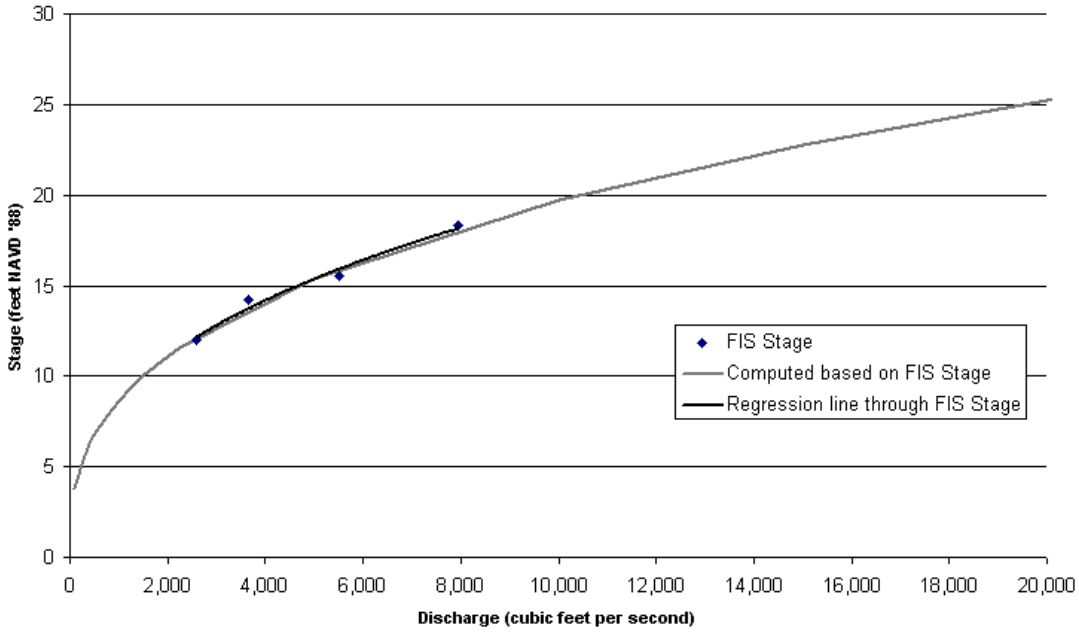


Figure 6.18-4. Computed Rating Curve, Turkey Creek at Ohio Avenue.

6.18.5.2 Summary of Without-Project Damages

Equivalent annual without-project damages for the Forrest Heights area were estimated using HEC-FDA program and evaluated for three future relative sea level rise scenarios; existing (Future 1), moderate (Future 3), and high (Future 5) relative sea level rise. The existing relative sea level rise condition, as described in the previous section, incorporates relative sea level rise to the base year, 2012, and does not project future relative sea level rise. The moderate and high relative sea level rise functions were used in the program by adding 0.9-feet for the moderate rate and 1.3-feet for the high rate to the existing relative sea level rise curves. Table 6.18-4 summarizes the without-project damages expected for the Forrest Heights area.

Table 6.18-4.
Without-Project Damages for the Forrest Heights Area by Future Scenario

Future Scenario 1	Future Scenario 3	Future Scenario 5
Existing Relative Sea Level Rise	Moderate Relative Sea Level Rise	High Relative Sea Level Rise
$107,550	$127,010	$141,290

6.18.6 List of Measures

- **Measure A - Elevation 17 ft NAVD88**

This option consists of an earthen dike around the Forrest Heights community as shown on the following Figure 6.18-5, along with the levee culvert/interior pump/detention location. The earth dike will be trapezoidal in shape with a 12-foot top width with one foot vertical to three foot horizontal slopes on both sides (1H:3V). For this option the two existing roadway entrances will be ramped over the restored levee. The total length of the levee will be approximately 7900 feet.

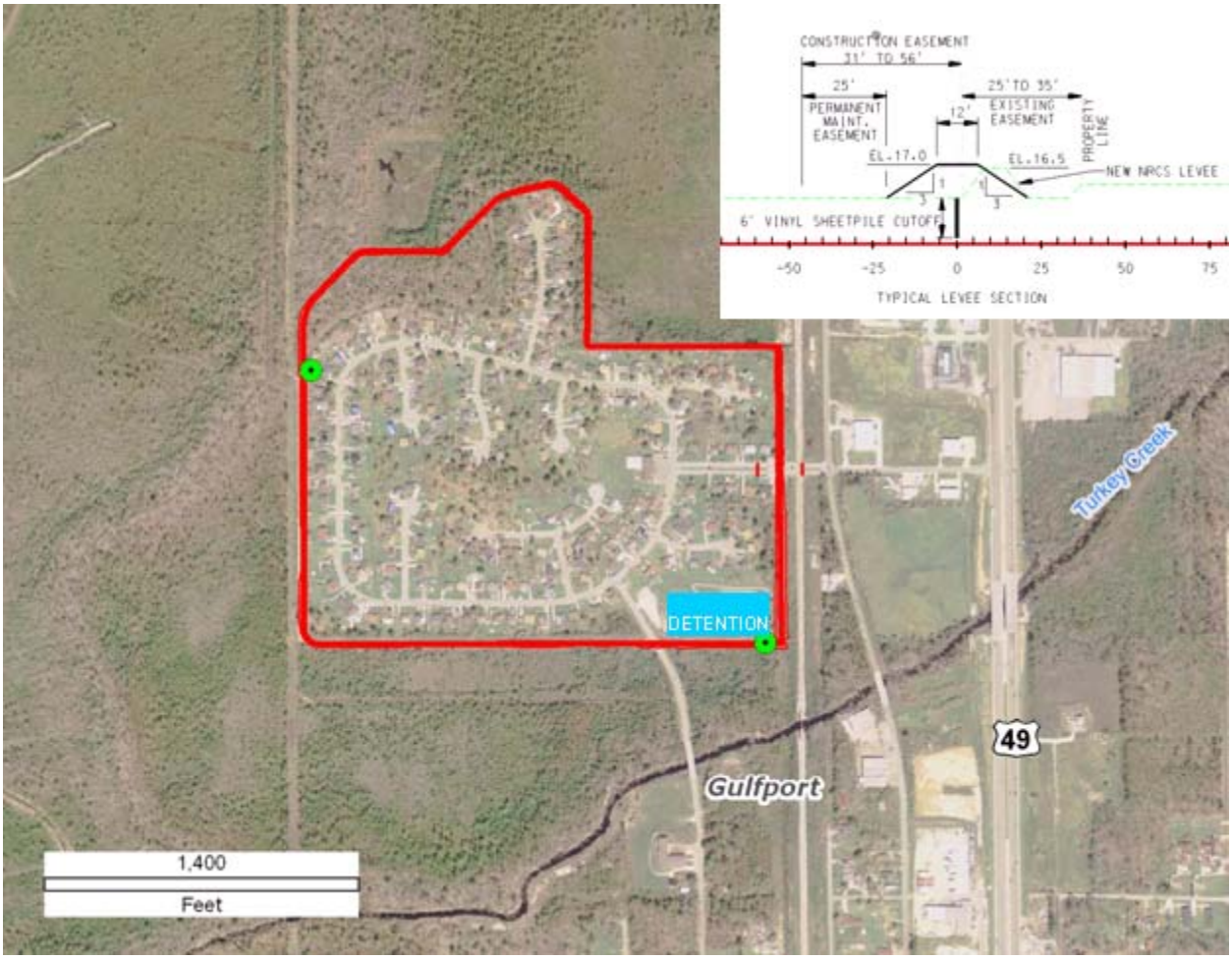


Figure 6.18-5. 17-ft Elevation Levee Alignment with Culvert and Pump/Detention Basin Locations

Levees reduce the storage capacity and overbank flow conveyance of the adjacent floodplain. The reductions in overbank flow area could induce higher water levels upstream. An HECRAS model was used to evaluate the potential for induced damages and solutions. The modeling indicates that selective clearing and snagging would prevent increases in water surface elevations upstream that would occur due the placement of the levees in the floodplain.

The selective clearing and snagging would extend for approximately 4.5 miles from the mouth of Turkey Creek at Bernard Bayou to the upstream limits as shown in Figure 6.18-6. Selective clearing and snagging would remove obstructions such as debris dams and excessive sedimentation that hinders the flow through the Turkey Creek channel. While the selective clearing and snagging component of the plan does not eliminate flooding along Turkey Creek, the plan does reduce flood damages along the creek and at the upper end of the canals at 28th Street. The main purpose of the selective clearing and snagging is to make sure that induced damages do not occur due to the construction of the levee.

The selective clearing and snagging work will follow Stream Obstruction Removal Guidelines established by the American Fisheries Society. Only debris, snags and sediment that obstruct the flow will be removed. Material to be removed includes: 1) fine sediment accumulations that obstruct flows and alter flow patterns; 2) Debris blockages that currently or in the near future cause obstructed flow and altered flow patterns; and 3) Rooted trees that obstruct flow or need to be cleared for equipment access. Access areas that are cleared will be reestablished at the conclusion

of the selective clearing and snagging activities. Some access points, however, may remain for the non-Federal sponsor to use for maintenance activity of the completed project. The existing bank alignment along the entire reach will not be changed, including the downstream reaches of Turkey Creek along the meander bends. Specific reaches to be cleared and snagged will be identified by an interdisciplinary team prior to construction.



Figure 6.18-6. Channel Clearing and Snagging Limits

Damage and failure by overtopping of levees could be caused by storm surges greater than the levee crest. Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 6.18-7 was caused by approximately 1-2 ft of overtopping crest depth.



Source: ERDC, Steven Hughes

Figure 6.18-7. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

An overtopping reach of the levee with a revetment at the detention/culvert location would be included in the levee design to prevent overtopping failure. The levee would be protected by gabions on filter cloth as shown in Figure 6.18-8, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

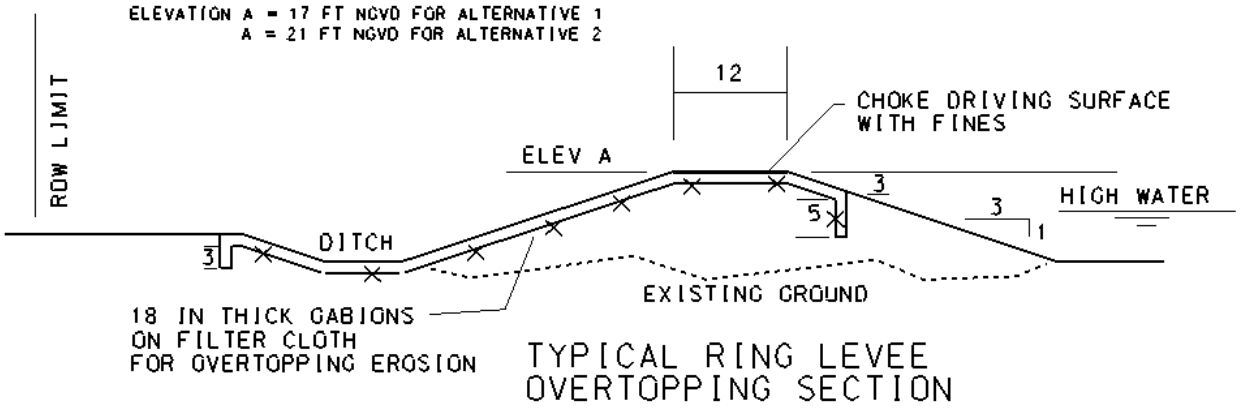


Figure 6.18-8. Typical Levee Overtopping Section

- **Option B - Elevation 21 ft NAVD88**

This option consists of an earthen levee around the entire community of Forrest Heights. The alignment of the levee is generally the same as Option A, above, with the required northern levee portion that would enclose the community within the levee as shown in Figure 6.18-3. The only difference between the description of this option and preceding description of Option A is the height of the levee and the length of the levee culverts. Other features and methods of analysis are the same.

6.18.7 With-Project Conditions

Equivalent annual damages reduced are those damages that are estimated to be reduced with a ring levee measure in place. Table 6.18-5 summarizes the equivalent annual damages reduced and table 6.18-6 summarizes residual damage.

Table 6.18-5.
Summary of Equivalent Annual Damages Reduced

Measure	Damages Reduced Future 1	Damages Reduced Future 3	Damages Reduced Future 5
No Action	$0	$0	$0
Measure A 17FT Levee	$8,860	$10,210	$11.580
Measure B 21FT Levee	$74,340	$89,340	$100,540

Table 6.18-6.
Summary of Equivalent Annual Residual Damages

Measure	Damages Reduced Future 1	Damages Reduced Future 3	Damages Reduced Future 5
No Action	$0	$0	$0
Measure A 17FT Levee	$98,690	$116,800	$129,710
Measure B 21FT Levee	$33,210	$37,670	$40,750

6.18.8 Summary of Costs

The rough order magnitude (ROM) costs for construction and for operations and maintenance are comparative-Level "Parametric Type" estimates and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. Table 6.18-7 summarizes the costs for the levee measures.

Table 6.18-7.
Summary of Costs by Measure for Forrest Heights

Measures	Total Cost to Implement (First Cost) ($)	IDC ($)	Total Initial Cost ($)	Average Annual Implementation Cost ($)	Average Annual O&M ($)	Total Average Annual Costs ($)
(No Action)	$0	$0	$0	$0	$0	$0
Measure A 17FT Levee	$6,100,000	$135,000	$6,235,000	$335,000	$42,000	$377,000
Measure B 21FT Levee	$11,400,000	$252,000	$11,652,000	$626,000	$114,000	$740,000

The implementation costs include 1/ supervision and administration (30 account), 2/ planning, engineering & design (31 account) and 3/ appropriate contingencies. See the Cost Appendix for more detail on the implementation cost breakdowns. Numbers are rounded to the nearest thousand.

6.18.9 Regional Economic Development (RED) Benefits Socioeconomic Impacts using the Economic Impact Forecast System

The purpose of this analysis is to determine the economic impact of the proposed project alternatives on business (sales volumes), income, employment, and population of the local area. Each of the alternatives would affect the local area of Hancock County, Mississippi. The expenditures for the alternatives are estimated to be $6,100,000 for Alternative 1 and $11,400,000 for the Alternative 2. Moreover, the Annual Operation and Maintenance (O&M) expenditures are estimated to be $700,000 for Alternative 1 and $1,400,000 for Alternative 2 (assuming a 50 year period of analysis and an interest rate of 5.375-percent). Tables 6.18-8 through 6.18-11 summarize the EIFS model inputs and outputs for the cost effective measures at Admiral Island.

Table 6.18-8.
EIFS Model Implementation Inputs for the Forrest Heights Area

	No Action	17FT Levee	21FT Levee
Region of Influence (ROI)	Harrison County	Harrison County	Harrison County
Change in Local Expenditures	$0	$6,100,000	$11,400,000

Based of the given inputs the outputs are as follows:

Table 6.18-9.
EIFS Model Implementation Outputs for the Forrest Heights Area

	No Action	17FT Levee	21FT Levee
Direct Sales Volume	$0	$6,100,000	$11,400,000
Induced Sales Volume	$0	$7,625,000	$14,250,000
Total Sales Volume	$0	$13,725,000	$25,650,000
Direct Income	$0	$1,291,220	$2,413,099
Induced Income	$0	$1,614,025	$3,016,374
Total Income	$0	$2,905,244	$5,429,473
Direct Employment	0	39	72
Induced Employment	0	48	91
Total Employment	0	87	163
Local Population	0	0	0

Table 6.18-10.
EIFS Model O&M Inputs for the Forrest Heights Area

	No Action	17FT Levee	21FT Levee
Region of Influence (ROI)	Hancock County	Harrison County	Harrison County
Change in Local Expenditures	$0	$782,000	$2,122,000

Based of the given inputs the outputs are as followed:

Table 6.18-11.
EIFS Model O&M Outputs for the Forrest Heights Area

	No Action	17FT Levee	21FT Levee
Direct Sales Volume	$0	$782,000	$2,122,000
Induced Sales Volume	$0	$977,500	$2,652,500
Total Sales Volume	$0	$1,759,500	$4,774,500
Direct Income	$0	$165,530	$449,175
Induced Income	$0	$206,913	$561,469
Total Income	$0	$372,443	$1,010,644
Direct Employment	0	5	13
Induced Employment	0	6	17
Total Employment	0	11	30
Local Population	0	0	0

CHAPTER VII. SENSITIVITY ANALYSIS

7.1 Period of Analysis Sensitivity

This section describes the sensitivity of the period of analysis on the evaluation of equivalent annual damage reduction and average annual costs for the various measures. There are two significant drivers inherit in the period of analysis that will be addressed in this section. The first is the effect of relative sea level rise depending on a 50-year or a 100-year horizon and the other is the concept of the time value of money and amortization.

In order to describe the effects of these variables, two specific sites were chosen; Pearlington and Gautier areas. These areas were specifically chosen because they reside in the western and eastern planning units of the state, planning units one and three respectively, and because they have been formulated for the comparison of structural and nonstructural measures. Measures for each area were evaluated using the 100-year and 50-year periods of analysis. The measures included a ring levee at 20-feet NAVD88, a ring levee at 30-feet NAVD88, an ABFE level nonstructural plan (acquisitions and elevate-in-place), a nonstructural plan to a 20-foot NAVD88 elevation, and a nonstructural plan with a 30-feet NAVD88 elevation. These elevations were chosen to develop a cost and benefit curve, and were not assigned a particular event frequency. At some point, the curve would be used to determine the elevation for various frequency events. The evaluation of these measures to determine cost-effectiveness is located in Chapter VI of this appendix.

7.1.1 Effects of the Period of Analysis on Damages

The Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) program was used to calculate equivalent annual without-project damages and equivalent annual damages reduced for the various measures. The HECFDA model calculates equivalent annual damages for a base year and a most likely future year, and then linearly interpolates damages and damages reduced between the years. Figure 7.1-1 depicts this process. The process is the same for a 50-year period of analysis except that the most likely future would be 2061.

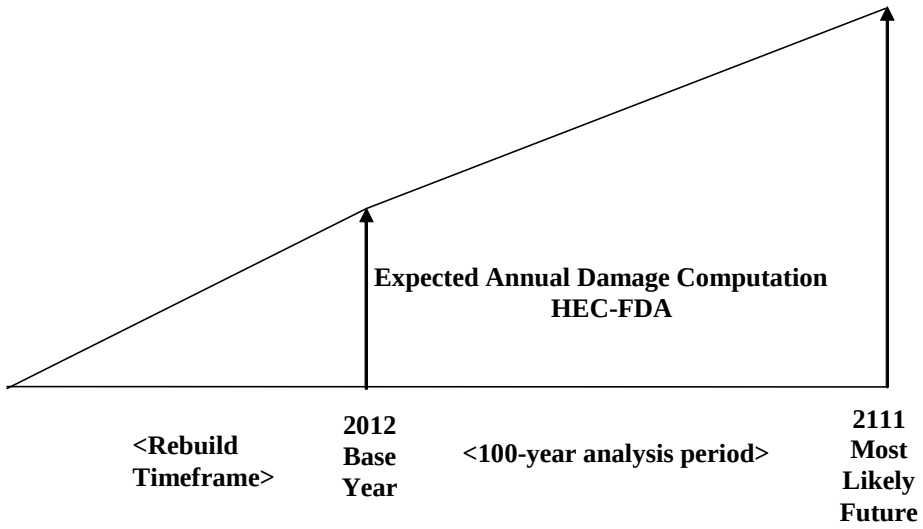


Figure 7.1-1. Calculation of Equivalent annual damages

There are six future without-project scenario conditions that were created for the MsCIP Comprehensive Plan. They are a combination of two different types of redevelopment scenarios with three types of relative sea level rise scenarios. Table 7.1-1 summarizes the six scenarios, which are described in greater detail in Chapter V of this appendix.

Table 7.1-1.
Overview of Future Scenarios

Future Scenario	Redevelopment Type	Relative Sea Level Rise 100-Years	Description
Future Scenario 1	Residential	Historical Only	Rebuild structures as existed pre-Hurricane Katrina with no relative sea level rise over the period of analysis. This future scenario applies to all three planning units.
Future Scenario 2	Mixed Residential & Commercial	Historical Only	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, no relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.
Future Scenario 3	Residential	Expected	Rebuild structures as existed pre-Hurricane Katrina with up to 2.4-feet relative sea level rise over the period of analysis. This future scenario applies to all three planning units.
Future Scenario 4	Mixed Residential & Commercial	Expected	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, a up to 2.4-feet relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.
Future Scenario 5	Residential	High Rate	Rebuild structures as existed pre-Hurricane Katrina with up to 3.4-feet of relative sea level rise over the period of analysis. This future scenario applies to all three planning units.
Future Scenario 6	Mixed Residential & Commercial	High Rate	Rebuild structures as existed pre-Hurricane Katrina except at water front where condo/casino rebuild will occur. Also, up to3.4-feet of relative sea level rise over the period of analysis. This future scenario applies only to planning units one and two. Planning unit three would not allow commercial type redevelopment based on local ordinances.

Future Scenarios One and Two are included only to evaluate the effects of relative sea level rise. These Future scenarios will not be used in the evaluation of potential measures. Futures Three, Four, Five, and Six will be the future scenarios by which potential measures will be evaluated depending on the planning unit.

The Pearlington and Gautier areas were on evaluated against future scenarios one, three, and five due to the geographic characteristics, historical development patterns, and political climate of the areas. SAM Engineering Division developed exceedance probability functions for each of the fifty-four planning sub-units; Pearlington is denoted as planning sub-unit six and Gautier as planning sub-unit thirty. The exceedance probability functions were developed by using an approach that combined historical Corps gage data and modeling conducted by the Engineer Research and Development Center (ERDC). The engineering appendix contains more information about the exceedance probability functions.

The exceedance probability function for the base year is the observed/modeled value, and the most like future year is the base year exceedance probability function plus some measure of relative sea level rise depending on the period of analysis. Future without-project scenario one is the full

redevelopment of the area back to pre-Hurricane Katrina levels with no addition for future relative sea level rise. Future without-project scenario three is the same redevelopment scenario as future one with an expected rate of relative sea level rise applied to the most likely future year (2111), and future without-project scenario five is the same redevelopment with a high rate of relative sea level rise included. Table 7.1-2 summarizes the future without-project scenario three and five conditions.

Table 7.1-2.
Details of Future Without-Project Scenarios One, Three, and Five 100-Year and 50-Year Periods of Analysis

Measure	Redevelopment Type	Approximate 100-Year Relative Sea Level Rise	Approximate 50-Year Relative Sea Level Rise
Pearlington Area (Planning sub-unit six)			
Future Scenario One	Redevelopment back to pre-Hurricane Katrina Levels	0.0-feet	0.0-feet
Future Scenario Three	Redevelopment back to pre-Hurricane Katrina Levels	1.8-feet	0.9-feet
Future Scenario Five	Redevelopment back to pre-Hurricane Katrina Levels	3.2-feet	1.3-feet
Gautier Area (Planning sub-unit 30)			
Future Scenario One	Redevelopment back to pre-Hurricane Katrina Levels	0.0-feet	0.0-feet
Future Scenario Three	Redevelopment back to pre-Hurricane Katrina Levels	2.4-feet	1.5-feet
Future Scenario Five	Redevelopment back to pre-Hurricane Katrina Levels	3.8-feet	2.0-feet

By comparing the change in equivalent annual damages, damages reduced, and residual damages for future without-project scenario one under the 100-year and 50-year periods of analysis, the effects of the time value of money can be isolated. This is true because future scenario one has no change in relative sea level rise whether it is being evaluated at 100-years or at 50-years. Thus, the only difference between future scenario one for the 100-year and 50-year is the change in the capital recovery factor. The Capital recovery factor is a ratio that is applied to total present worth damages in order to estimate the average annual value of a number. For damages, it is calculated as:

Average Annual damages = Total Present Worth of Damages x Capital Recovery Factor

Total Present Worth = $\sum_n$ (Cost / (1+ i) ^n)

Capital Recovery Factor (CRF) = i / (1-(1+i) ^-n)

Where:

i = discount rate

n = period of analysis

The capital recovery factor is calculated by the HEC-FDA program based on the user input discount rate (4.875-percent) and the period of analysis (100-years or 50-years). The HEC-FDA program was run for periods of analysis for future without-project scenario one. Without-project damages for the Pearlington area were $11,569,000 and $12,640,000 for the 100-year and 50-year analysis respectively, and without project damages for the Gautier area for future scenario one are

$4,920,000 and $5,376,000 for the 100-year and 50-year period of analysis respectively. This represents a 9.26-percent difference for the Pearlington area and a 9.27-percent difference for the Gautier area for equivalent annual without-project damages. Thus, the effects of a 50-year period of analysis are higher equivalent annual damages than would be expected under the 100-year period of analysis. The same higher effect can be seen for the equivalent annual damages reduced and the equivalent annual residual damages. Tables 7.1-3 and 7.1-4 show the comparison of the damages reduced and the residual damages for future without-project scenario one for the two periods of analysis.

Table 7.1-3.
Equivalent Annual Damage Reduction Comparison of 50-Year Compared to 100-Year Future Without-Project Scenario One Pearlington and Gautier Area Measures

Measure	100-Year Equivalent annual damages ($)	50-Year Equivalent annual damages ($)	Percent Difference 50-Yr to 100-Yr (%)
Pearlington Area Measures			
Ring Levee 20FT	$11,241,000	$12,282,000	9.26%
Ring Levee 30FT	$11,560,000	$12,630,000	9.26%
ABFE Nonstructural	$10,998,000	$12,016,000	9.26%
Gautier Area Measures			
Ring Levee 20FT	$4,378,000	$4,784,000	9.27%
Ring Levee 30FT	$4,897,000	$5,350,000	9.26%
ABFE Nonstructural	$3,104,000	$3,391,000	9.25%

Damages are rounded to the nearest thousand.

Table 7.1-4.
Equivalent Annual Residual Damage Comparison of 50-Year Compared to 100-Year Future Without-Project Scenario One Pearlington and Gautier Area Measures

Measure	100-Year Equivalent Annual Residual Damages ($)	50-Year Equivalent Annual Residual Damages ($)	Percent Difference 50-Yr to 100-Yr (%)
Pearlington Area Measures			
Ring Levee 20FT	$328,000	$358,000	9.15%
Ring Levee 30FT	$9,000	$10,000	11.11%
ABFE Nonstructural	$571,000	$624,000	9.28%
Gautier Area Measures			
Ring Levee 20FT	$542,000	$592,000	9.23%
Ring Levee 30FT	$23,000	$26,000	13.04%
ABFE Nonstructural	$1,816,000	$1,985,000	9.31%

Damages are rounded to the nearest thousand.

Future without-project scenarios three and five are different from future without-project scenario one in that they account for some rate of relative sea level rise over the period of analysis. As previously displayed in table 7.1-2, the 50-year period of analysis would constitute a smaller rate of relative sea level rise than the 100-year period of analysis. This smaller rate, given all other things equal, would mean that the equivalent annual without-project damages, equivalent annual damages reduced, and the equivalent annual residual damages for the 50-year period of analysis would be lower than the 100-year period of analysis. However, the time value of money effect that was described for future scenario one also comes into play for future scenarios three and five, resulting in and upward effect. Thus, there is a simultaneous push upward (time value of money) and downward (relative sea level rise) from these two variables when comparing the equivalent annual damages under a 50-year to the 100-year period of analysis. This can be seen in the effects of the change in equivalent annual without-project damages for future scenarios three and five are displayed in table 7.1-5. For the Pearlington area, the change to equivalent annual without-project damages is 3.24 and -4.01(negative 4.01)-percent for future without-project scenario conditions three and five respectively. The changes for the Gautier are 1.90 and -7.65 (negative 7.65)-percent for future scenarios three and five respectively. The effects of the change in scenario three are dominated by the time value of money factor, causing and increase in equivalent annual damages; where scenario five is dominated by a reduction in relative sea level rise (the difference in a 100-year estimate compared to a 50-year estimate), thus causing a lowering effect.

Table 7.1-5.
Equivalent Annual Without-Project Damage Comparison of 50-Year Compared to 100-Year Future Without-Project Scenarios Three and Five Pearlington and Gautier Area Measures

Measure	100-Year Equivalent annual damages ($)	50-Year Equivalent annual damages ($)	Percent Difference 50-Yr to 100-Yr (%)
Pearlington Area Measures			
Future Scenario Three Without Project Damages	$12,885,000	$13,303,000	3.24%
Future Scenario Five Without Project Damages	$14,205,000	$13,635,000	-4.01%
Gautier Area Measures			
Future Scenario Three Without Project Damages	$5,831,000	$5,942,000	1.90%
Future Scenario Five Without Project Damages	$6,702,000	$6,189,000	-7.65%

Damages are rounded to the nearest thousand.

Table 7.1-6 displays the equivalent annual damage reduction for the 100-year and 50-year periods of analysis for future without-project scenario three and table 7-1.7 for future without-project scenario five. Residual damages, damages that remain even if the measure were to be implemented, are shown in table 7.1-8 for future-without project scenario three and table 7.1-9 for future without-project scenario five.

Table 7.1-6.
Equivalent Annual Damage Reduction Comparison of 50-Year Compared to 100-Year Future Without-Project Scenario Three Pearlington and Gautier Area Measures

Measure	100-Year Equivalent annual damages ($)	50-Year Equivalent annual damages ($)	Percent Difference 50-Yr to 100-Yr (%)
Pearlington Area Measures			
Ring Levee 20FT	$11,894,000	$12,918,000	8.61%
Ring Levee 30FT	$12,267,000	$13,292,000	8.35%
ABFE Nonstructural	$12,260,000	$12,652,000	3.20%
Gautier Area Measures			
Ring Levee 20FT	$5,166,000	$5,279,000	2.19%
Ring Levee 30FT	$5,800,000	$5,912,000	1.93%
ABFE Nonstructural	$3,623,000	$3,713,000	-5.27%

Damages are rounded to the nearest thousand.

Table 7.1-7.
Equivalent Annual Damage Reduction Comparison of 50-Year Compared to 100-Year Future Without-Project Scenario Five Pearlington and Gautier Area Measures

Measure	100-Year Equivalent annual damages ($)	50-Year Equivalent annual damages ($)	Percent Difference 50-Yr to 100-Yr (%)
Pearlington Area Measures			
Ring Levee 20FT	$13,088,000	$13,236,000	1.13%
Ring Levee 30FT	$13,228,000	$13,623,000	2.99%
ABFE Nonstructural	$13,520,000	$12,970,000	-4.07%
Gautier Area Measures			
Ring Levee 20FT	$5,923,000	$5,492,000	-7.28%
Ring Levee 30FT	$6,663,000	$6,156,000	-7.61%
ABFE Nonstructural	$3,984,000	$3,844,000	-3.51%

Damages are rounded to the nearest thousand.

Table 7.1-8.
Equivalent Annual Residual Damage Comparison of 50-Year Compared to 100-Year Future Without-Project Three Pearlington and Gautier Area Measures

Measure	100-Year Equivalent Annual Residual Damages ($)	50-Year Equivalent Annual Residual Damages ($)	Percent Difference 50-Yr to 100-Yr (%)
Pearlington Area Measures			
Ring Levee 20FT	$991,000	$385,000	-61.15%
Ring Levee 30FT	$618,000	$11,000	-98.22%
ABFE Nonstructural	$625,000	$651,000	4.16%
Gautier Area Measures			
Ring Levee 20FT	$665,000	$663,000	-0.30%
Ring Levee 30FT	$31,000	$30,000	-3.24%
ABFE Nonstructural	$2,208,000	$2,229,000	0.95%

Damages are rounded to the nearest thousand.

Table 7.1-9.
Equivalent Annual Residual Damage Comparison of 50-Year Compared to 100-Year Future Without-Project Five Pearlington and Gautier Area Measures

Measure	100-Year Equivalent Annual Residual Damages ($)	50-Year Equivalent Annual Residual Damages ($)	Percent Difference 50-Yr to 100-Yr (%)
Pearlington Area Measures			
Ring Levee 20FT	$1,117,000	$399,000	-64.28%
Ring Levee 30FT	$977,000	$12,000	-98.77%
ABFE Nonstructural	$685,000	$665,000	-2.92%
Gautier Area Measures			
Ring Levee 20FT	$779,000	$697,000	-10.53%
Ring Levee 30FT	$39,000	$33,000	-15.38%
ABFE Nonstructural	$2,718,000	$2,345,000	-13.72%

Damages are rounded to the nearest thousand.

The results of the sensitivity of the period of analysis on future without project scenarios three and five vary by location and plan. As previously noted, this is due to the upward effect of the time value of money and the lowering effect that results from a lesser relate of relative sea level rise for the 50-year period of analysis. The only conclusive evidence that can be deduced from this exercise is that there will be higher residual damages under the 100-year period of analysis as compared to the 50-year period of analysis, and, in some cases, the difference in residual damages are very large.

It is important to note that the 20-feet NAVD88 and 30-feet NAVD88 elevations were fixed point elevations for cost and benefit evaluation purposes only, and not directly tied to a particular frequency event. When implemented to a particular frequency event, an elevation would have to be selected to provide for that level of protection. By using a 50-year period of analysis, the selection of an elevation for a particular event level would be lower than the selection for the same event level

under the 100-year period of analysis due to the difference in relative sea level rise. Thus, if you were to pick the elevation for the 1-percent event under the 50-year period of analysis and relative sea level rise were more like the 100-year period of analysis, the risk of overtopping and increased level of residual damages could be significant.

7.1.2 Effects of the Time Value of Money

7.1.2.1 Average Annual Implementation Cost

Traditionally, the Corps of Engineers reports costs on an average annual basis. Average annual costs are calculated by multiplying the total present worth of costs times the capital recovery factor.

Average Annual Implementation Costs = Total Present Worth of Costs x Capital Recovery Factor

Total Present Worth = Cost / (1+ i) ^n))

Capital Recovery Factor (CRF) = i / (1-(1+i) ^-n)

Where:

i = interest rate

n = period of analysis

Typically, costs are associated to the years they would be expended in should the project be constructed. Those expenditures are then brought back, or present worthed, to the same fiscal year (FY) as the benefits in order for a direct and accurate comparison. At this point in the analysis of the potential measures, the timing of expenditures have not yet been identified; therefore the total implementation cost act as the total present worth of the implementation costs and will be multiplied by the capital recovery factor to get the average annual implementation cost values.

A simple case example is to imagine that a project costs one dollar to implement, or the present worth of the project is one dollar. This is the same whether you chose a 50-year period of analysis or a 100-year period of analysis, thus the changing variable is the capital recovery factor. The capital recovery factors for a 100-year and 50-year period of analysis are 0.049171225 and 0.053722282 respectively. Using the average annual cost equation expressed above the average annual costs of the one dollar project is:

100-Year

$1 x 0.049171225 = $0.049

50-Year

$1 x 0.053722282 = $0.053

This simple comparison shows that the difference in cost for a 100-year period of analysis compared to a 50-year period of analysis is that the 50-year average annual cost is 9.26-percent higher. This result would be expected since the costs are attributed to a shorter period. The everyday example of this is a person saving to buy something. If you save monthly over two years compared to one year, you will have to save less every month to achieve the same goal. Table 7.1-10 shows this effect on the measures for the Pearlington area and the Gautier area. **Note:** Future without-project scenarios have no bearing on the implementation cost of the various measures.

Table 7.1-10.
Average Annual Implementation Cost Comparison of 50-Year Compared to 100-Year Pearlington and Gautier Area Measures

Measure	100-Year Average Annual Costs ($)	50-Year Average Annual Costs ($)	Percent Difference 50-Yr to 100-Yr (%)
Pearlington Area Measures			
Ring Levee 20FT	$4,754,857	$5,194,945	9.26%
Ring Levee 30FT	$5,620,271	$6,140,457	9.26%
ABFE Nonstructural	$19,073,518	$20,838,873	9.26%
Gautier Area Measures			
Ring Levee 20FT	$16,629,708	$18,168,876	9.26%
Ring Levee 30FT	$21,620,587	$23,621,687	9.26%
ABFE Nonstructural	$9,362,201	$10,228,723	9.26%

7.1.2.2 Interest During Construction

Interest during construction is an added economic cost because it is the opportunity cost of having construction monies tied up until the measure becomes fully operational. Since, at this point in the analysis, the length of construction for these measures have not been identified, interest during construction was not calculated for the analyzed Pearlington and Gautier area measures and is not included in the total average annual costs. Further study would be required in order to calculate interest during construction on each of the measures. However, since interest during construction is a function of the discount rate and the period of time it takes to construct the project, it will have no bearing on whether a 100-year or 50-year period of analysis is used, i.e. interest during construction would be the same regardless of the period of analysis.

Average annual operation and maintenance costs for the structural ring levee measures was calculated as two-percent of the contract cost for the structure. This number was provided by MOBILE DISTRICT (SAM) Engineering Division and would not be impacted under a 100-year or 50-year period of analysis. Average annual operation and maintenance costs for nonstructural measures were provided but the Corps of Engineers Nonstructural Flood Proofing Committee (NSFPC) and were based on factors that are not directly affected by the period of analysis.

7.2 First Floor Elevation Uncertainty Sensitivity

The HEC-FDA program is a Monte Carlo based program that allows and compensates for the uncertainty pertaining to multiple structure characteristic inputs. The main uncertainty variables are those pertaining to the exceedance probability function, structure value, content value, and first floor elevation. Initial sensitivity runs on these variables determined that the first floor elevation uncertainty is the most sensitive to change. For that reason, the first floor elevation was chosen for this sensitivity analysis.

In a typical feasibility level study, the first floor elevation of each structure is determined by a survey crew in the field. For the MsCIP Comprehensive Plan Report, the survey of over 130,000 structures was not feasible from a time, labor, and funding perspective. Therefore, a sampling technique was used to estimate the first floor elevation of each structure using a combination of LIDAR data and field estimation of the finished floor above ground elevation. The uncertainty pertaining to the

estimated first floor elevation was found to be 3.52-feet for one standard deviation. This was attained by surveying a two-percent sample, approximately 3,000 structures, using the typical feasibility level survey method and then comparing it to the estimates attained from the LIDAR plus finished floor estimates. Chapter IV describes the inventory sampling process and first floor elevation estimates in greater detail.

Given the nature of sensitivity and the magnitude of the uncertainty pertaining to the first floor elevation, a sensitivity analysis was conducted to determine the extent of influence this variable had on the equivalent annual damages that were estimated for the entire study area. The sensitivity analysis was conducted for the equivalent annual without-project damages for all six future without-project scenarios. Details on those scenarios can be found above in table 7.1.1 or in chapter V of this appendix.

The intent of this sensitivity analysis was to compare the first floor elevation uncertainty in the MsCIP Comprehensive data to the uncertainty expressed in previous Corps studies using more accurate and traditional surveying methods. In order to determine a typical uncertainty that is associated with the standard survey of ach structure, previous Mobile District reports were utilized. Uncertainty pertaining to the first floor elevation used for previous feasibility studies ranged from 0.3-feet and 0.9-feet for one standard deviation. For this sensitivity analysis, the mean of these values (0.6-feet) was used. The future without-project conditions for each of the six scenarios were run with both the 3.52-feet of uncertainty and the 0.6-feet of uncertainty and compared to determine the sensitivity. The following tables show the results of the first floor elevation sensitivity analysis on equivalent annual damages and damages reduced for the Pearlington and Gautier area measures.

Table 7.2-1.
First Floor Uncertainty Sensitivity on Equivalent Annual Without-Project Damages
Pearlington and Gautier Area Measures

Measure	3.52FT Uncertainty Equivalent annual damages ($)	0.6FT Uncertainty Equivalent annual damages ($)	Percent Difference (%)
Pearlington Area Measures			
Future Scenario One Without Project Damages	$11,569,000	$6,950,000	-39.93%
Future Scenario Three Without Project Damages	$12,885,000	$8,856,000	-31.27%
Future Scenario Five Without Project Damages	$14,205,000	$9,586,000	-32.52%
Gautier Area Measures			
Future Scenario One Without Project Damages	$4,920,000	$2,992,000	-39.19%
Future Scenario Three Without Project Damages	$5,831,000	$3,686,000	-36.79%
Future Scenario Five Without Project Damages	$6,702,000	$4,288,000	-36.02%

Damages are rounded to the nearest thousand.

Table 7.2-2.
First Floor Uncertainty Sensitivity on Equivalent annual damages Reduced Future Without Project Scenario One Pearlington and Gautier Area Measures

Measure	3.52FT Uncertainty Equivalent annual damages Reduced ($)	0.6FT Uncertainty Equivalent annual damages Reduced ($)	Percent Difference (%)
Pearlington Area Measures			
Ring Levee 20FT	$11,241,000	$6,611,000	-41.19%
Ring Levee 30FT	$11,560,000	$6,941,000	-39.96%
ABFE Nonstructural	$10,998,000	$6,501,000	-40.89%
Gautier Area Measures			
Ring Levee 20FT	$4,378,000	$2,410,000	-44.95%
Ring Levee 30FT	$4,897,000	$2,968,000	-39.39%
ABFE Nonstructural	$3,104,000	$1,917,000	-38.24%

Damages are rounded to the nearest thousand.

Table 7.2-3.
First Floor Uncertainty Sensitivity on Equivalent annual damages Reduced Future Without Project Scenario Three Pearlington and Gautier Area Measures

Measure	3.52FT Uncertainty Equivalent annual damages Reduced ($)	0.6FT Uncertainty Equivalent annual damages Reduced ($)	Percent Difference (%)
Pearlington Area Measures			
Ring Levee 20FT	$11,894,000	$8,421,000	-29.20%
Ring Levee 30FT	$12,267,000	$8,843,000	-27.91%
ABFE Nonstructural	$12,260,000	$8,315,000	-32.18%
Gautier Area Measures			
Ring Levee 20FT	$5,166,000	$2,975,000	-42.41%
Ring Levee 30FT	$5,800,000	$3,654,000	-37.00%
ABFE Nonstructural	$3,623,000	$2,405,000	-33.62%

Damages are rounded to the nearest thousand.

Table 7.2-4.
First Floor Uncertainty Sensitivity on Equivalent annual damages Reduced Future Without Project Scenario Five Pearlington and Gautier Area Measures

Measure	3.52FT Uncertainty Equivalent annual damages Reduced ($)	0.6FT Uncertainty Equivalent annual damages Reduced ($)	Percent Difference (%)
Pearlington Area Measures			
Ring Levee 20FT	$13,088,000	$9,115,000	-30.36%
Ring Levee 30FT	$13,228,000	$9,571,000	-27.65%
ABFE Nonstructural	$13,520,000	$9,047,000	-33.08%
Gautier Area Measures			
Ring Levee 20FT	$5,923,000	$3,451,000	-41.74%
Ring Levee 30FT	$6,663,000	$4,247,000	-36.26%
ABFE Nonstructural	$3,984,000	$2,809,000	-29.49%

Damages are rounded to the nearest thousand.

CHAPTER VIII. TENTATIVELY-SELECTED PLAN FEATURES

The tentatively-selected system wide plan features for the MsCIP Comprehensive plan, explained in more detail in the Main Report, have multiple levels. Some of the features will be recommended as work for entities other than the Corps of Engineers, some will be recommended for further construction, and some will be recommended for implementation. The list of measures in this appendix which are recommended for further study include the ring levee and nonstructural measures at the Pearlington, Ocean Springs, Gautier, Gulf Park Estates, Belle Fontaine, and Pascagoula/Moss Point areas, as well as further inquiry into the coast wide 20-foot, 30-foot, and 40-foot elevation nonstructural measures. Among the list of tentatively-selected plan features for construction that were analyzed in this appendix include barrier island restoration, beach and dune placement, ecosystem restoration at the Admiral Island, Turkey Creek, Bayou Cumbest, Dantzler, and Franklin Creek areas, the 21-foot elevation levee at the Forrest Heights area, and the acquisition of parcels within high risk areas.

For planning and screening purposes, the analysis in this appendix used a 100-year period of analysis for measures that were determined to be complex in nature such as the barrier island restoration or measures that had a high risk of residual damages due to relative sea level rise such as flood risk management measures. Other measures that were not as complex in nature, such as the beach and dune placement and the ecosystem restoration measures were evaluated at the traditional 50-year period of analysis used in Corps of Engineers studies. In order to show consistency among the plans recommended for construction, those measures that were initially screened at a 100-year period of analysis have been converted to a 50-year period of analysis for costs and benefits and are summarized in table 8-1. The costs in table 8-1 represent Rough Order Magnitude (ROM) utilized for screening. Detailed Micro-Computer Aided Cost Estimating System (MCACES) costs can be found in the cost estimating appendix.

Table 8-1.
Summaries of Benefits and Costs for Measures Recommended for Implementation[1]

	Equivalent Annual Damages Reduced Future 3 (Annual $)	Recreation (Annual $)	Environmental Impacts	Changes in Sales Volume ($)	Changes in Income ($)	Changes in Employment	Total First Cost with IDC ($)[2]	Average Annual Cost (Annual $)
Barrier Island Restoration	$18,028,000	$466,000	$43,618,000 Fishery Losses Avoided	$798,984,000	$167,850,000	4,920	$370,439,000	$20,372,000
Beach and Dune Placement	Moderate Reduction	N/A	736 Functional Habitat Index (FHI) Score	$33,413,200	$7,307,000	208	$15,890,800	$854,000
Acquisition in High Risk Areas	$22,000,000 to $33,000,000	Potential Recreational Opportunities	Potential Restoration Opportunities	$3,238,602,000	$706,330,000	19,452	$447,274,000	$18,532,000
Forrest Heights 21-FT Ring Levee	$89,000	N/A	3.6 Acres Impacted	$30,425,000	$6,440,000	193	$11,652,000	$740,000
Admiral Island Ecosystem Rest.	Increased Surge Storage	N/A	60 Average Annual Functional Units (AAFU)	$49,750,000	$ 11,996,000	301	$24,320,000	$1,364,000
Turkey Creek Ecosystem Rest.	Increased Surge Storage	N/A	1,565 Average Annual Functional Units (AAFU)	$15,237,000	$3,226,000	97	$6,017,000	$370,000
Bayou Cumbest Ecosystem Rest.	Increased Surge Storage	N/A	188 Average Annual Functional Units (AAFU)	$54,073,000	$ 10,546,000	306	$23,870,000	$1,396,000
Dantzler Ecosystem Rest.	Increased Surge Storage	N/A	1,244 Average Annual Functional Units (AAFU)	$ 5,054,000	$ 986,000	29	$1,922,000	$129,000
Franklin Creek Ecosystem	Increased Surge Storage	N/A	516 Average Annual Functional Units (AAFU)	$3,890,000	$ 759,000	22	$1,670,000	$101,000

1/ These measures were analyzed for economic benefits and do not represent the entire tentatively-selected plan features for implementation. See the main report for more detail.
2/ Implementation costs are based on ROM cost estimates at an FY 08 price level and do not include escalation. See the engineering appendix for more details on the costs.
3/ Average annual damages reduced and costs are based on a 50-year period of analysis and an FY 08 discount rate of 4.875-percent. Dollar values are rounded to the nearest thousand.

ADDENDUM A – HEC-FDA DEPTH DAMAGE FUNCTIONS

CHAPTER A-I. OVERVIEW

Damages for assets and contents were calculated using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. Damage of an structure and its contents are estimated as a function of stage, first floor elevation, depth of water in asset, percent of damage at each depth, and the value of the structure and its contents (see equation below). This function derives the stage damage in terms of dollar value damage for the structure and its contents. At each stage, the stage damage for all assets and their contents are aggregated to determine a total damage for each stage. The HEC-FDA model, described in detail in the Economic Appendix, applies a Monte Carlo simulation to the aggregated stage damage to determine Equivalent Annual Damages (EAD). The purpose of this addendum is to detail the depth-damage relationships (percent of damage at each depth) that were used in the HEC-FDA model runs, 2/ why they were used, 3/ how they were developed, and 4/ the uncertainty that is included within the relationships.

Stage Damage ($) = Stage – First Floor Elevation = water depth in structure = % damage x asset/content value

Depth-damage relationships are a mathematical function that describes the extent of damage to an structure and its contents for each foot of water that is deposited into the structure by a storm event. The general premise is that the entire structure and its contents are not damaged by just one foot of water within it, but increase as the water depth within the structure rises. Typically, depth-damage relationships are developed using a combination of observed data that is collected after a storm event and by expert elicitation. Depth-damage relationships take into account multiple variables such as whether the water is fresh water or salt water, the duration the water remains in the asset, the materials that the structure is constructed of, and whether a person or business occupies the asset.

A-1.1 Selection of Depth-Damage Relationships

The depth-damage relationships for assets and contents that were used in the HEC-FDA model runs for the Mississippi Coastal Improvement Program (MsCIP) Comprehensive Plan include generic relationships developed by the Institute for Water Resources and depth-damage relationships developed for the U.S. Army Corps of Engineers, New Orleans District. According to ER 1105-2-100, E-19q. (2), depth-damage relationships for feasibility studies should be developed either based on site-specific data or from comparable floodplain data. For this analysis, site-specific data was not readily available for use given the scope, complexity, and timing constraints pertaining to the MsCIP Comprehensive Plan Report; therefore, comparable floodplain data was used.

For residential structures, generic relationships for residential one-story and two-story assets and their contents are from The Corps of Engineers *Economic Guidance Memorandum (EGM) 01-03, Generic Depth Damage Relationships*. These relationships were developed for nation-wide applicability in flood damage reduction studies for assets without basements.

The depth-damage relationships used in association with commercial, municipal, and mobile home assets and their contents are those that were develop for the Lower Atchafalaya and Morganza Feasibility Studies. These relationships are saltwater short-term duration relationships, meaning that the period of inundation (the time that water is in the asset) is approximately twenty-four hours. The Lower Atchafalaya and Morganza short-duration relationships were specifically chosen because of the vast similarities between structures in Louisiana and the Mississippi Gulf Coast. These

similarities include building code requirements, quality of material and labor used for construction, size, and design, and other attributes that make the Lower Atchafalaya and Morganza short-duration relationships a perfect match for the MsCIP Comprehensive Plan Report. These curves are further described in section 1.4 of this addendum.

A-1.2 Uncertainty

A statistical definition of uncertainty is the 'estimated amount or percentage by which an observed or calculated value may differ from the true value.' Since depth-damage relationships are developed through data sampling and/or by using expert opinion, some amount of uncertainty naturally exists. To account for this uncertainty, each structure and content curve contains uncertainty bounds. For residential assets and their contents, a bell-curve distribution was used in which the mean and the standard deviation were input into the HEC-FDA model, and then the model accounted for two standard deviations of error, or approximately a ninety-five percent confidence level. For commercial and municipal assets and contents, an upper and lower bound surrounds a mean value.

The HEC-FDA model uses Monte Carlo simulation to randomly sample damage percentages at each stage. The random sampling allows for multiple values to be analyzed for depth-damage relationship. For example, one-foot of water depth within a Mobile Home asset, see Table A1-3 below, can equate to structure damage ranging from 42.5-percent to 53.6-percent to the Mobile Home. The Monte Carlo simulation used by the HEC-FDA model will select values within this range and determine a 'typical' damage for that one-foot water depth. Thus, the model incorporates the uncertainty of the depth-damage relationship in this process.

A-1.3 Residential Damage Relationships

Residential assets and their contents were divided into and analyzed as one-story, two-story, and mobile homes as per EGM 01-03. These residential relationships were developed based primarily on the findings of the Flood Damage Data Collection Program. According to EGM 01-03, "Proper planning and evaluation of flood damage reduction projects require knowledge of actual damage caused to various types of properties. The primary purpose of the Flood Damage Data Collection Program is to meet that requirement by providing Corps district offices with standardized relationships for estimating flood damage and other costs flooding that occurred in various parts of the United States in 1996, 1997, and 1998. Damage estimates are based on comprehensive accounting of losses from flood victims' records. The standardized functions represent a substantive improvement over other generalized depth-damage functions such as the Flood Insurance Administration (FIA) Rate Reviews." The residential depth-damage relationships for structure and content are shown in Tables 1, 2, and 3.

Table A1-1.
Residential One-Story Damage Relationship

Residential One-Story				
	Structure		Content	
Depth	Mean	Standard Deviation	Mean	Standard Deviation
-2	0%	0.0%	0%	0.0%
-1	2.5%	2.7%	2.4%	2.1%
0	13.4%	2.0%	8.1%	1.5%
1	23.3%	1.6%	13.3%	1.2%
2	32.1%	1.6%	17.9%	1.2%
3	40.1%	1.8%	22.0%	1.4%
4	47.1%	1.9%	25.7%	1.5%
5	53.2%	2.0%	28.8%	1.6%
6	58.6%	2.1%	31.5%	1.6%
7	63.2%	2.2%	33.8%	1.7%
8	67.2%	2.3%	35.7%	1.8%
9	70.5%	2.4%	37.2%	1.9%
10	73.2%	2.7%	38.4%	2.1%
11	75.4%	3.0%	39.2%	2.3%
12	77.2%	3.3%	39.7%	2.6%
13	78.5%	3.7%	40.0%	2.9%
14	79.5%	4.1%	40.0%	3.2%
15	80.2%	4.5%	40.0%	3.5%
16	80.7%	4.9%	40.0%	3.8%

[1] Source: EGM 01-01, 4 December, 2000

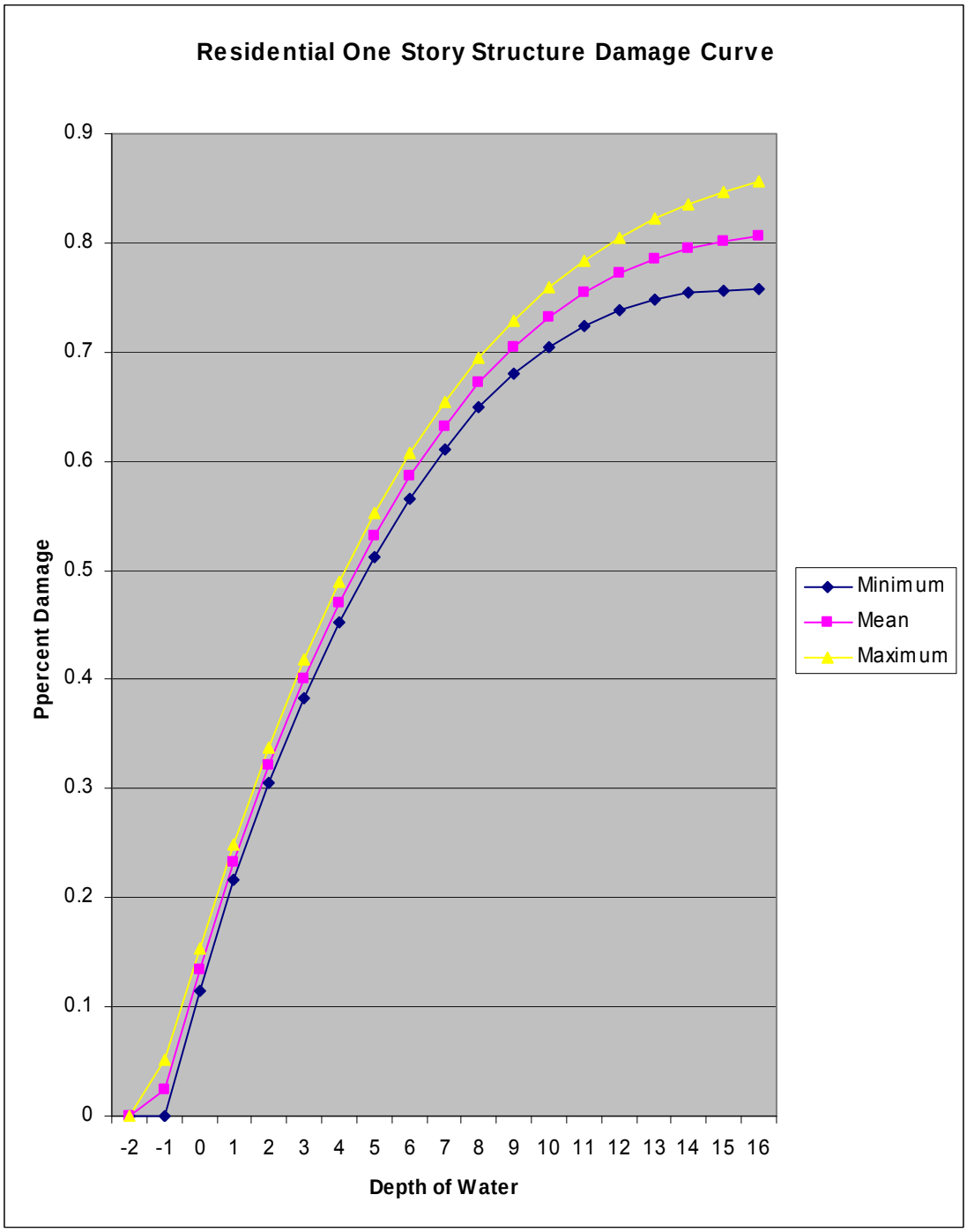


Figure A-1. Residential One-Story Structure Damage Relationship

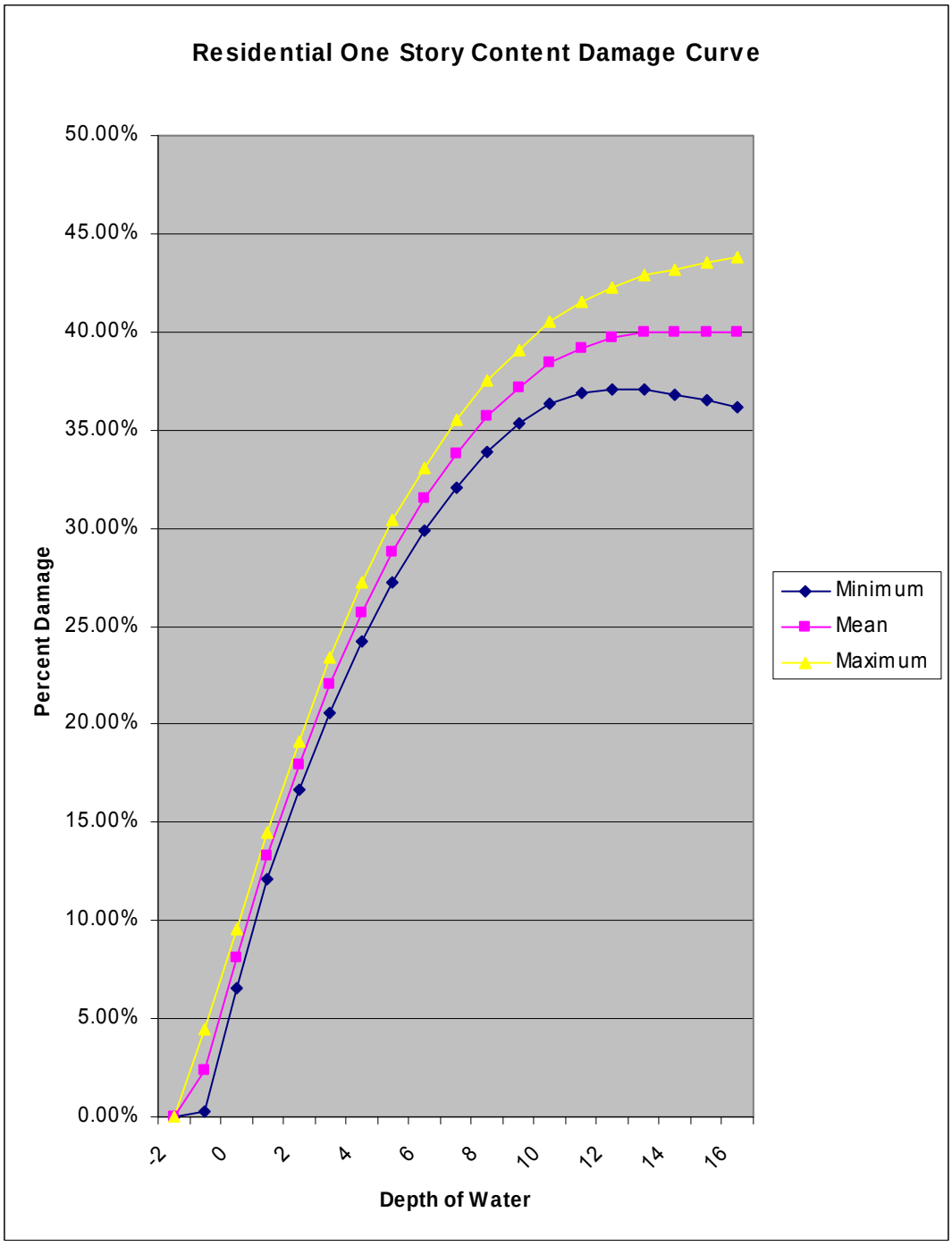


Figure A-2. Residential One-Story Content Damage Relationship

Table A1-2.
Residential Two-Story Damage Relationship

Residential Two-Story				
	Structure		Content	
Depth	Mean	Standard Deviation	Mean	Standard Deviation
-2	0%	0.0%	0%	0.0%
-1	3.0%	4.1%	1.0%	3.5%
0	9.3%	3.4%	5.0%	2.9%
1	15.2%	3.0%	8.7%	2.6%
2	20.9%	2.8%	12.2%	2.5%
3	26.3%	2.9%	15.5%	2.5%
4	31.4%	3.2%	18.5%	2.7%
5	36.2%	3.4%	21.3%	3.0%
6	40.7%	3.7%	23.9%	3.2%
7	44.9%	3.9%	26.3%	3.3%
8	48.8%	4.0%	28.4%	3.4%
9	52.4%	4.1%	30.3%	3.5%
10	55.7%	4.2%	32.0%	3.5%
11	58.7%	4.2%	33.4%	3.5%
12	61.4%	4.2%	34.7%	3.5%
13	63.8%	4.2%	35.6%	3.5%
14	65.9%	4.3%	36.4%	3.6%
15	67.7%	4.6%	36.9%	3.8%
16	89.2%	5.0%	37.2%	4.2%

[1] Source: EGM 01-01, 4 December, 2000

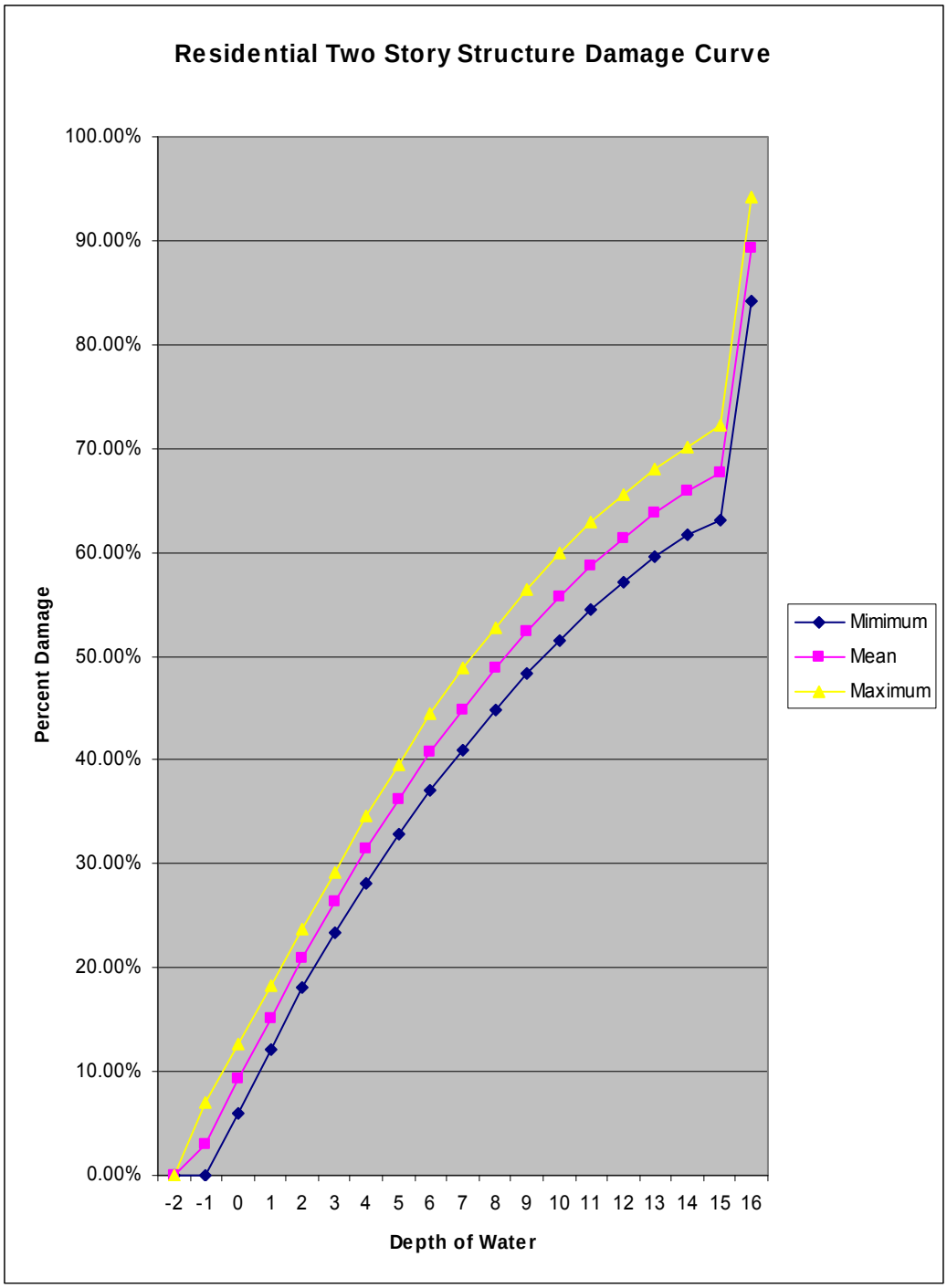


Figure A-3. Residential Two-Story Structure Damage Relationship

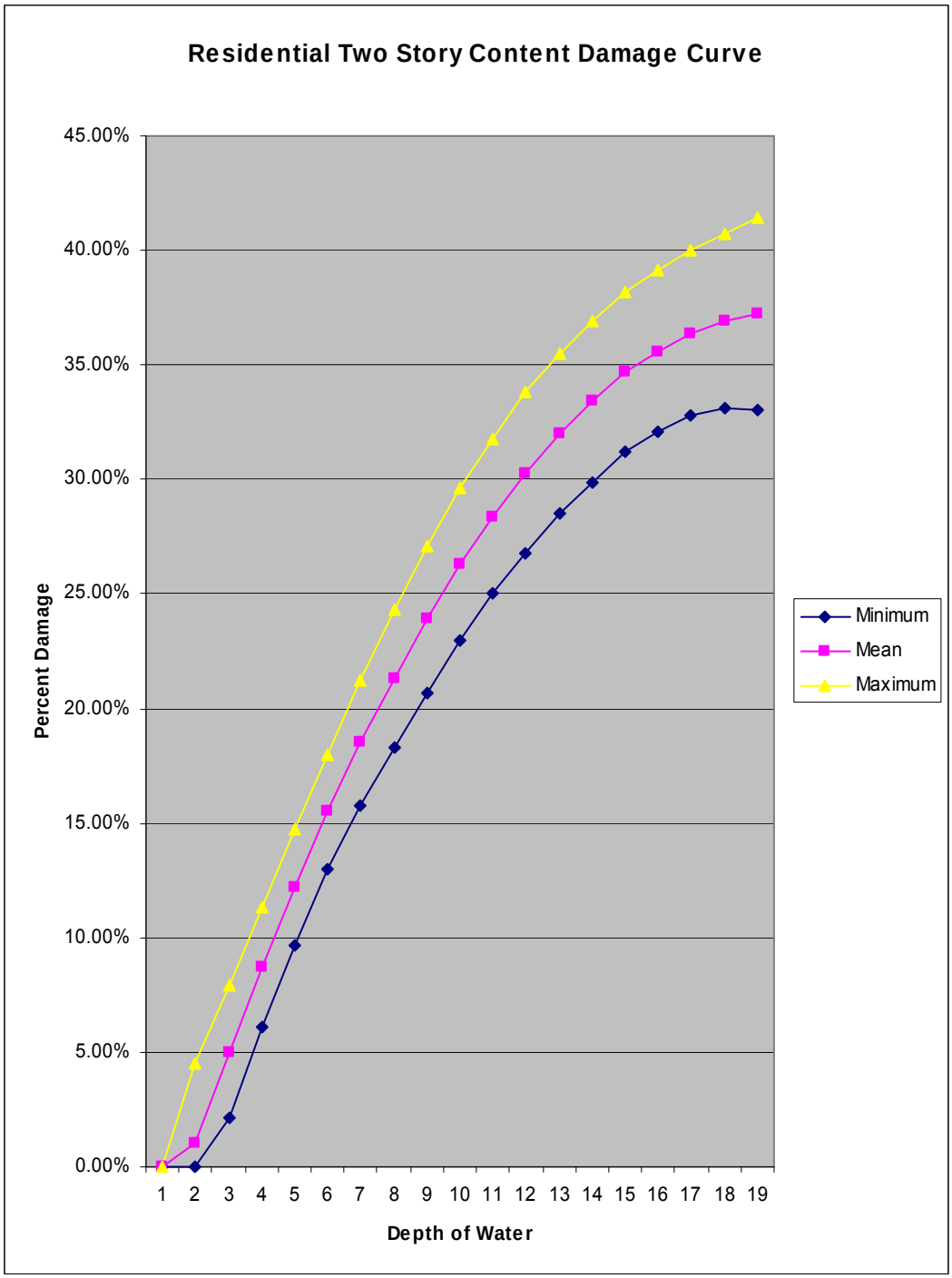


Figure A-4. Residential Two-Story Content Damage Relationship

Table A1-3.
Residential Mobile Home Damage Relationship

Residential: Mobile Homes						
	Structure			Content		
Depth	Mean	Minimum	Maximum	Mean	Minimum	Maximum
-1	6.4%	6.1%	7.7%	0.0%	0.0%	0.0%
-0.5	7.3%	6.9%	8.8%	0.0%	0.0%	0.0%
0	9.9%	9.4%	11.9%	0.0%	0.0%	0.0%
0.5	43.4%	41.2%	52.1%	36.7%	13.7%	48.0%
1	44.7%	42.5%	53.6%	45.4%	32.2%	53.7%
1.5	45.9%	43.6%	55.1%	48.8%	43.1%	53.7%
2	46.6%	44.3%	55.9%	64.3%	60.0%	73.3%
3	46.8%	44.5%	56.2%	71.2%	65.7%	73.9%
4	51.0%	48.5%	61.2%	82.2%	79.6%	84.5%
5	66.9%	63.5%	80.2%	92.1%	89.2%	94.7%
6	66.9%	63.5%	80.2%	92.3%	89.4%	94.9%
7	67.3%	64.0%	80.8%	95.7%	92.7%	100%
8	67.3%	64.0%	80.8%	95.7%	92.7%	100%
9	67.3%	64.0%	80.8%	95.7%	92.7%	100%
10	67.3%	64.0%	80.8%	95.7%	92.7%	100%
11	67.3%	64.0%	80.8%	95.7%	92.7%	100%
12	67.3%	64.0%	80.8%	95.7%	92.7%	100%
13	67.3%	64.0%	80.8%	95.7%	92.7%	100%
14	67.3%	64.0%	80.8%	95.7%	92.7%	100%
15	67.3%	64.0%	80.8%	95.7%	92.7%	100%

[1] Morganza to the Gulf, Louisiana Feasibility Studies, July 1997.

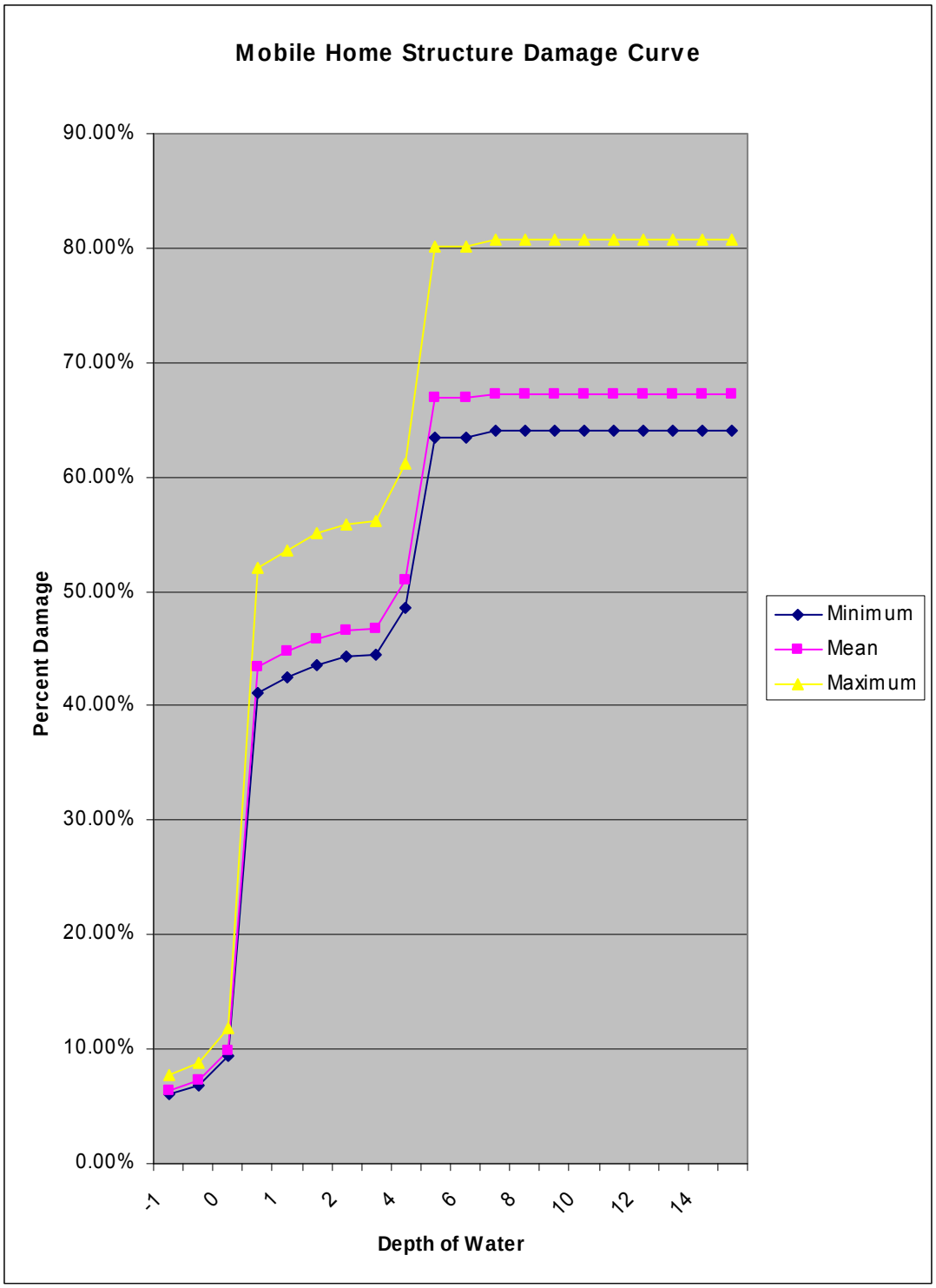


Figure A-5. Mobile Home Structure Damage Relationship

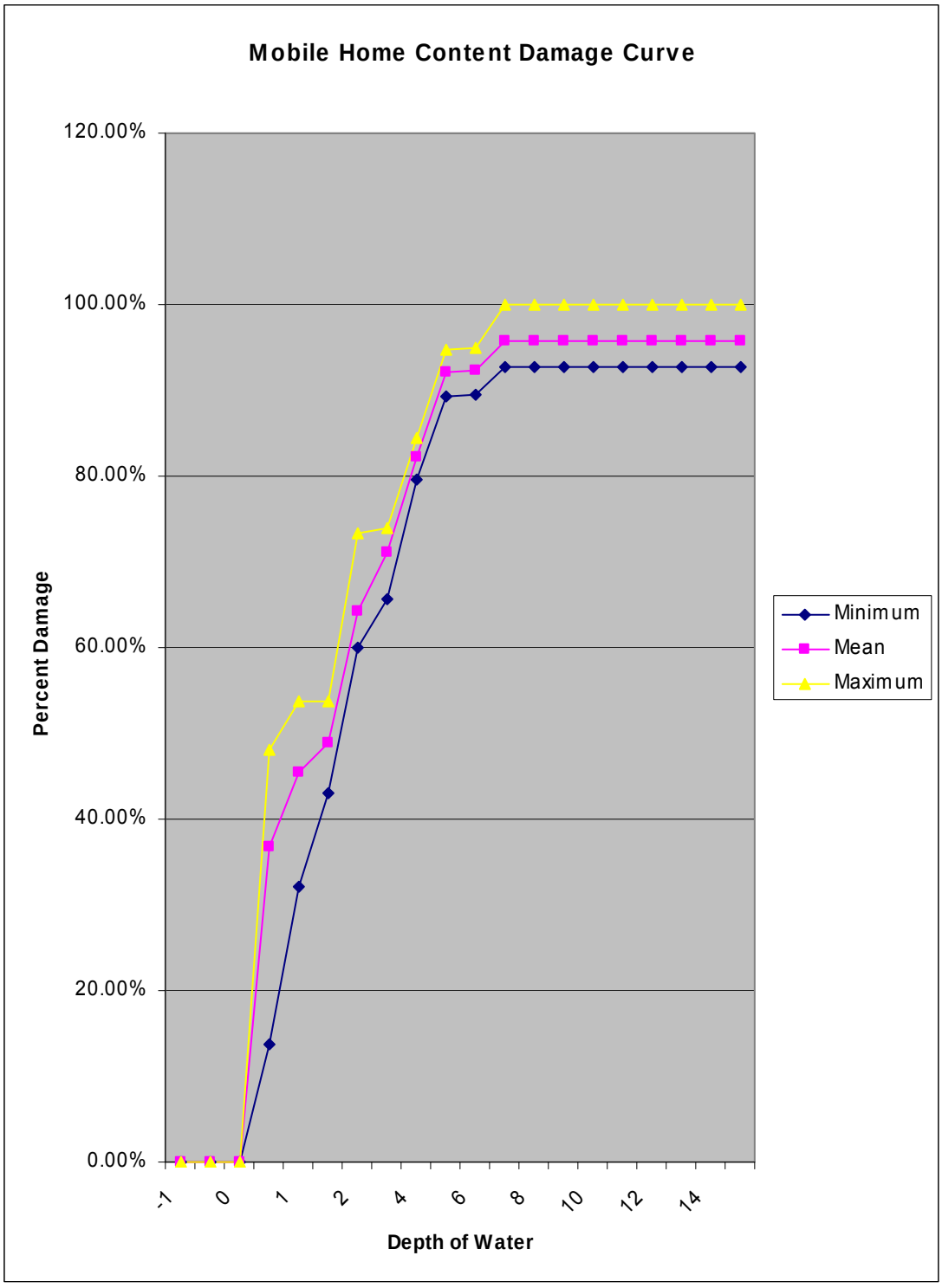


Figure A-6. Mobile Home Content Damage Relationship

A-1.4 Commercial Damage Relationships

Commercial and mobile home structure and content relationships are from the July 1997 final Report entitled Depth-Damaged Relationships for Assets, Contents, and Vehicles and Content-To-Asset Value Ratios (CSVR) in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies prepared for New Orleans District Corps of Engineers. These relationships are based on field surveys, interviews, and expert panel opinions. Interviews with commercial operators yielded owner/operator estimates of damage that would occur to assets and contents at various flooding levels. Expert panel opinions were based on the "Expert Opinion" method described in the Handbook of Forecasting Techniques (IWR Contract Report 75-7, December 1975) and the Handbook of Forecasting Techniques, Part II, Description of 31 Techniques (Supplement of IWR Contract Report 75-7, August 1977). The panel was asked to determine depth-damage relationships for typical assets in the Lower Atchafalaya and Morganza study areas. The depth-damage relationship is the expected amount of damage either in dollars, or as a percentage of total value for each foot of flooding above or below the first floor of a asset. Commercial structure types were categorized as metal frame, masonry bearing walls, and wood or steel frame walls. However, commercial content categories were divided into the following types: (1) eating and recreation, (2) groceries and gas stations, (3) multi-family residences, (4) repair and home use, (5) retail and personal services, (6) professional business, (7) public, semi-public, and (8) warehouse and contractor services. The commercial depth-damage relationships for structure and content are shown in Tables 4 to 11.

Table A1-4.
Commercial Eating and Recreation Damage Relationship

Commercial: Eating and Recreation						
	Structure Type: Masonry Bearing Walls			Content		
Depth	Mean	Minimum	Maximum	Mean	Minimum	Maximum
-1	0%	0%	0%	0.0%	0.0%	0.0%
-0.5	0%	0%	0%	0.0%	0.0%	0.0%
0	1.8%	1.6%	2.1%	0.0%	0.0%	0.0%
0.5	13.2%	12.3%	15.9%	18.7%	16.8%	22.4%
1	13.2%	12.3%	15.9%	25.0%	22.5%	30.1%
1.5	18.9%	17.0%	22.7%	46.8%	42.1%	56.1%
2	19.1%	17.2%	23.5%	50.2%	45.2%	60.3%
3	24.7%	21.7%	29.6%	80.3%	72.3%	96.4%
4	29.0%	24.6%	36.2%	95.8%	86.2%	100%
5	32.5%	27.6%	40.6%	98.2%	88.4%	100%
6	32.5%	27.6%	40.6%	99.1%	89.2%	100%
7	32.5%	27.6%	40.6%	100%	90.0%	100%
8	35.1%	29.8%	43.9%	100%	90.0%	100%
9	46.5%	39.5%	58.1%	100%	90.0%	100%
10	53.3%	45.3%	66.6%	100%	90.0%	100%
11	57.7%	45.3%	66.6%	100%	90.0%	100%
12	57.7%	49.0%	72.1%	100%	90.0%	100%
13	57.7%	49.0%	72.1%	100%	90.0%	100%
14	57.7%	49.0%	72.1%	100%	90.0%	100%
15	57.7%	49.0%	72.1%	100%	90.0%	100%

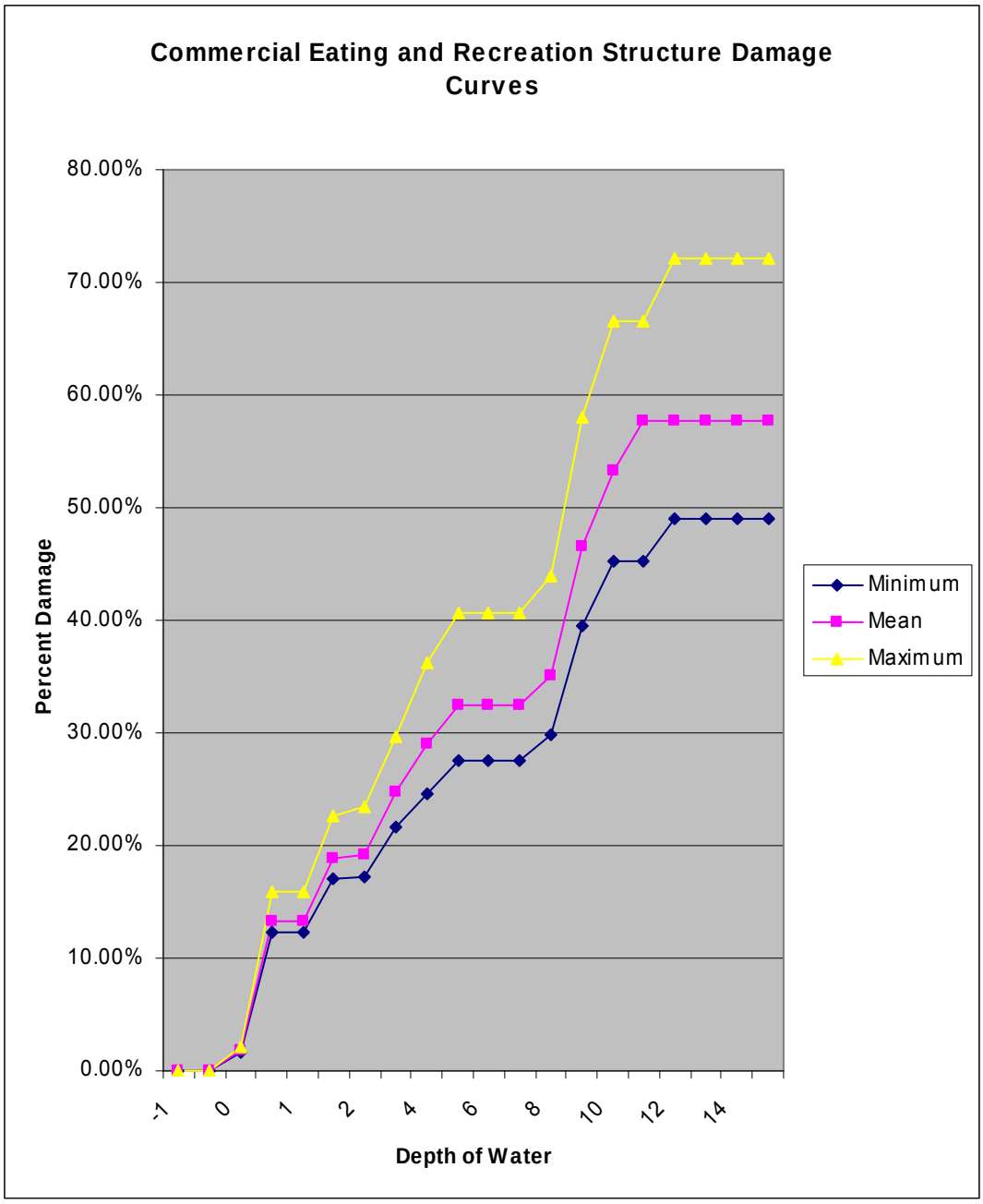


Figure A-7. Eating and Recreation Structure Damage Relationship

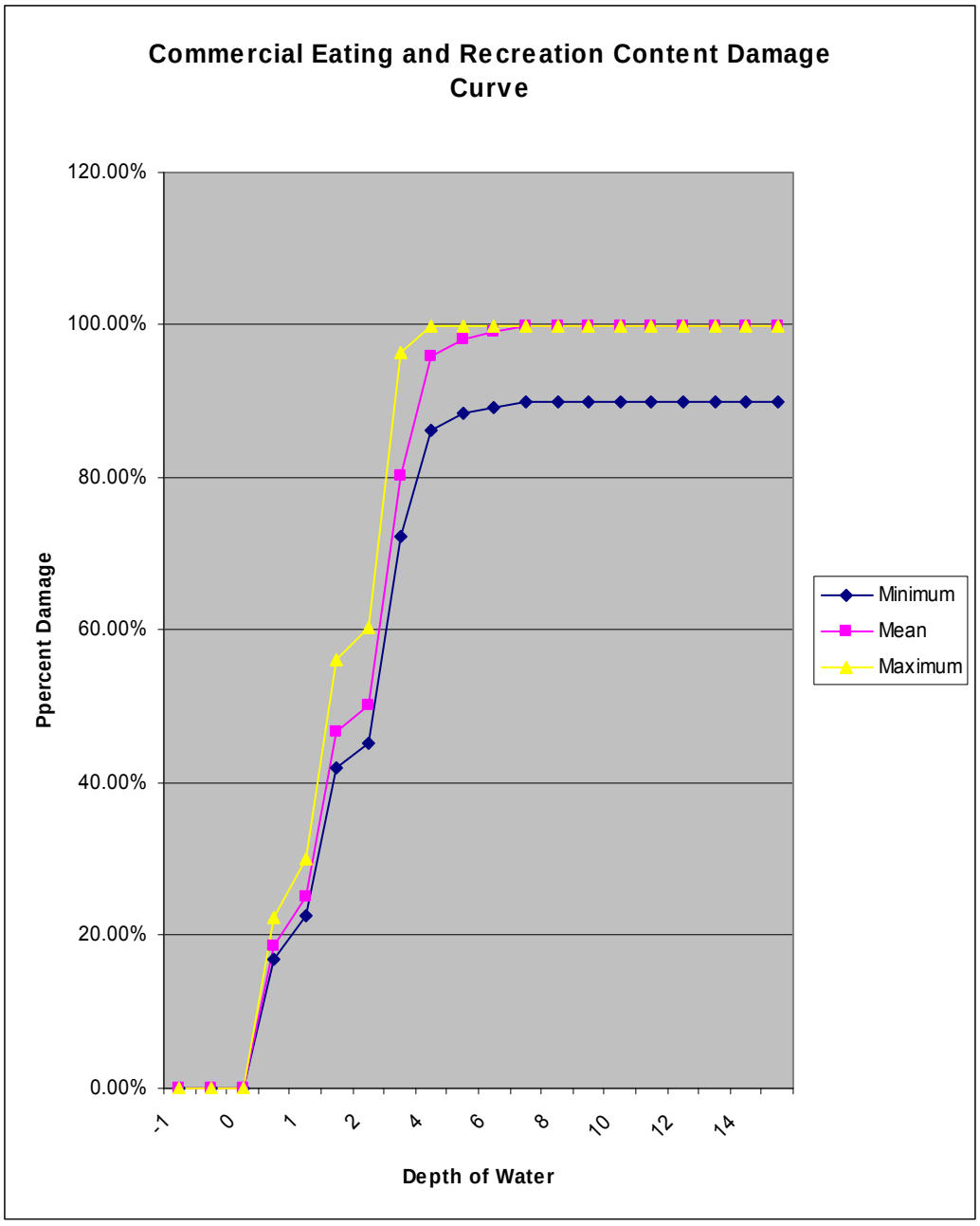


Figure A-8. Eating and Recreation Content Damage Relationship

Table A1-5.
Commercial Grocery and Gas Station Damage Relationship

Commercial: Gas Station and Grocery Store						
	Structure Type Masonry Bearing Walls			Content		
Depth	**Mean**	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
-1	0%	0%	0%	0.0%	0.0%	0.0%
-0.5	0%	0%	0%	0.0%	0.0%	0.0%
0	1.8%	1.6%	2.1%	0.0%	0.0%	0.0%
0.5	13.2%	12.3%	15.9%	18.7%	16.8%	22.4%
1	13.2%	12.3%	15.9%	25.0%	22.5%	30.1%
1.5	18.9%	17.0%	22.7%	46.8%	42.1%	56.1%
2	19.1%	17.2%	23.5%	50.2%	45.2%	60.3%
3	24.7%	21.7%	29.6%	80.3%	72.3%	96.4%
4	29.0%	24.6%	36.2%	95.8%	86.2%	100%
5	32.5%	27.6%	40.6%	98.2%	88.4%	100%
6	32.5%	27.6%	40.6%	99.1%	89.2%	100%
7	32.5%	27.6%	40.6%	100%	90.0%	100%
8	35.1%	29.8%	43.9%	100%	90.0%	100%
9	46.5%	39.5%	58.1%	100%	90.0%	100%
10	53.3%	45.3%	66.6%	100%	90.0%	100%
11	53.3%	45.3%	66.6%	100%	90.0%	100%
12	57.7%	49.0%	72.1%	100%	90.0%	100%
13	57.7%	49.0%	72.1%	100%	90.0%	100%
14	57.7%	49.0%	72.1%	100%	90.0%	100%
15	57.7%	49.0%	72.1%	100%	90.0%	100%

[1] Morganza to the Gulf, Louisiana Feasibility Studies, July 1997.

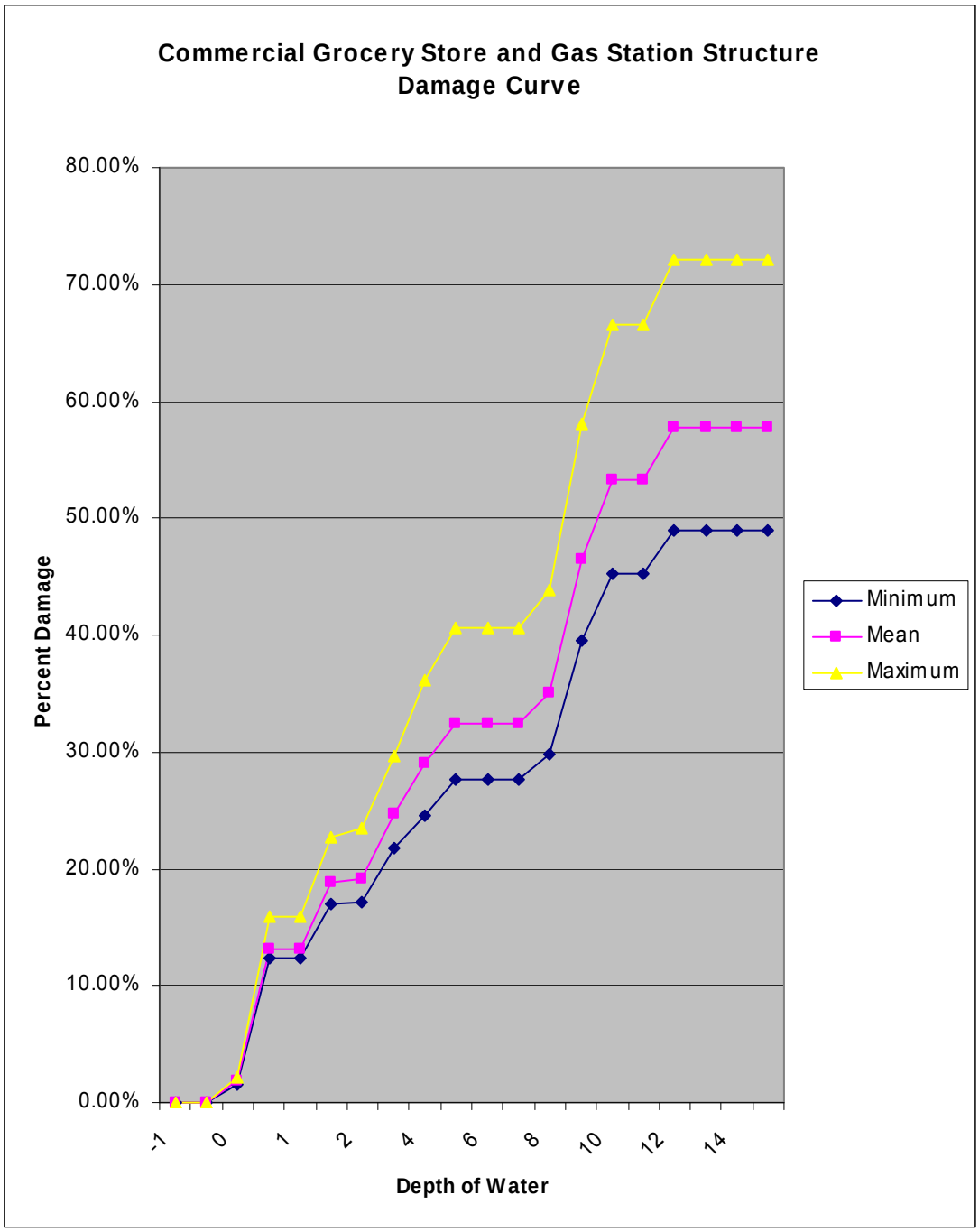


Figure A-9. Grocery Store and Gas Station Structure Damage Relationship

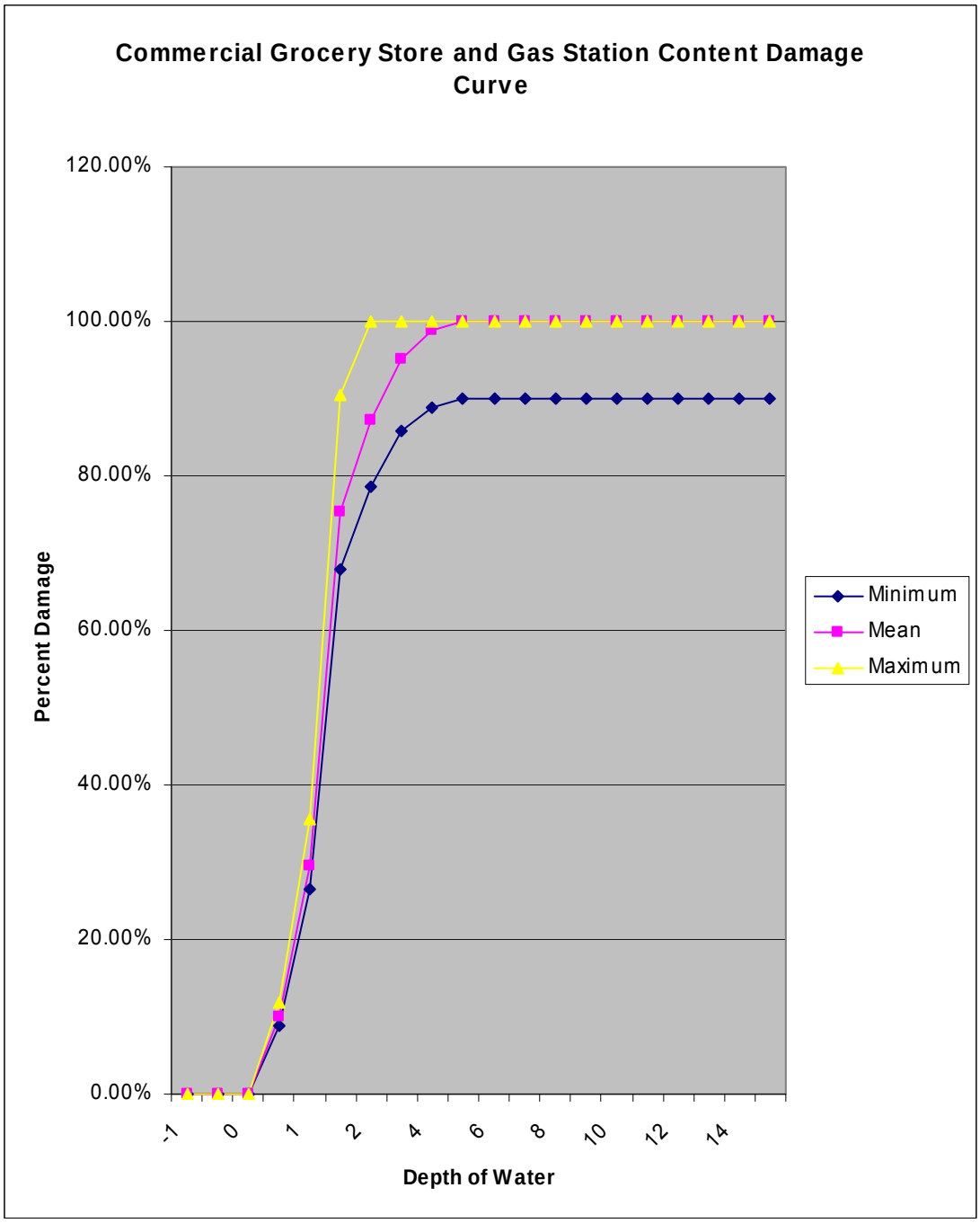


Figure A-10. Grocery Store and Gas Station Content Damage Relationship

Table A1-6.
Municipal Damage Relationship

Municipal Structures						
	Structure Type Masonry Bearing Walls			Content		
Depth	**Mean**	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
-1	0%	0%	0%	0.0%	0.0%	0.0%
-0.5	0%	0%	0%	0.0%	0.0%	0.0%
0	1.8%	1.6%	2.1%	0.0%	0.0%	0.0%
0.5	13.2%	12.3%	15.9%	40.0%	36.0%	50.0%
1	13.2%	12.3%	15.9%	72.0%	64.8%	90%
1.5	18.9%	17.0%	22.7%	72.0%	64.8%	90%
2	19.1%	17.2%	23.5%	72.0%	64.8%	90%
3	24.7%	21.7%	29.6%	99.7%	89.7%	100%
4	29.0%	24.6%	36.2%	100%	90%	100%
5	32.5%	27.6%	40.6%	100%	90%	100%
6	32.5%	27.6%	40.6%	100%	90%	100%
7	32.5%	27.6%	40.6%	100%	90%	100%
8	35.1%	29.8%	43.9%	100%	90%	100%
9	46.5%	39.5%	58.1%	100%	90%	100%
10	53.3%	45.3%	66.6%	100%	90%	100%
11	53.3%	45.3%	66.6%	100%	90%	100%
12	57.7%	49.0%	72.1%	100%	90%	100%
13	57.7%	49.0%	72.1%	100%	90%	100%
14	57.7%	49.0%	72.1%	100%	90%	100%
15	57.7%	49.0%	72.1%	100%	90%	100%

[1] Morganza to the Gulf, Louisiana Feasibility Studies, July 1997.

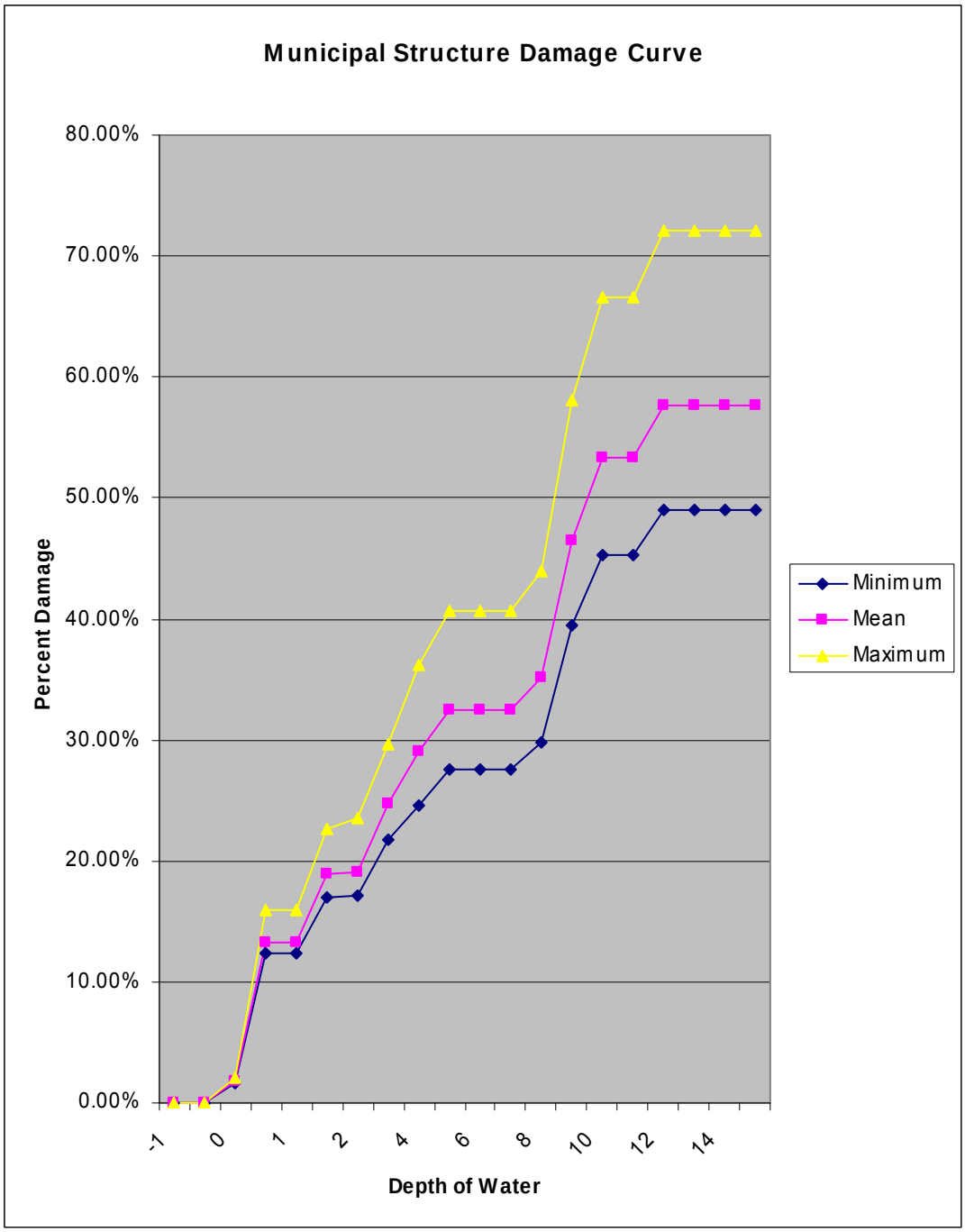


Figure A-11. Municipal Structure Damage Relationship

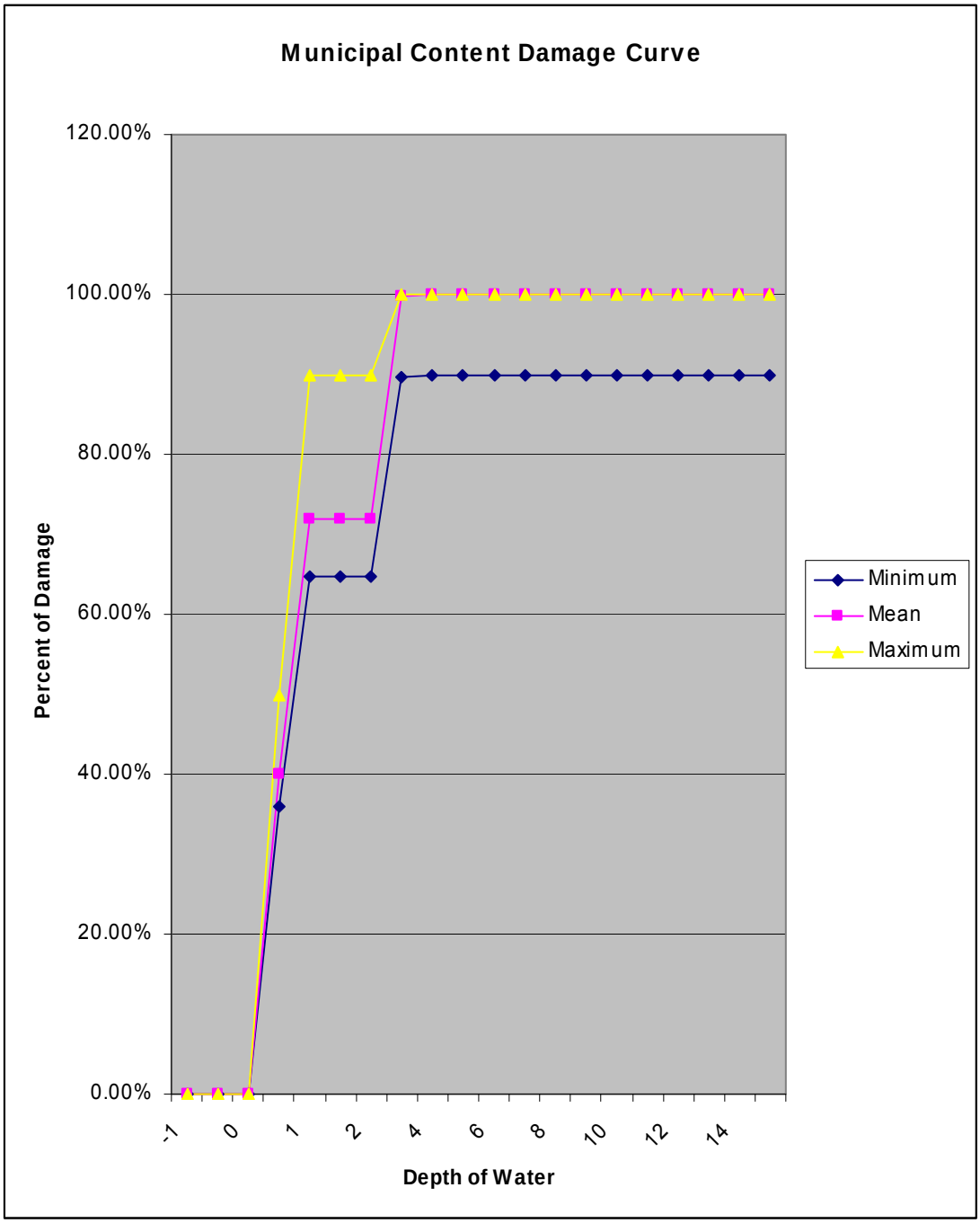


Figure A-12. Municipal Content Damage Relationship

Table A1-7.
Retail and Personal Services Damage Relationship

Commercial: Retail and Personal Services						
	Structure Type Masonry Bearing Walls			Content		
Depth	**Mean**	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
-1	0%	0%	0%	0.0%	0.0%	0.0%
-0.5	0%	0%	0%	0.0%	0.0%	0.0%
0	1.8%	1.6%	2.1%	0.0%	0.0%	0.0%
0.5	13.2%	12.3%	15.9%	12.0%	10.8%	14.4%
1	13.2%	12.3%	15.9%	25.3%	22.7%	30.3%
1.5	18.9%	17.0%	22.7%	36.6%	32.9%	43.9%
2	19.1%	17.2%	23.5%	60.5%	54.5%	72.6%
3	24.7%	21.7%	29.6%	75.4%	67.8%	90.5%
4	29.0%	24.6%	36.2%	85.1%	76.6%	100%
5	32.5%	27.6%	40.6%	94.5%	85.0%	100%
6	32.5%	27.6%	40.6%	100%	90.0%	100%
7	32.5%	27.6%	40.6%	100%	90.0%	100%
8	35.1%	29.8%	43.9%	100%	90.0%	100%
9	46.5%	39.5%	58.1%	100%	90.0%	100%
10	53.3%	45.3%	66.6%	100%	90.0%	100%
11	53.3%	45.3%	66.6%	100%	90.0%	100%
12	57.7%	49.0%	72.1%	100%	90.0%	100%
13	57.7%	49.0%	72.1%	100%	90.0%	100%
14	57.7%	49.0%	72.1%	100%	90.0%	100%
15	57.7%	49.0%	72.1%	100%	90.0%	100%

[1] Morganza to the Gulf, Louisiana Feasibility Studies, July 1997.

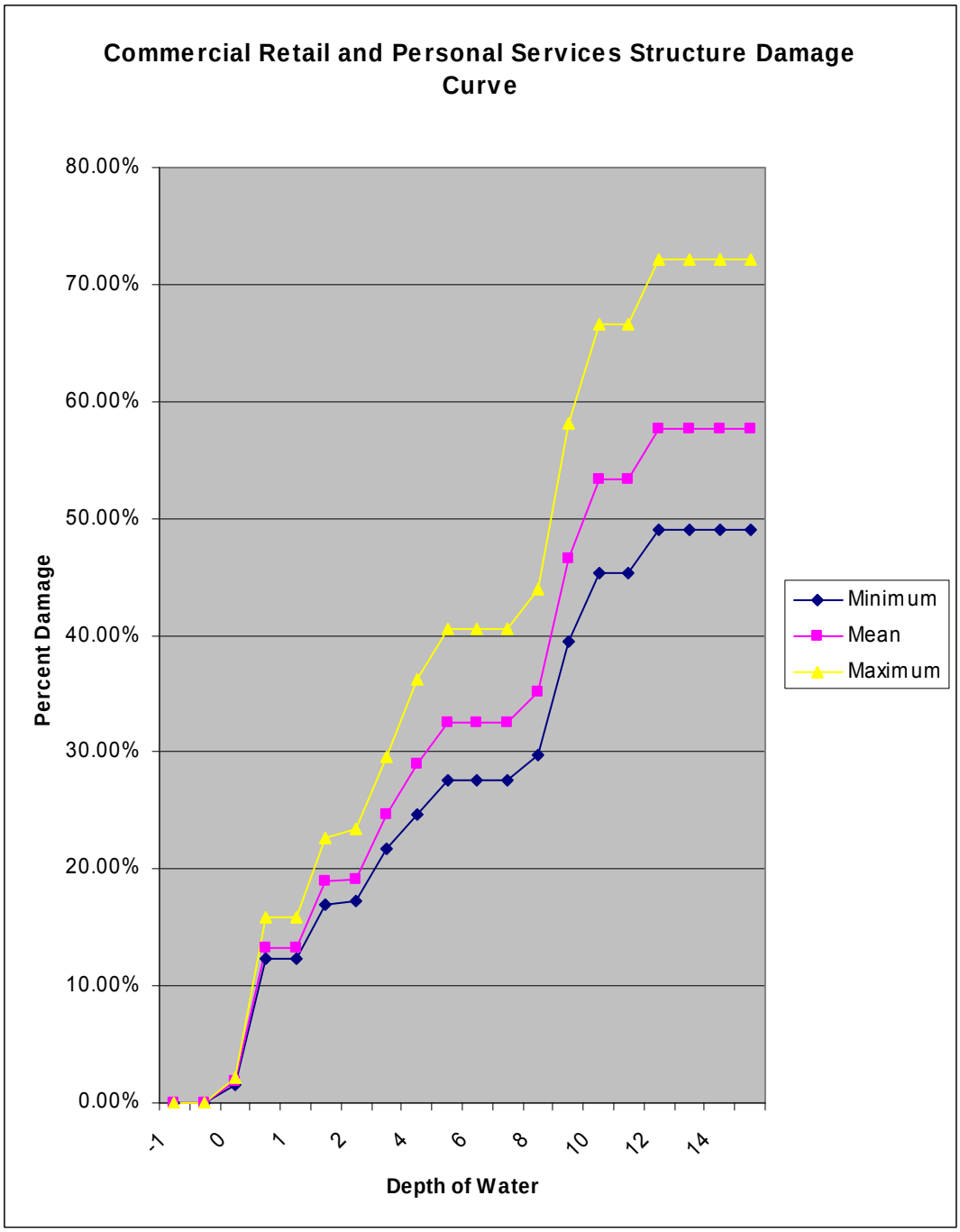


Figure A-13. Retail and Personal Services Structure Damage Relationship

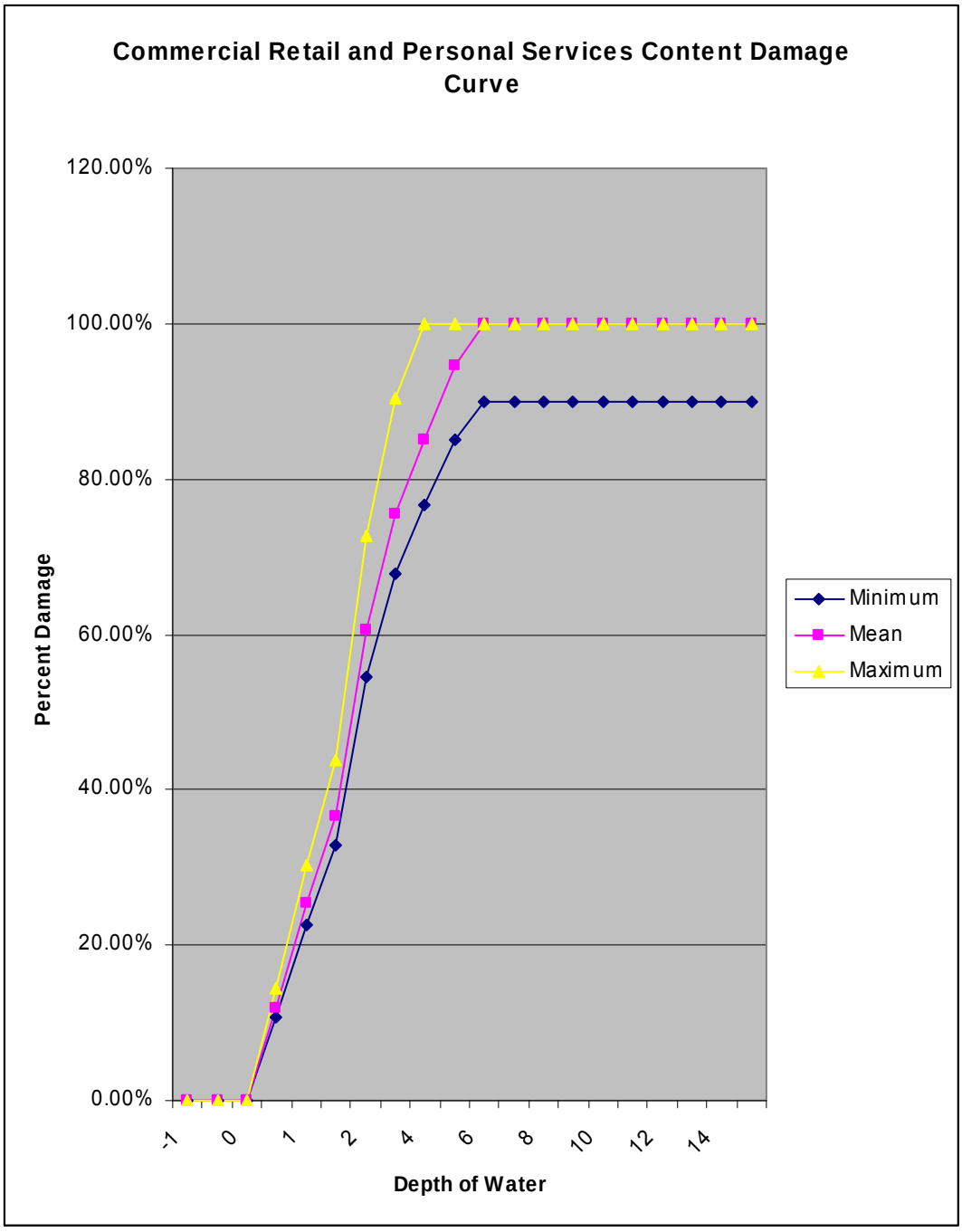


Figure A-14. Retail and Personal Services Content Damage Relationship

Table A1-8.
Multi-Family Damage Relationship

Municipal Structures						
	Structure Type Wood or Steel Frame			Content		
Depth	**Mean**	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
-1	0%	0%	0%	0.0%	0.0%	0.0%
-0.5	0%	0%	0%	0.0%	0.0%	0.0%
0	1.1%	1.0%	1.3%	0.0%	0.0%	0.0%
0.5	20.1%	18.7%	24.1%	7.9%	3.0%	10.3%
1	20.1%	18.7%	24.1%	15.3%	10.9%	18.1%
1.5	25.8%	18.7%	31.0%	18.8%	16.6%	20.5%
2	29.9%	23.2%	36.7%	23.5%	21.9%	26.7%
3	34.0%	26.9%	40.8%	39.7%	36.6%	41.2%
4	40.7%	29.9%	50.9%	45.3%	43.8%	46.5%
5	49.0%	34.6%	61.3%	47.2%	45.7%	48.5%
6	49.0%	41.7%	61.3%	47.2%	45.7%	48.5%
7	50.8%	41.7%	63.6%	47.2%	45.7%	50.3%
8	52.4%	43.2%	65.5%	47.2%	45.7%	50.3%
9	57.3%	44.5%	71.6%	47.2%	45.7%	50.3%
10	57.3%	48.7%	71.6%	55.1%	50.6%	72.1%
11	57.3%	48.7%	71.6%	66.0%	58.4%	72.1%
12	60.4%	51.3%	75.4%	86.9%	80.2%	90.2%
13	60.4%	51.3%	75.4%	92.5%	89.5%	95.1%
14	60.4%	51.3%	75.4%	94.4%	91.4%	97.1%
15	60.4%	51.3%	75.4%	94.4%	91.4%	97.1%

[1] Morganza to the Gulf, Louisiana Feasibility Studies, July 1997.

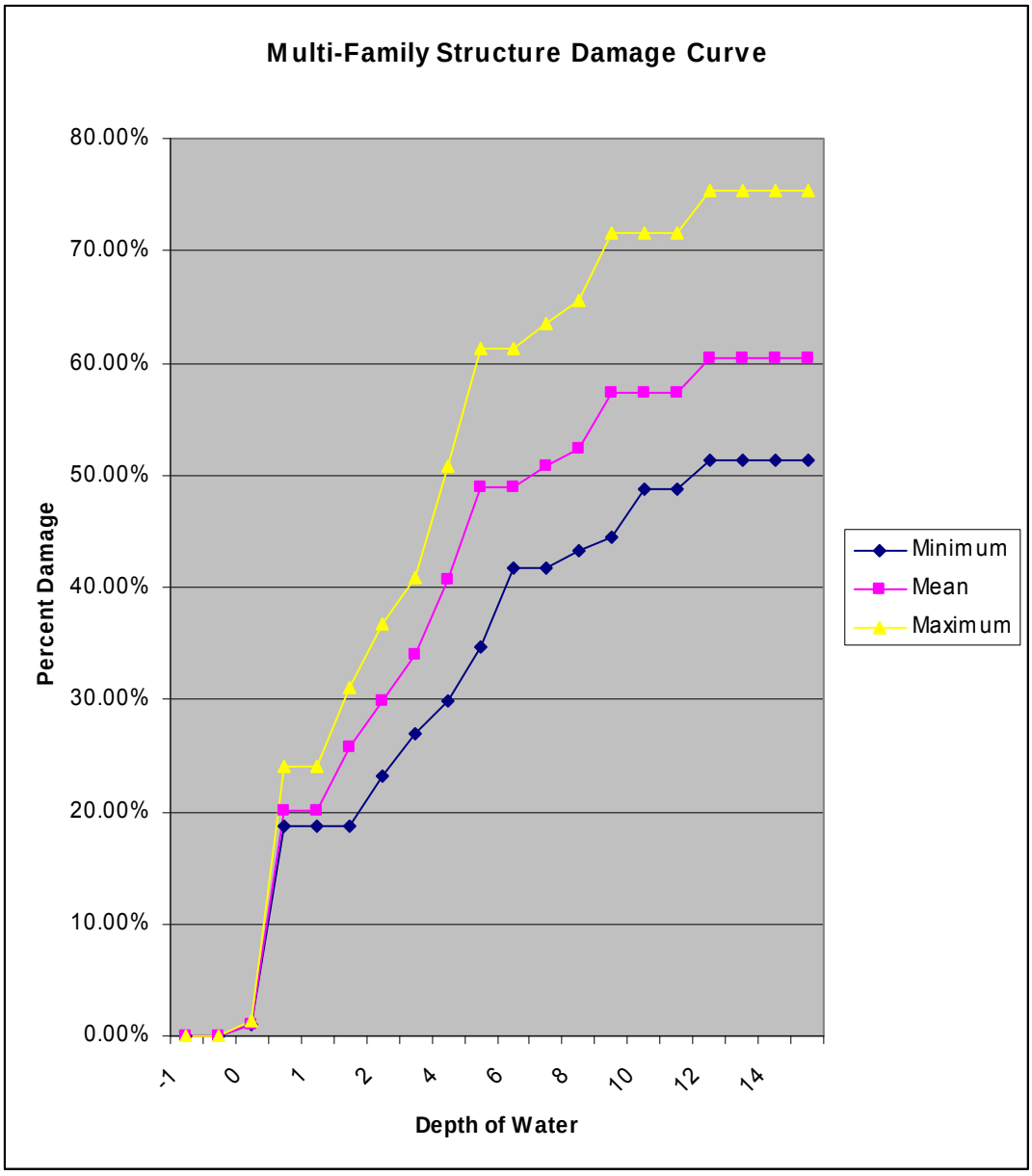


Figure A-15. Multi-Family Structure Damage Relationship

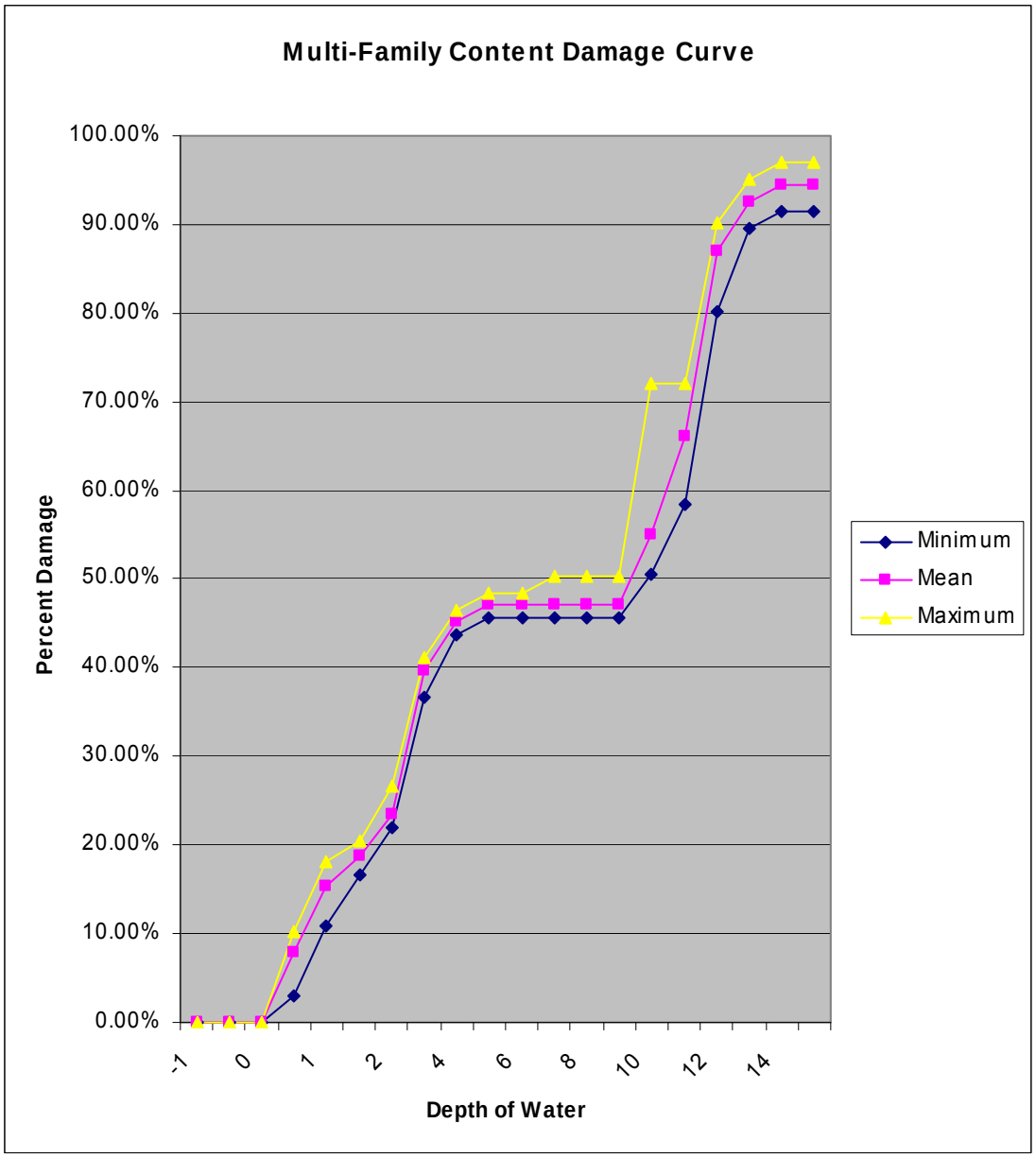


Figure A-16. Multi-Family Content Damage Relationship

Table A1-9.
Professional Businesses Damage Relationship

Professional Business Structures						
	Structure Type Wood or Steel Frame			Content		
Depth	**Mean**	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
-1	0%	0%	0%	0.0%	0.0%	0.0%
-0.5	0%	0%	0%	0.0%	0.0%	0.0%
0	1.1%	1.0%	1.3%	0.0%	0.0%	0.0%
0.5	20.1%	18.7%	24.1%	14.8%	13.3%	18.4%
1	20.1%	18.7%	24.1%	18.6%	16.7%	23.2%
1.5	25.8%	18.7%	31.0%	33.3%	30.0%	41.6%
2	29.9%	23.2%	36.7%	39.0%	35.1%	48.8%
3	34.0%	26.9%	40.8%	74.6%	67.1%	93.2%
4	40.7%	29.9%	50.9%	92.2%	83.0%	100%
5	49.0%	34.6%	61.3%	94.1%	84.7%	100%
6	49.0%	41.7%	61.3%	100%	90.0%	100%
7	50.8%	41.7%	63.6%	100%	90.0%	100%
8	52.4%	43.2%	65.5%	100%	90.0%	100%
9	57.3%	44.5%	71.6%	100%	90.0%	100%
10	57.3%	48.7%	71.6%	100%	90.0%	100%
11	57.3%	48.7%	71.6%	100%	90.0%	100%
12	60.4%	51.3%	75.4%	100%	90.0%	100%
13	60.4%	51.3%	75.4%	100%	90.0%	100%
14	60.4%	51.3%	75.4%	100%	90.0%	100%
15	60.4%	51.3%	75.4%	100%	90.0%	100%

[1] Morganza to the Gulf, Louisiana Feasibility Studies, July 1997.

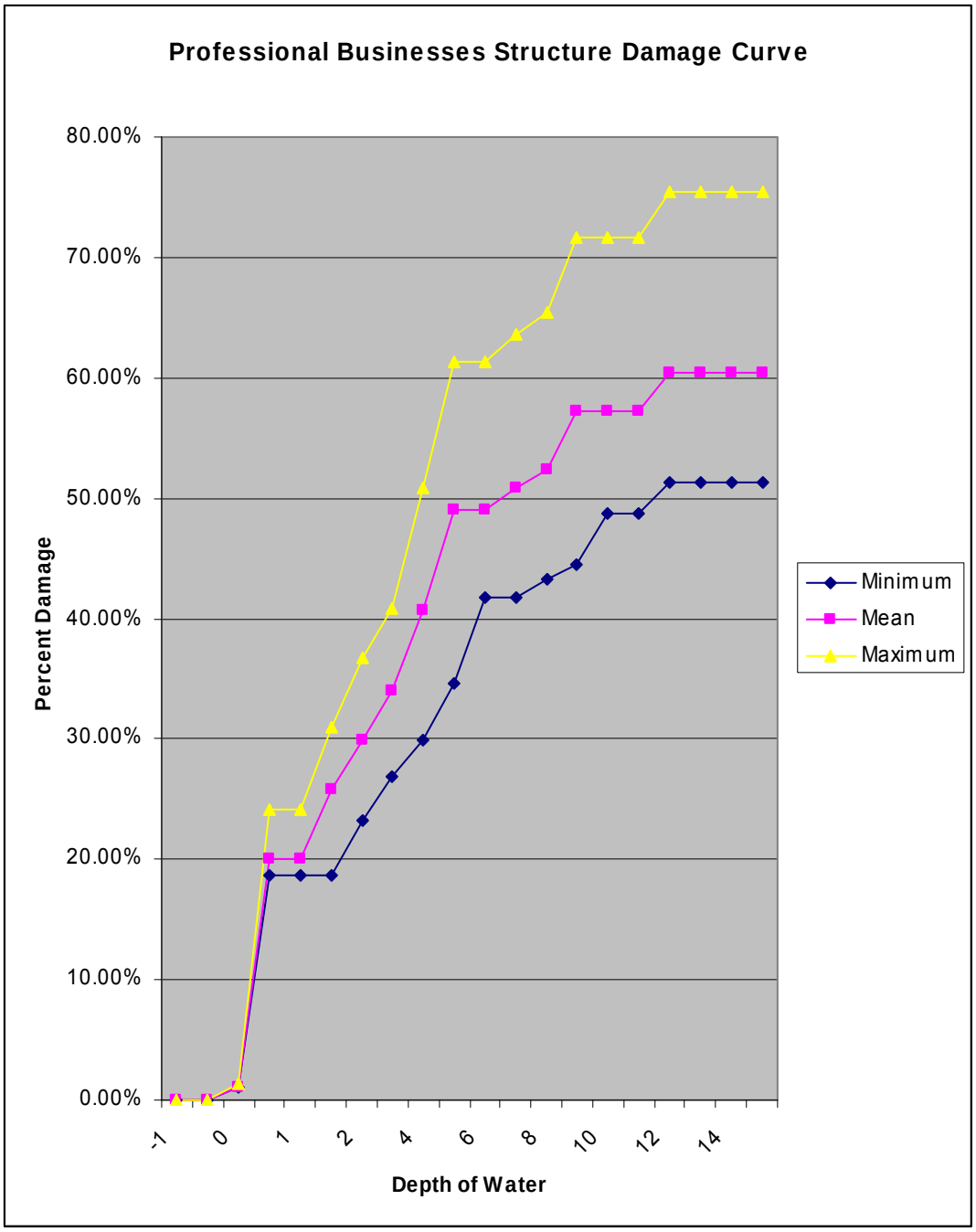


Figure A-17. Professional Businesses Structure Damage Relationship

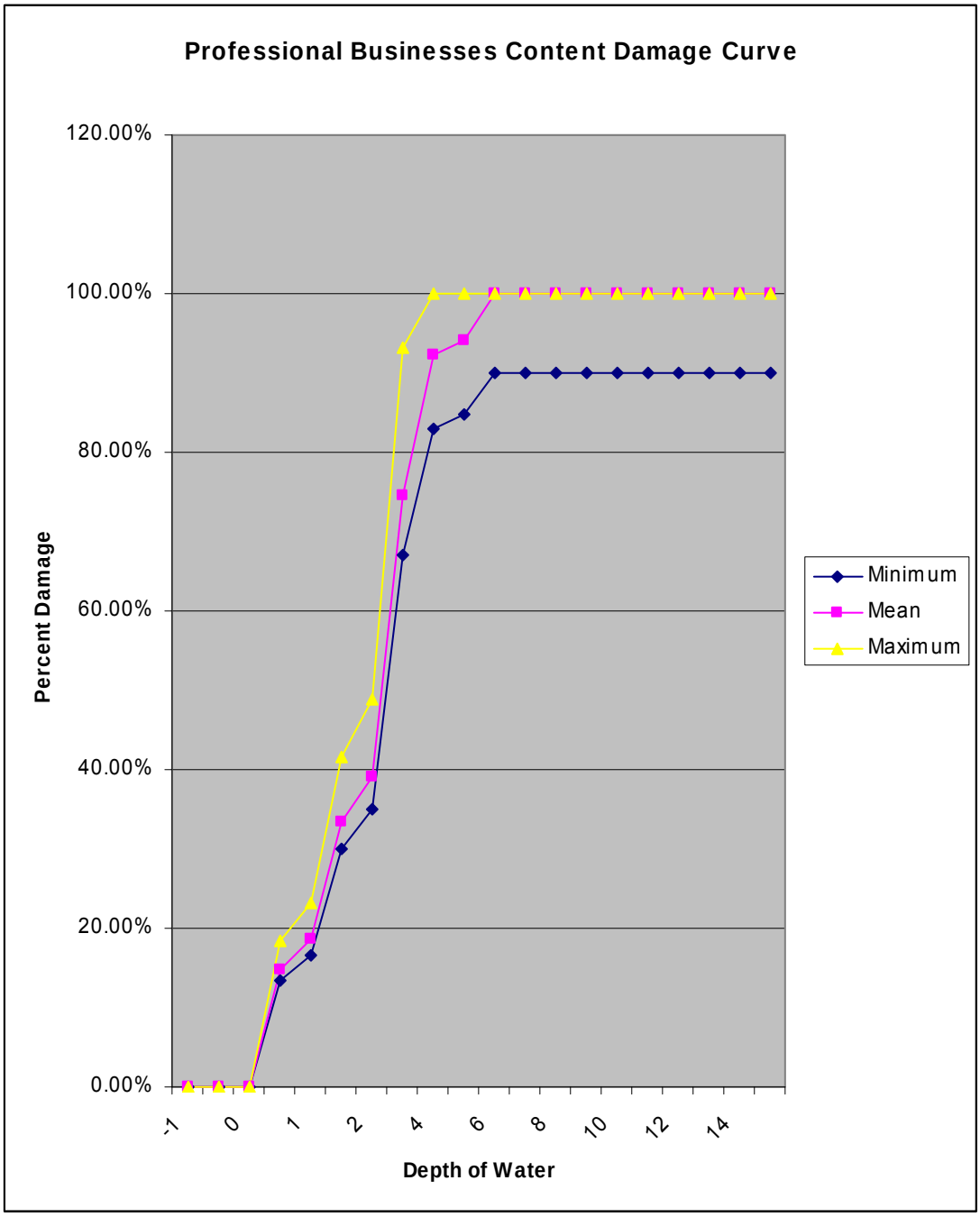


Figure A-18. Professional Businesses Content Damage Relationship

Table A1-10.
Commercial Repair and Home Damage Relationship

Commercial Repair and Home Use						
	Structure Type Wood or Steel			Content		
Depth	**Mean**	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
-1	0%	0%	0%	0.0%	0.0%	0.0%
-0.5	0%	0%	0%	0.0%	0.0%	0.0%
0	1.1%	1.0%	1.3%	0.0%	0.0%	0.0%
0.5	13.0%	12.1%	15.6%	14.6%	13.1%	17.5%
1	13.0%	12.1%	15.6%	20.6%	18.5%	24.7%
1.5	18.2%	16.4%	21.9%	31.8%	28.6%	38.2%
2	18.7%	16.9%	23.0%	32.8%	29.5%	39.3%
3	22.3%	19.6%	26.7%	66.0%	59.4%	79.2%
4	26.9%	22.8%	33.6%	67.4%	60.7%	80.9%
5	28.7%	24.4%	35.9%	68.8%	62.0%	82.6%
6	28.7%	24.4%	35.9%	76.9%	69.3%	92.3%
7	28.7%	24.4%	35.9%	79.9%	71.9%	95.9%
8	32.5%	27.6%	40.6%	79.9%	71.9%	95.9%
9	39.9%	34.0%	49.9%	79.9%	71.9%	95.9%
10	39.9%	34.0%	49.9%	79.9%	71.9%	95.9%
11	39.9%	34.0%	49.9%	79.9%	71.9%	95.9%
12	39.9%	34.0%	49.9%	79.9%	71.9%	95.9%
13	39.9%	34.0%	49.9%	79.9%	71.9%	95.9%
14	39.9%	34.0%	49.9%	79.9%	71.9%	95.9%
15	39.9%	34.0%	49.9%	79.9%	71.9%	95.9%

[1] Morganza to the Gulf, Louisiana Feasibility Studies, July 1997.

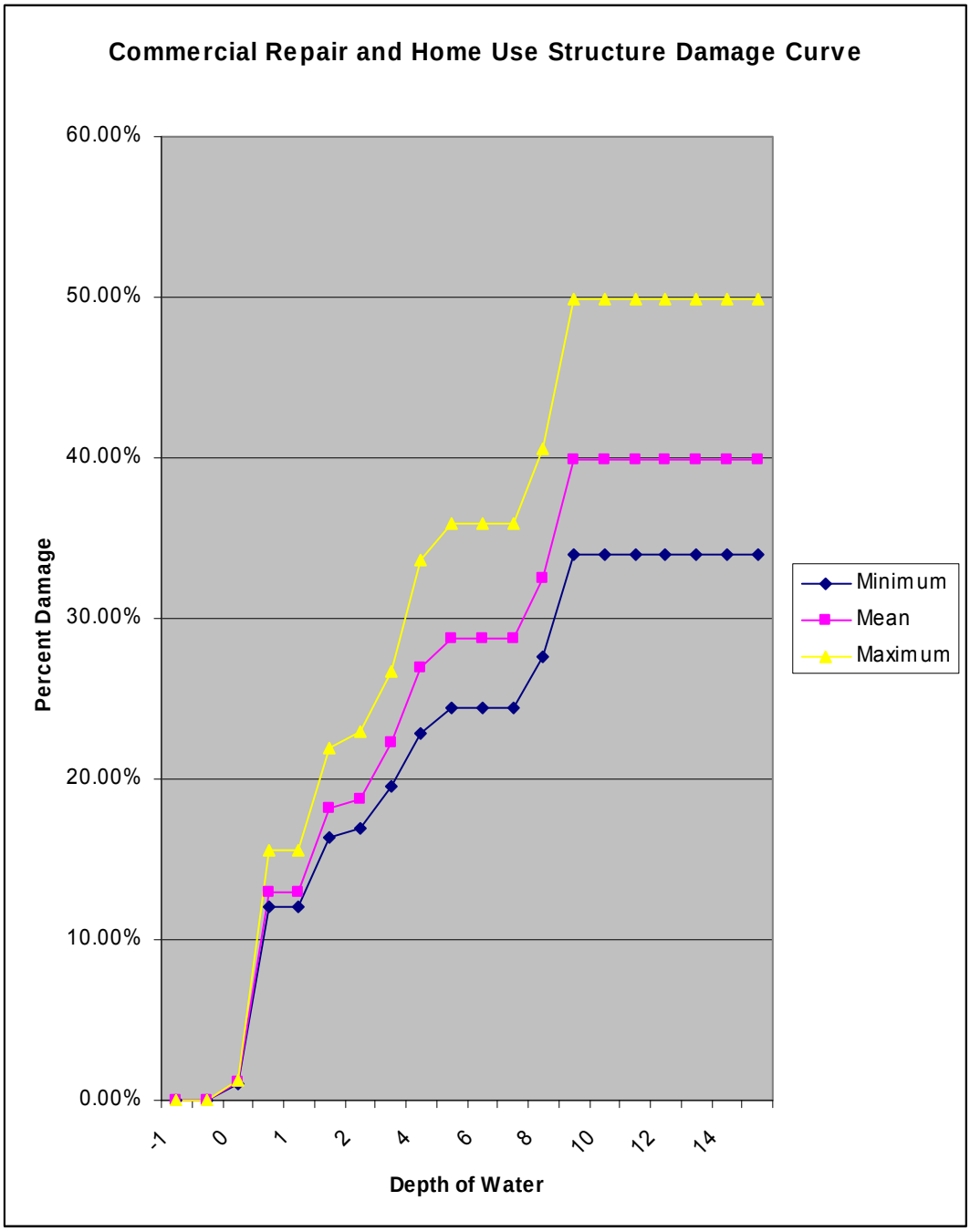


Figure A-19. Commercial Repair and Home Use Structure Damage Relationship

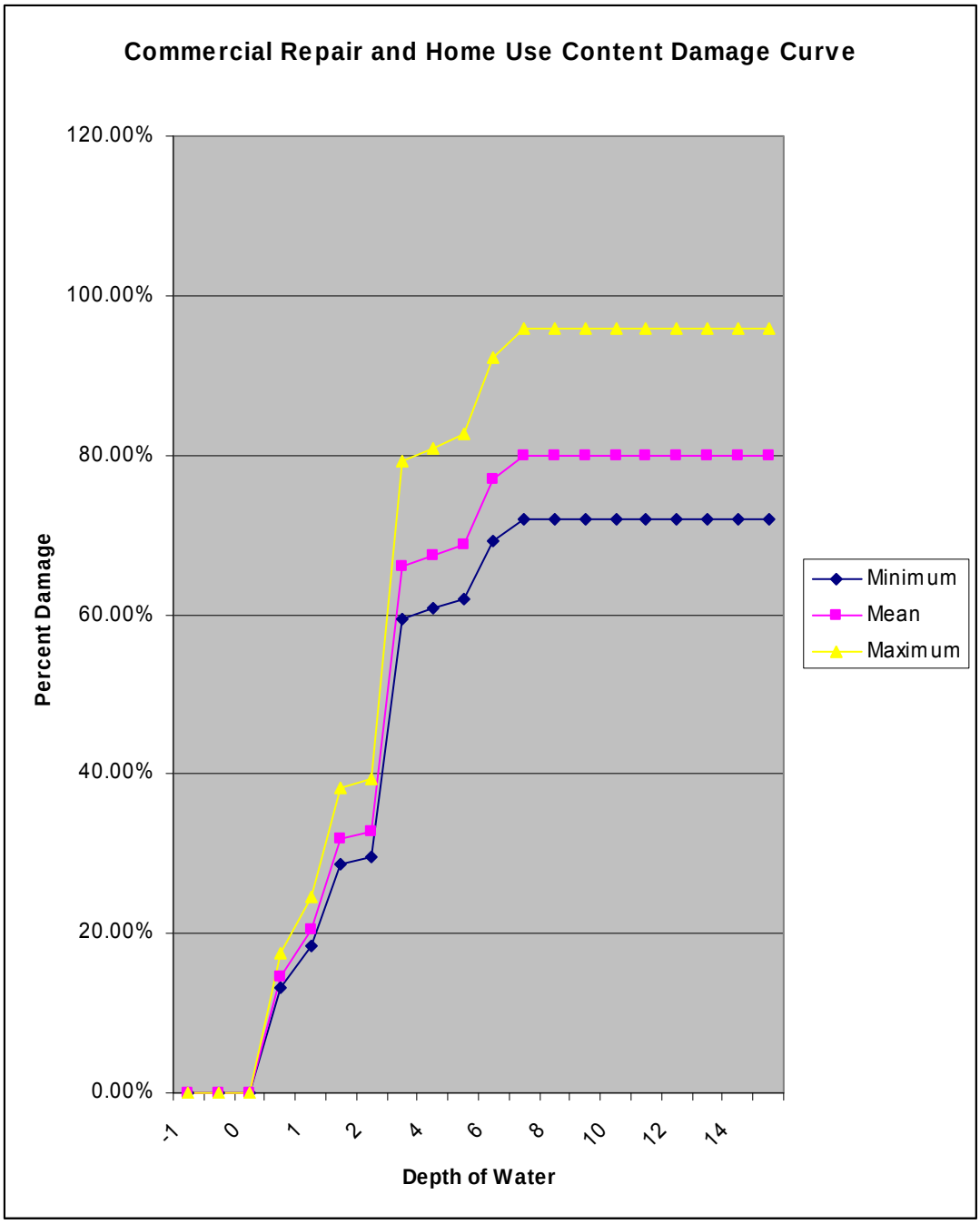


Figure A-20. Commercial Repair and Home Use Damage Relationship

Table A1-11.
Warehouse and Contractor Services Damage Relationship

Commercial Repair and Home Use						
	Structure Type Metal Frame			Content		
Depth	**Mean**	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
-1	0%	0%	0%	0.0%	0.0%	0.0%
-0.5	0%	0%	0%	0.0%	0.0%	0.0%
0	1.1%	1.0%	1.3%	0.0%	0.0%	0.0%
0.5	13.0%	12.1%	15.6%	8.5%	7.6%	10.2%
1	13.0%	12.1%	15.6%	12.6%	11.4%	15.2%
1.5	18.2%	16.4%	21.9%	16.8%	15.2%	20.2%
2	18.7%	16.9%	23.0%	21.1%	19.0%	25.4%
3	22.3%	19.6%	26.7%	27.9%	25.1%	33.5%
4	26.9%	22.8%	33.6%	32.5%	29.2%	39.0%
5	28.7%	24.4%	35.9%	40.9%	36.8%	49.1%
6	28.7%	24.4%	35.9%	48.5%	43.6%	58.2%
7	28.7%	24.4%	35.9%	56.1%	50.5%	67.3%
8	32.5%	27.6%	40.6%	63.7%	57.3%	76.4%
9	39.9%	34.0%	49.9%	71.3%	64.1%	85.5%
10	39.9%	34.0%	49.9%	76.1%	68.5%	91.3%
11	39.9%	34.0%	49.9%	76.1%	68.5%	91.3%
12	39.9%	34.0%	49.9%	76.1%	68.5%	91.3%
13	39.9%	34.0%	49.9%	76.1%	68.5%	91.3%
14	39.9%	34.0%	49.9%	76.1%	68.5%	91.3%
15	39.9%	34.0%	49.9%	76.1%	68.5%	91.3%

[1] Morganza to the Gulf, Louisiana Feasibility Studies, July 1997.

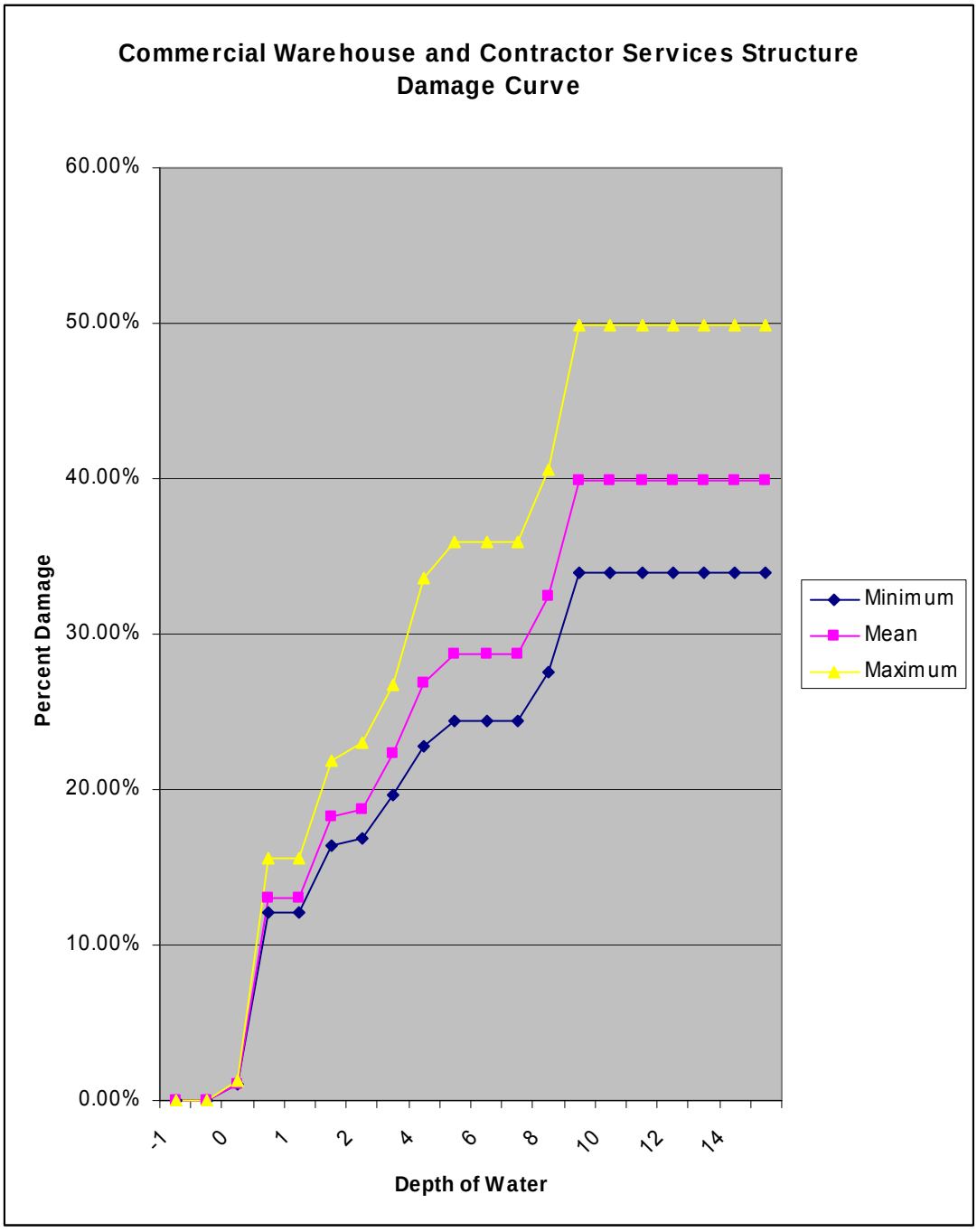


Figure A-21. Warehouse and Contractor Services Structure Damage Relationships

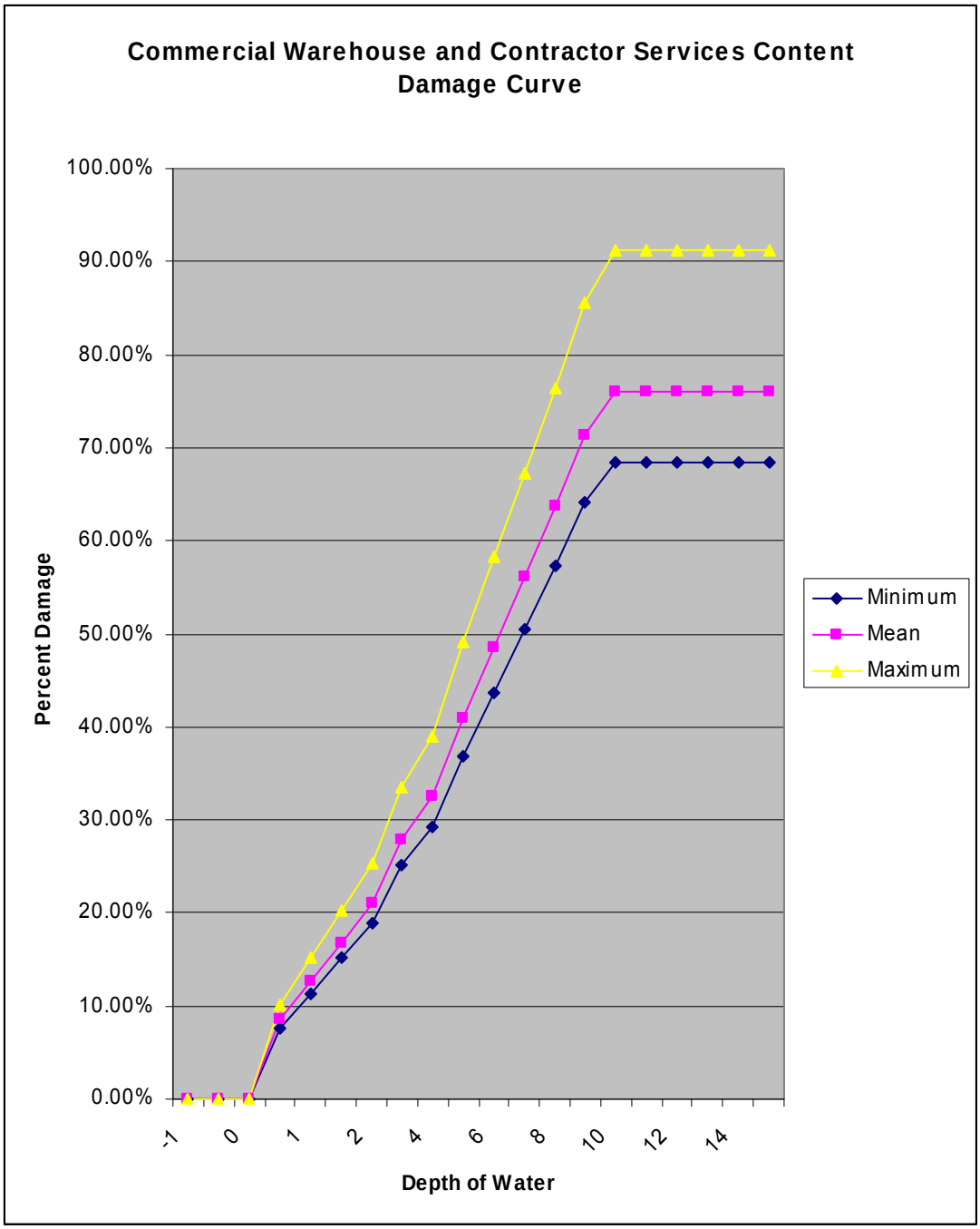


Figure A-22. Warehouse and Contractor Services Structure Damage Relationships

Moreover, each of the eight commercial content categories included a wide variety of business establishments as shown in the following list:

1/ Eating and Recreation: fast food restaurants, full-service restaurants, lounges, bowling alleys, movie theaters, etc.

2/ Groceries and Gas Stations: large and neighborhood groceries, bakeries, candy Stores, wine stores, liquor stores, drug stores, gas stations, convenience stores, and etc.

3/ Multi-Family Residences: garden apartments, high-rise apartments, condominiums, townhomes, motels, hotels, and etc.

4/ Professional Businesses: banks, real estates offices, legal offices, accounting firms, medical offices, veterinary offices, dentist offices, funeral homes, etc.

5/ Public and Semi Public: schools, civic associations, churches, government facilities, utility companies, etc.

6/ Repairs and Home Use: auto repair, watch repair, re-upholstery, home repair, and etc.

7/ Retail and Personal Services: department stores, furniture stores, clothing stores, shoe stores, barber shops, beauty salon, Laundromats, etc.

8/ Warehouse and Contractor Services: transit warehouse, distribution warehouse, storage warehouse, factory, manufacturers, plumbing services, heating and air condition services, carpeting services, etc.

ADDENDUM B – EXPERT ELICITATION ABSTRACT

Institute for Water Resources, U.S. Army Corps of Engineers

Version 1 dated January 30, 2009

COASTAL STORM DAMAGE RELATIONSHIPS BASED ON EXPERT OPINION ELICITATION

(DRAFT)

U. S. Army Corps of Engineers
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Humphreys Engineer Center, Casey Building
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Alexandria, VA 22315-3868

CHAPTER B-I. ABSTRACT

This report documents the results of the Coastal Storm Damage Workshop on June 5, 6, 2002 in Alexandria, Virginia where expert-opinion was elicited for economic consequence assessment of coastal storm damage. The objectives of this workshop were to discuss and recommend damage relationships needed for predicting structural damage from coastal storms as functions of hazard intensity levels, with associated uncertainties, resulting from erosion, waves, inundation, and their combined effects. Because information on the relationship between residential structural damage and storm parameters is limited, this workshop used expert-opinion as a means of gaining information on these relationships (see Aye 2001). This report describes the results of the workshop both in terms of damage relationships and future information needs identified by the experts at the workshop.

This workshop is part of longer-term research effort whose objective is to develop a peer-reviewed, step-by-step methodology for estimating coastal storm damages. The methodology will be incorporated as part of the inputs to a new hurricane and storm damage reduction estimation model being developed by IWR. The methodology will be able to stand alone for use in Corps' districts or by other national or local agencies including potential incorporation as an option in FEMA's HAZUS model.

CHAPTER B-II. INTRODUCTION

B-2.1 Program Overview

The objective of this research is to develop a peer-reviewed, step-by-step methodology for estimating damages from coastal storms to property and improvements. The methodology will also be incorporated as part of the inputs to a new hurricane and storm damage reduction estimation model being developed by the Institute for Water Resources (IWR). The methodology will be able to stand alone for use in Corps' districts or by other national or local agencies including potential incorporation as an option in FEMA's HAZUS model.

The objective will be achieved using a two-stage process to elicit opinions from experts to develop damage functions to estimate storm damages. The first stage of this process consisted of developing framework to quantitatively describe the damage done to a structure from storm hazards such as inundation, waves, erosion, and wind. Preliminary damage relationships (curves) were also developed. As a starting point for the first stage, the project core team from IWR proposed a “straw man” framework to be modified by a small group of experts. Inputs for this first stage included the models presently in use by Corps' offices (e.g. Wilmington and Jacksonville) and other agencies around the country, as well as a framework that is being developed for this purpose for the Corps’ Wilmington District. Experts were chosen from within the Corps’, from contractors and academics with experience in coastal storm damage, and from the Federal Emergency Management Authority. Although a focus was on the hurricane-prone southeastern U.S., the workshop also included expertise from the North Atlantic and California.

The second stage will involve additional data collection through a full review of the initial framework and relationships by a review team, by Corps' offices, and by the professional community at-large, and from damage data collected in post-storm surveys. Experts will then be convened in a formal expert elicitation to use this additional information to modify the preliminary depth-damage relationships and develop final estimates of likely economic damages from a coastal storm.

B-2.3 Needs and Existing Storm Damage Information

This study was prompted by a widely-perceived need for better information on coastal storm damage relationships. A December 2000 letter from the Assistant Secretary of the Army to the Wilmington District requested a “Corps-wide-survey of damage functions used for all types of structures and the rationale for using them, for hurricane and storm damage reduction projects”. The expectation was that “better guidance can be provided to field offices on the conduct of economic analysis if we have the benefit of … better tools to evaluate hurricane and storm damage projects”. This research seeks to provide these better tools.

In investigating storm damage relationships, available sources of information can be divided into two general categories: 1) data on storm damages and on existing structures, and 2) models of the relationships between storm parameters and damage. Whereas the relationships between storm parameters and damage are the ultimate purpose of this investigation, the relationships need to be grounded in the data on actual storm damages. As background for the research and in preparation for the workshop, the project core team from IWR reviewed coastal damage methodologies from various sources including: Corps Districts in Jacksonville, Wilmington, New Orleans, Mobile, New York, Philadelphia; the HAZUS model - a natural hazard loss estimation methodology developed by the Federal Emergency Management Agency in partnership with the National Institute of Building Sciences; FEMA building performance studies; Federal Insurance claims data; USACE reports on Hurricane Fran and on Shoreline Protection and Beach Erosion Control; state data from Hurricane Opal (FL); the Heinz Center’s Evaluation of Erosion Hazards, and various articles from the open literature (i.e. Budge 1991, King et al. 1991, Ulrich et al. 1994, Kato and Torii 2002, Tomalley et al. 2002).

B-2.4 Use of Expert Opinions

The primary reason for using expert opinions is provide "data" where little or no data exists about an issue or problem. It can also deal with uncertainty in selected technical issues related to a system of interest. Issues with significant uncertainty, issues that are controversial and/or contentious, issues that are complex, and/or issues that can have a significant effect on risk are most suited for expert-opinion elicitation. Here we used an informal, consensus-based elicitation process to promote creative thinking about potential frameworks and problem definition. The value of any expert-opinion elicitation comes from its initial intended uses as a heuristic tool, not a scientific tool, for exploring vague and unknowable issues that are otherwise inaccessible. It is not a substitute to scientific, rigorous research.

The identification of the need for the information developed during the elicitation process and its communication to experts are essential for the success of the elicitation. The need identification and communication should include the definition of the goal of the study and relevance of issues to this goal. Establishing this relevance would make the experts stakeholders and thereby increase their attention and sincerity levels. Relevance of each issue and/or question to the study needs to be established. This question-to-study relevance is essential to enhancing the reliability of collected data from the experts. Each question or issue needs to be relevant to each expert especially when dealing with subjects with diverse views.

The expert-opinion elicitation process can be defined as a formal, heuristic process of obtaining information or answers to specific questions about certain quantities, called issues, such as failure rates, unsatisfactory-performance consequences and expected service life. This process should not be used in lieu of rigorous reliability and risk analytical methods, but should be used to supplement them and to prepare for them. It should be preferably performed during a face-to-face meeting of members of an expert panel that is developed specifically for the issues under consideration. The

meeting of the expert panel should be conducted after communicating to the experts in advance to the meeting background information, objectives, list of issues, and anticipated outcome from the meeting. The different components of the expert-opinion elicitation process are described in Aye (2001).

B-2.5 Recent USACE Expert-Opinion Elicitation Studies

Expert-opinion elicitation is a technique for using a panel of individuals with various areas of specialized knowledge for estimating parameters or addressing issues of interest based on their expertise. The March 2002 expert elicitation conducted by IWR on the Economic Consequence Assessment of Residential Flood Damage is a recent example of use of the technique. Expert-opinion elicitation has also been recently applied by the New Orleans District's study of the Lower Atchafalaya Basin and reevaluation of the Morganza to the Gulf of Mexico feasibility studies, by Vicksburg District's Pearl River study, and by the Sacramento District's Feather River flood damage study. Building contractors, insurance adjusters, home decorators, and other individuals with knowledge of construction, prices, and typical home furnishings were used to estimate depth-damage and content-to-structure value ratios. Details on some of these studies are provided in Aye (1999 and 2001).

B-2.6 Residential Damage Due to Coastal Storms

The scope of this study consists of structural damage to single-family homes from coastal storms. These economic consequences can be described by mathematical functions that relate storm parameters such as wave crest height or the depth of still water flooding to the percent of damage that occurs to structures. The percent damage to structure refers to the percent of the depreciated replacement costs of the structure that is damaged. Coastal storms damage structures through wave action, still water flooding, wave run-up, erosion, and wind. These hazard types are described briefly below.

Waves: Most of the energy delivered to the shore by the ocean originates from the wind acting on the ocean to produce waves. Wave characteristics are determined by the wind direction, wind speed, wind duration, how far the wind blows over water, and how far the wave travels before reaching land. Wave action can cause significant damage to coastal structures. Conventional wisdom is that if breaking waves strike at or above a building's first floor elevation, that structure will be severely damaged. This is the rationale for the National Flood Insurance Program's (NFIP) characterization of a highly vulnerable zone (V-zone) for damage from wave action. The ability to prevent wave damage is considered a major benefit of Corps' shore protection measures. Although FEMA demarks the V-zone as an area subject to breaking waves at least 3 feet high, recent, FEMA-sponsored tests indicate that 1.5-foot waves can break away walls. This research suggests that the V-zone might more appropriately extend to all areas subject to 1.5-foot high breaking waves.

Stillwater flooding: Storms can cause inundation of structures with still water either through overtopping of a dunes system (coastal flooding) or through flood waters coming from the bay side of a coastal island (bay-side flooding). Coastal flooding implies still-water level flooding of structures because of overtopping of a dune system or storm surge breaking through from the coastal side and inundating beach areas. A major benefit of Corps' shore protection measures may be reduced coastal flooding damages. Bayside flooding implies still water level flooding of structures, with flooding coming from the bayside. Natural or man-made structures may have prevented flooding from storm surge on the coastal side of an island, but high seas inundated structures from the bay or backside of an island. Structures on the bayside of islands are frequently constructed with a lower level of flood protection than structures across the island on the oceanfront. For example bayside

houses may be built lower to the ground whereas oceanfront houses might be raised on piles. Damage from bayside flooding is generally not reduced through shore protection measures.

Erosion: On average, the nation's shorelines are receding at an annual rate of slightly more than one foot per year, although rates vary significantly across regions and across shoreline types. In addition to long-term erosion, erosion during a storm may destroy a dune and undermine shorefront structures. The extent of damage will depend on the amount of storm-induced erosion at the structure and structural characteristics such as foundation and piling embedment. Damages from storm-induced erosion can be significant, regardless of the long-term erosion rate or whether natural processes rebuild the dune in the months following a storm. Corps shore protection measures can provide significant reduction in damages attributable to erosion. Because erosion causes beaches to narrow over time, it is a major factor to consider in conducting a life cycle analysis of project benefits and costs.

Wave Run-up: Wave run-up is the upper level reached by a wave on a beach or coastal structure, relative to still-water level (Coastal Engineering Manual, 2002). Wave run-up applies pressure on a structure in both a vertical and horizontal direction and is a function of the water depth and the square of the water velocity. Wave run-up ceases to be a damage factor when breaking waves attack a structure.

Wind Damages: High winds associated with storms can cause significant damages to structures both on the coast and much further inland. High winds and associated flying projectiles can damage doors, windows or roofs. This damage to the integrity of the structure may combine with high winds to cause severe damage or structural failure. Such breaching also allows rainwater damage to the structure. Most of the damages from Hurricanes Andrew, Inky, and Hugo were caused by wind and wind-related rainwater as opposed to waves, flooding, wave run-up, or erosion. Because Corps' projects do not significantly affect the wind speed of storms, wind damage is not reduced through shore protection measures. Nonetheless, wind damage plays a significant role in life cycle cost analysis for Corps' storm damage reduction projects.

CHAPTER B-III. PARTICIPANTS

B-3.1 Requirements

The IWR project core team has the lead responsibility for achieving the project objectives, but relied on input from a larger, working group of experts to develop appropriate damage relationships. The working group represented Corps' Districts that had been active in shoreline protection projects and represented different geographic regions. In addition, it included outside experts from the Federal Emergency Management Agency, universities, and the private sector who had expertise in coastal storm damage assessment.

B-3.2 Participants

A list of the IWR project core team and working group for the workshop is below.

PROJECT CORE TEAM

Affiliation	Name	Role
IWR	Stuart Davis	Project Leader
IWR	Hal Cardwell	Project Leader
IWR	David Moser	IWR Program Manager

USACE-HQ	Lillian Almodovar	HQ Program Manager
BMA Engr/Un. of MD	Bilal Ayyub	Facilitator

WORKING GROUP

Affiliation	**Name**	**Role**
USACE/Wilmington	Bob Finch	In-house Technical Advisor (S.Atlantic)
USACE/Wilmington	Mike Wutkowski	In-house Technical Advisor (S.Atlantic)
USACE/Jacksonville	Dan Peck	In-house Technical Advisor (S.Atlantic)
USACE/Jacksonville	Tom Smith	In-house Technical Advisor (S.Atlantic)
USACE/SAD	Gerald Melton	In-house Technical Advisor (S.Atlantic)
USACE/New Orleans	Brian Maestri	In-house Technical Advisor (Gulf)
USACE/Los Angeles	Dan Sulzer	In-house Technical Advisor (W.Coast)
USACE/Los Angeles	Susie Ming	In-house Technical Advisor (W.Coast)
USACE-HQ	Harry Shoudy	In-house Technical Advisor
USACE-HQ	Charlie Chesnutt	In-house Technical Advisor
USACE-HQ	Jay Warren	In-house Technical Advisor
URS	Bill Coulbourne	Outside Technical Advisor (N.Atlantic)
URS	Mike Cannon	Outside Technical Advisor (N.Atlantic)
Consultant	Chris Jones	Outside Technical Advisor (S.Atlantic)
NC SeaGrant	Spencer Rogers	Outside Technical Advisor (S.Atlantic)
FEMA	Paul Tertell	Outside Technical Advisor

CHAPTER B-IV. WORKSHOP RESULTS

B-4.1 Straw man Coastal Storm Damage Framework

The starting point for discussions of coastal storm damage processes was a "straw man framework" for structural damage estimation that was put forth by the IWR project core team. The straw man framework assumes as known, the physical parameters of the area and of the storm. These parameters include surface water elevation, ground elevation, and shoreline type, wave heights, storm-induced erosion depth. Also assumed known are structural characteristics such as location, foundation type, height of lowest supporting beam of structures including their location. Long-term erosion is considered by progressively moving the shoreline landward, therefore increasing the storm-induced erosion and inundation potential from subsequent storms. Economic losses (damages) due to land lost are outside the scope. Wind damages are estimated outside of this framework; this estimate will be used to modify damage to structures from coastal flooding and erosion as appropriate. We also assume the surface water elevation accounts for bay-side flooding and dune breaches.

Inundation: Damage to both contents and structures from wave run-up, breaking waves, and still water flooding is assumed to be captured through the use of FIMA[5] V-zone curves for all areas that experience breaking waves of 1.5 ft above the lowest structural horizontal member of the structure. For areas that experience less than 1.5 feet of flooding, FIMA A-zone curves will be used for structure damage.

[5] The Federal Insurance and Mitigation Administration (FIMA – formerly the Federal Insurance Administration - FIA) developed and uses depth-damage curves to estimate actuarial premiums for flood insurance. FIMA has two sets of curves, A-zone curves for riverine and coastal areas without high wave velocity, and V-zone curves for coastal areas that are expected to experience wave action. FIMA defines the V-zone as those coastal areas expected to experience a 3-foot high breaking wave.

Storm-induced erosion: A curve relating damage to the depth of vertical erosion at the center of building will be developed for various foundation types. This curve will be applied for sandy beaches with small dunes (as defined by FEMA). An additional relationship for high dunes and sandy bluff shoreline types will describe storm-induced damages from near-vertical erosion scarps.

Combined Damage vectors: The total damage to a structure will be the sum of the inundation damages and the storm-induced erosion damages, with the total not to exceed the value of the structure.

B-4.2 Revised Framework

Discussion at the workshop produced consensus on a revised framework for structural damage estimation. Once the damage hazards were identified, the experts focused on determining the appropriate storm variable that would relate to damage for each hazard type. For example, depth of water above the walking surface for the lowest main floor was selected as the best variable to relate to still water flooding damages. This is the X-axis in a depth (or other variable) versus damage curve. The experts then agreed on the number of relationships that would have to be developed to properly predict damages to different foundation types (e.g. slab on grade or pile) or materials (wood, concrete, masonry) were appropriate for each damage hazard. Discussion then moved to different ways to combine the damages across hazards, and how to account for regional differences in shorelines, with a focus on estimating damages to bluffs. We describe the discussions and decisions in this section. Appendix A contains results in the form of quantified relationships (curves) for storm damages.

B-4.2.1 Inundation Damage

For damages from still water inundation the workshop determined that the appropriate storm variable to use was the “Depth of water above the walking surface of the lowest main floor”. Although damages to the floors of a structure occur before the water depth reaches the walking surface, using the depth of water surface is an easier variable to use for data collection. **Structural damages that occur from inundation of the floors at slightly lower depths can be included by assigning positive values to damages when depth of water above the walking surface is negative.**

The workshop determined that damages from inundation also depend on the foundation type, on material, number of floors, and, for structures on piles, on the existence of ground-level enclosures. Separate relationship (although using the same X-axis) would need to be developed for each of the following cases:

- Wood frame with piles (with & without enclosures – small medium and full)
- Wood frame without piles
- Concrete & masonry with piles (with & without enclosure – small medium and full)
- Concrete & masonry without piles
- Number of floors (1, 1.5 and 2)

The workshop considered various existing data sources to quantify the relationships for inundation. These data sources included FIMA coastal A-zone curves, curves from New Orleans District for structures on piles and on piers, and curves issued by the Corps in 2000 based on post-flood surveys of actual damages in various parts of the United States.

B-4.2.2 Waves Damage

For damages due to breaking waves the workshop determined that the appropriate storm variable to use was the "difference between the top of wave (crest) and the bottom of the lowest horizontal member". The workshop considered using the walking floor elevation as the datum for comparison with the top of the wave height for consistency with the measure suggested for inundation. However the workshop decided that the framework would be clearer and more rigorous if it used the bottom of the lowest horizontal member as the reference point because it is at this point that waves can start to damage the structure. If practical considerations preclude measurements of the bottom of the lowest horizontal member, this value can be estimated based on the elevation of the walking surface.

The workshop determined that damages from inundation also depended on the foundation type for structures on piles and on the existence of ground-level enclosures. Separate relationships (although using the same X-axis) would need to be developed for each of the following cases:

- Structures on piles (with & without enclosures – small medium and full)
- Structures not on piles

B-4.2.3 Wave Run-up Damage

The workshop concluded that damages from wave run-up were attributable to the "Difference between the top of water and the bottom of the lowest horizontal member, and its velocity at the seaward face of the structure". The force applied by wave run-up could be described as directly dependent on the depth of the water and the square of the velocity. Forces would likely act in both a horizontal and vertical direction and be measured in lbs/linear foot. However the workshop participants did not feel that the there was enough known about the damage from wave run-up to determine an appropriate storm variable to use, and opted to delay development of a damage relationship as a long-term need.

B-4.2.4 Erosion Damage

For damages from storm-induced erosion, the workshop determined that the appropriate storm variable to use both for structures with shallow foundations and ones on piers was the "percent of footprint compromised." Shallow foundation structures were defined as structures that are on slabs or on piers. Houses on bluffs that experience erosion can be considered as structures with shallow foundations. When a shallow foundation experiences vertical erosion such that it loses support from the ground, the foundation is compromised. Six inches of vertical erosion or undermining has been conventionally considered to cause a loss of support. Whereas the workshop participants felt that this definition was relatively straightforward for shallow foundations, the selection of a variable for deep or pile-supported foundations was more contentious.

The distinction was made between a structure that was undermined by erosion and one that had its foundation "compromised". Whereas for structures on shallow foundations undermining (six vertical inches of erosion) is equivalent to compromised, pile structures can be extensively undermined with little or no damage. In these cases the entire footprint could experience vertical erosion of six inches yet no damage would occur because, although undermined, the erosion does not compromise the ability of the foundation to support the structure. Conversely, a compromised pile can be defined as one whose remaining embedment depth renders it ineffective against lateral forces such as wind and waves. Using, as the independent variable (X-axis) the "percent of footprint compromised" would allow correct categorization of damages done to a pile-support house that, because of erosion, might have its entire footprint in the surf zone (and hence undermined), but yet had minimal damage because its foundation was not compromised. The workshop noted that relating storm

parameters to the percent of footprint compromised would be difficult and likely be regionally and structurally specific. Comment: This percent of footprint compromised is pretty useless to predict damage from a storm unless this can be predicted from the extent of vertical erosion at the structure. I don't think there will be any model that keeps track of all piles of a pile-founded structure. We will have to make assumptions about where piles are located and the extent of embedment.

Because the appropriate storm variable was defined so broadly, the workshop only called for two separate relationships to be developed for erosion damages: one for shallow foundation and one for deep foundations (piles). More relationships may need to be developed as definitions of "footprint compromised" are developed for specific regions and projects.

B-4.2.5 Combining Damages

Because a structure may be damaged by more than one of the four storm damage hazards identified by the workshop, a methodology must be developed for how to combine the damages. The Straw man Framework proposed a simple additive combination with a constraint that the total damages to a structure could not exceed its value. The can be expressed as %A + %B. A more commonly used rule for combining damages is to simply use the maximum percent damage from any hazard, or Max [%A, %B]. Whereas the first rule assumes that there is no common damage caused by different hazards, the latter rule assumes the other extreme - which no damage occurs that is not covered by the most damaging hazard. A third rule to consider would be the sum of the hazard percentages minus their product: %A + %B -%A%B. This framework was used in the Portland District and is akin to the probability of occurrence at least one of two independent events A and B.

The workshop concluded that the combination rule must be dependent on the types of hazard that cause damages. If both waves and inundation cause damage the workshop suggested the rule be to only use the damages caused by waves (this is consistent with FEMA's V-zone definition). If both erosion and inundation cause damage the proposed rule is to use the sum of the damages minus their product. Similarly, if both erosion and run-up cause damage the rule is to use the sum of the damages minus their product. For the case where both run-up and erosion cause damages, the workshop proposed two definitions, one for shallow foundation structures, where the rule is to use the maximum of the two damages, and one for pile foundation structures where the rule is to use the sum of the damages minus their product. We summarize these relationships below for the various cases of combination

Case 1 – Inundation + Waves	%W
Case 2 – Run-up + Waves	%W
Case 3 – Inundation + Run-up	will not occur
Case 4 – Inundation + Erosion	%I + %E - %I*%E
Case 5 – Run-up + Erosion	%R + %E - %R*%E
Case 6 – Waves + Erosion	Max %W, %E (shallow foundation)
	%W + %E - %W*%E (pile foundation)

These cases cover all likely combinations of hazards because a structure would not be subject to both moving water (run-up) at the same time as still-water inundation, and waves damages would subsume run-up as it does inundation damages. The workshop noted as a long term need, better information as to when to "switch" from the inundation damage curve to the wave damage curve. Similarly this could be one area of investigation when determining the run-up damage relationships.

Discussion at the workshop included concerns on how to calibrate damage relationships from multiple sources, and noted that the structure should permit direct data collection for the calibration

B-4.2.6 Coastlines with of Bluffs

Storm damages on coastlines with bluffs differ from those on a beach and dune coastline. Inundation is not an issue for bluffs, and neither are waves or run-up except as they promote erosion. Also, all foundations on bluffs can be treated as shallow foundations or slabs, because erosion from a bluff will undermine a deep pile foundation in the same way as a shallow foundation. Failure of a bluff can be from top to bottom or from bottom to top.

B-4.2.7 Long-term and Short-term Needs / Next Steps

The following table summarizes the long-term and short-term needs and future steps in this area:

Priority	Long-term and Short-term Needs / Next Steps
High	Methodology (including authority) for post storm data collection to determine flood conditions during event and erosion conditions at the end of an event.
High	Define/issue guidance for "Compromised" regional Differences
High	Beach profile translation
High	Contents
High	Land Loss/estimated value
High	Post storm data – wave crest water level elevations, lower limit (elevation) of wave damage.
High	Pre-storm building inventory
High	Collection of Existing loss information (including analysis of data from Fran)
Medium	Wave damage height threshold (1.5 ft vs 3 ft) – When do we abandon the inundation curve? How far inland is wave damage an issue?
Medium	RUN-UP RELATIONSHIPS - HOW TO QUANTIFY (WEST COAST)
Medium/Low	Sedimentation damage during inundation
Medium/Low	Duration of inundation
Low	Bluff Erosion processes
Low	Curves/response of engineered buildings, and other non residential structures
Low	Salt versus fresh water inundation damage

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CHAPTER B-VI. DAMAGE RELATIONSHIP DETAILS

The following figures contain the details of the damage relationships developed in the workshop. The "Proposed" curve represents the experts' median estimate of damages, whereas the upper and lower represent estimates of the range of the damages. Here, 75 percent of the time damages will be less than the "Upper" curve and 25 percent of the time damages will be lower than the "Lower" curve. For the inundation curves, the upper and lower bounds were set equivalent to the estimates used by New Orleans district for structures on piers (N.O. pier), and by the FIMA coastal A-zone curves, respectively. For damages from inundation, the workshop only developed curves for the selected cases noted below. The workshop assumed that estimates for inundation damages in structures with partial enclosures would flow from the curves developed here. Likewise all curves apply for single story houses.

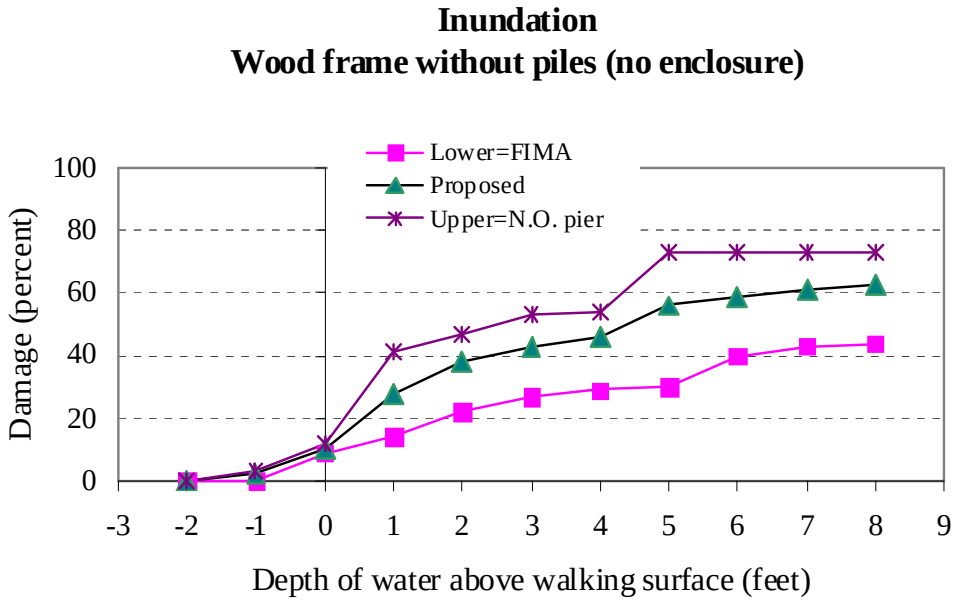


Figure B-1. Inundation Wood Frame without Piles (no enclosure)

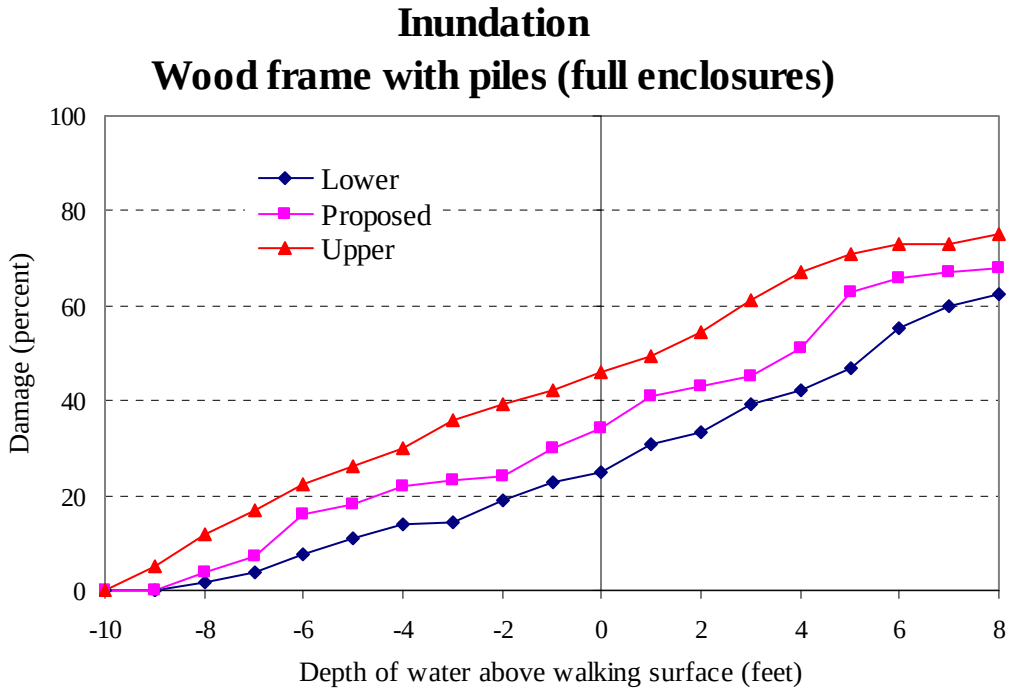


Figure B-2. Inundation Wood Frame with Piles (full enclosure)

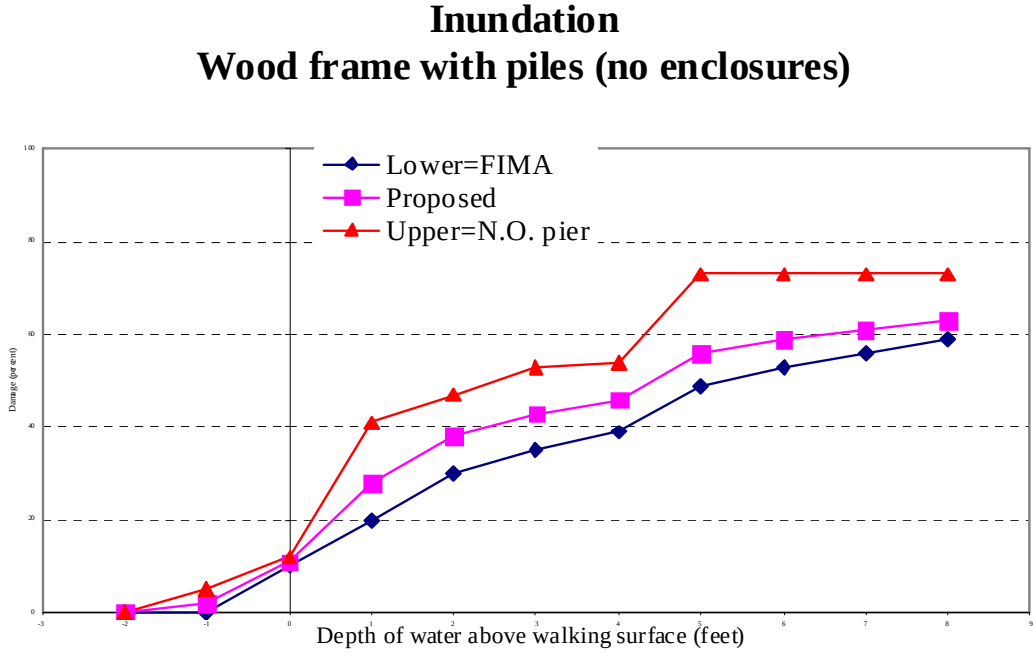


Figure B-3. Inundation Wood Frame with Piles (no enclosure)

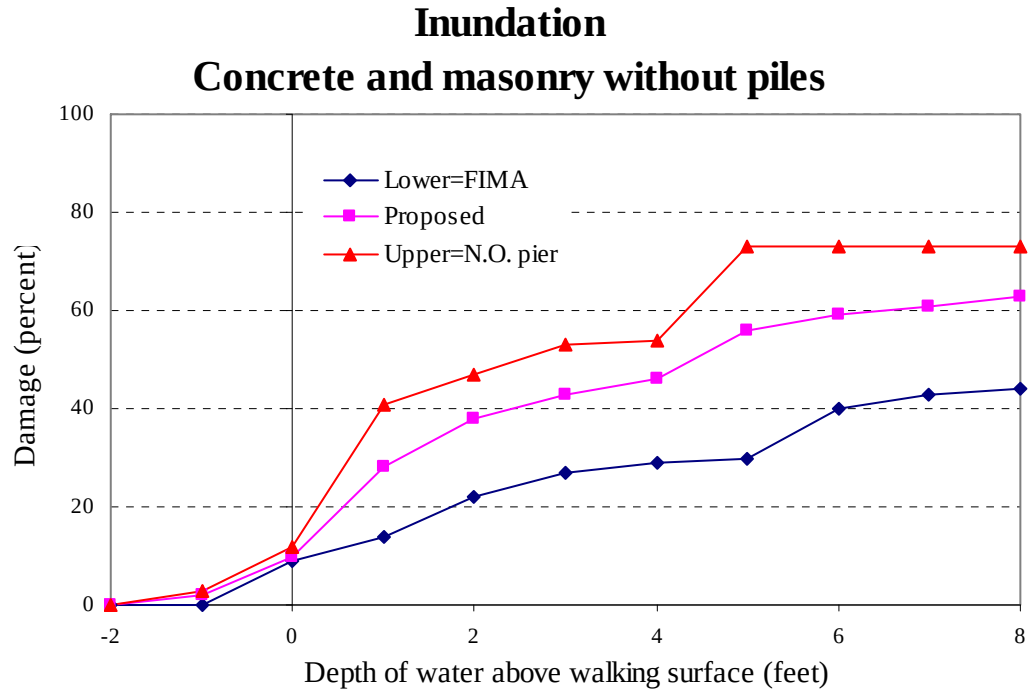


Figure B-4. Inundation Concrete and Masonry without Piles

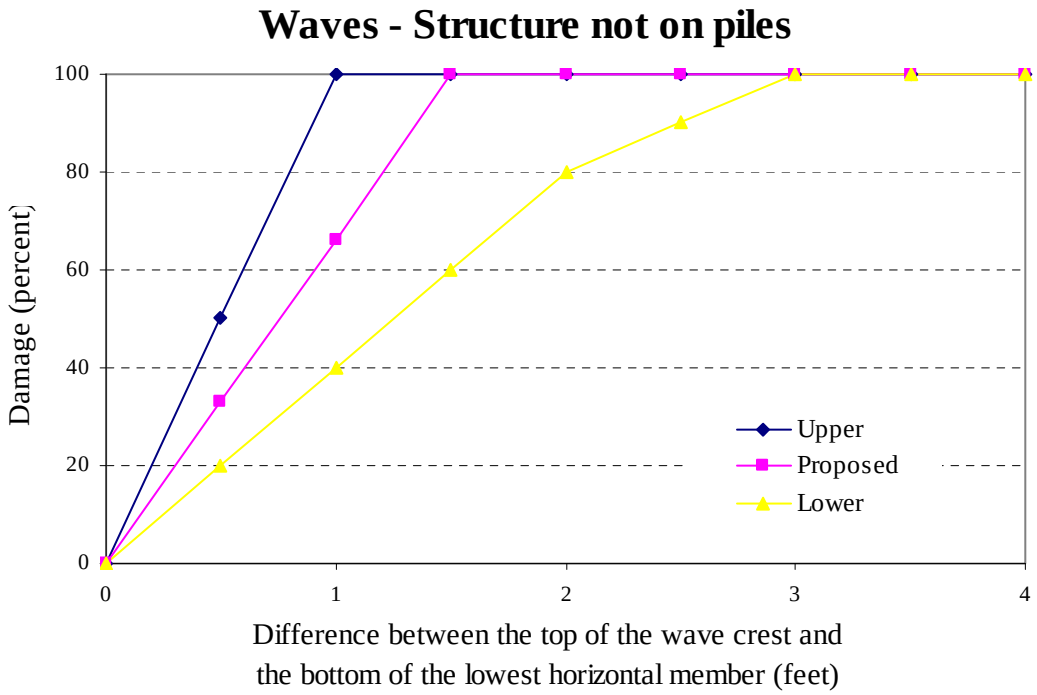


Figure B-5. Waves – Structure not on Piles

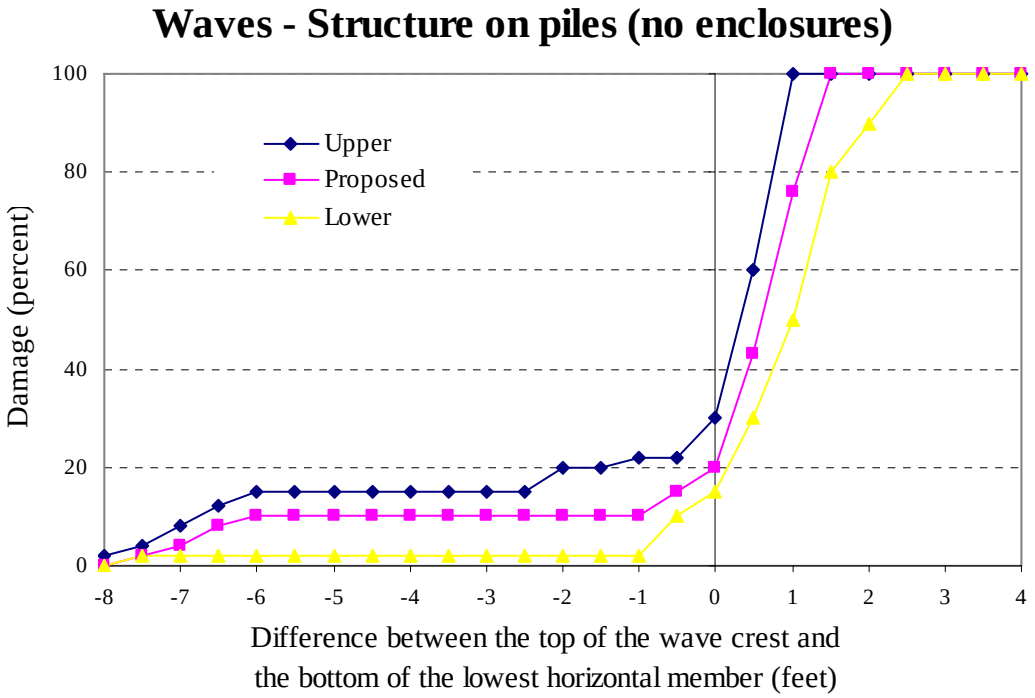


Figure B-6. Waves – Structure on Piles (no enclosure)

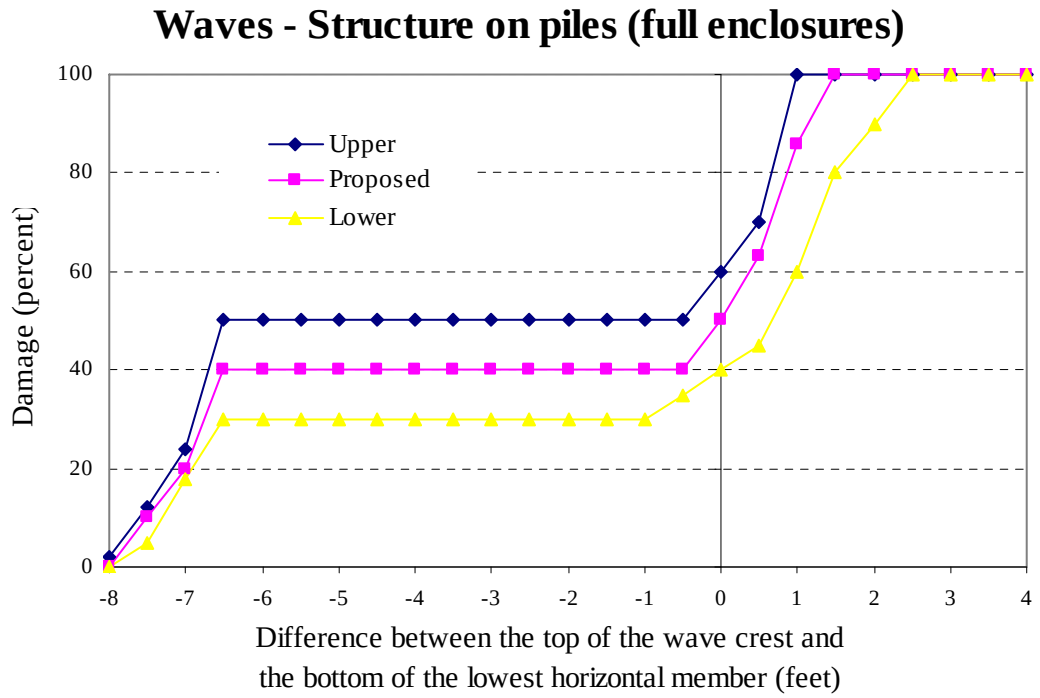


Figure B-7. Waves – Structure on Piles (full enclosure)

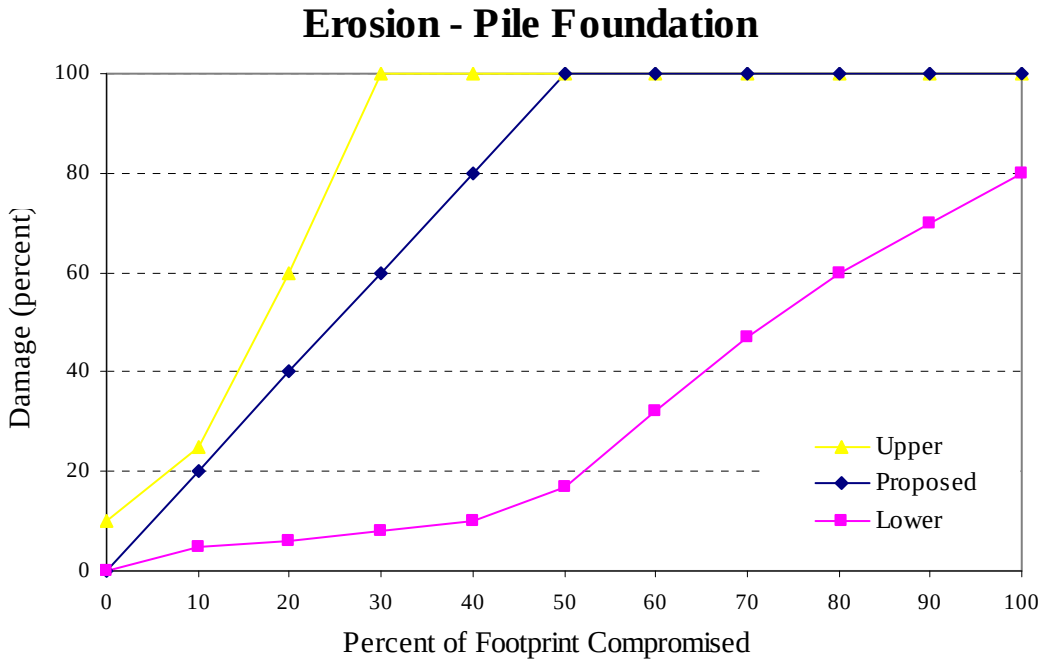


Figure B-8. Erosion – Pile Foundation

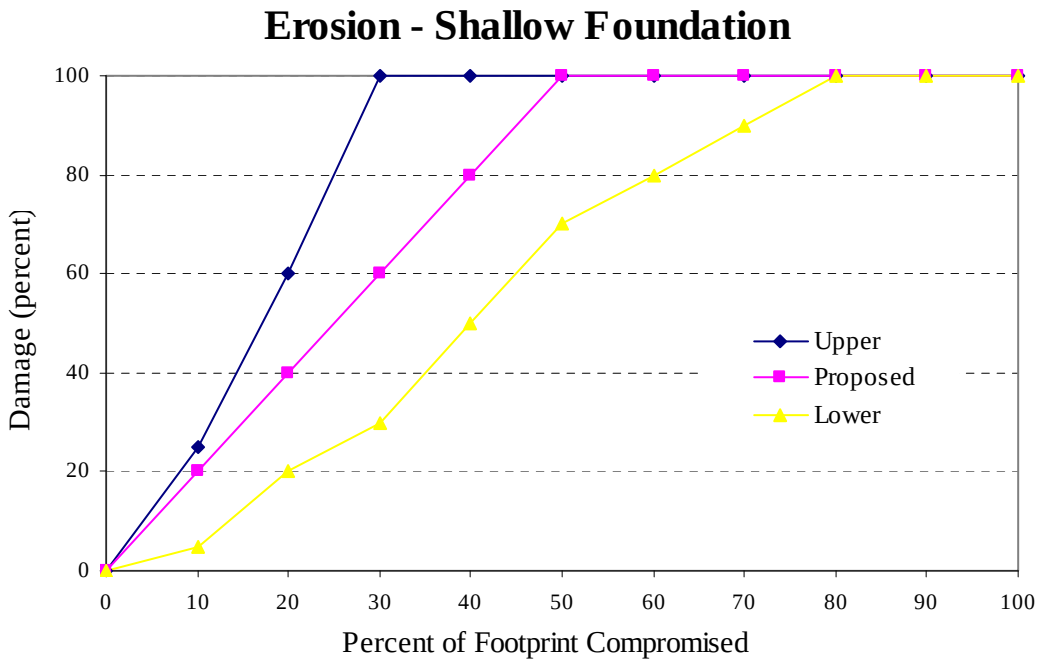


Figure B-9. Erosion – Shallow Foundation

ADDENDUM C – PARKING AND ACCESS

CHAPTER C-I. USER FEES, PUBLIC ACCESS AND PARKING

This addendum describes the public access, and parking for the length of the beach construction evaluated in the Mississippi Coastal Improvement Program (MsCIP) Comprehensive Report. This parking and access analysis was conducted in accordance with ER 1165-2-130 "Water Resource Policies and Authorities – Federal Participation in Shore Protection" dated 15 June 1989. The data provided in this addendum was collected through field verification.

According to ER 1165-2-130, "Unless the protection of privately-owned beaches is incidental to protection of public beaches (paragraph 9), they must be open to all visitors regardless of origin or home area, or provide protection to nearby public property to be eligible for Federal assistance. Items affecting public use are… 1/ parking, 2/ access, and 3/ user fees." Typically, these items serve a dual purpose of both identifying the basis for federal participation and to justify the recreation benefits of the proposed shoreline protection project. For the MsCIP Comprehensive Report, the shoreline protection measures (Line of Defense 2) have zero net recreational benefits, in other words, the future with project condition recreation benefits are the same as the future without project recreation benefits. Since there is no claim on recreation benefits, this analysis is not intended to show public availability for justifying benefits claimed, but merely to show whether or not there is sufficient availability to use that would warrant federal participation.

C-1.1 Parking

The coast of Mississippi is approximately 70 miles long and spans Hancock (planning unit 1), Harrison (planning unit 2) and Jackson Counties (planning unit 3), from west to east respectively. Within each county there is public parking and access to the beach. There are a total of 3,730 free parking spaces along the beach in the three-county study area.

The Coast of Hancock County is approximately 16 miles long. Beach Blvd spans 8 miles of the eastern portion of Hancock County's coast. Along Beach Blvd there are 592 free parking spaces, both in lots and along the street. The beach can be accessed without significant hindrance from virtually anywhere along South Beach Blvd.

The Coast of Harrison County is approximately 25 miles long. Highway 90 spans the entire coast of Harrison County. Along Highway 90 there are 2,788 free parking spaces, both in lots and along the street. The beach can be accessed without significant hindrance from virtually anywhere along Highway 90.

The Coast of Jackson County is approximately 29 miles long. There are a few roads which run along various portions of the coast. Some of these roads have parking either on the street or in lots. There are a total of 350 free parking spaces. In areas where there is both beach and road along the coast, the beach can be accessed without significant hindrance.

Data on the parking areas for each of the three counties are displayed separately in the tables below. Table C1-1 displays data for Hancock County. Table C1-2 displays data for Harrison County. Table C1-3 displays data for Jackson County. Each table begins with the parking area furthest west

in the county that it represents and ends with the parking area furthest east in the same county. Following the tables are maps of the study area and images of some parking areas.

Table C1-1.
Hancock County Parking

	Location	Spaces	Parking Type	Distance from Previous Access Point	Distance from previous lot (miles)
1	Silver Slipper Casino	241	Free, Lot	Continuous	0.0
2	Lakeshore Rd	100	Free, Street	Continuous	0.1
3	State Park Rd 1	10	Free, Street	Continuous	1.7
4	State Park Rd 2	40	Free, Street	Continuous	0.1
5	Terrace Ave	51	Free, Lot	Continuous	2.8
6	Washington St	150	Free, Lot	Continuous	2.8

Table C1-2.
Harrison County Parking

	Location	Spaces	Parking Type	Distance from previous access point	Distance from previous lot (miles)
1	5th Ave	20	Free, Street	Continuous	0.0
2	Boisdore Ave	8	Free, Street	Continuous	0.3
3	Sherman Ave	12	Free, Street	Continuous	0.2
4	Brown Ave	3	Free, Street	Continuous	0.1
5	Magnolia Ave	5	Free, Street	Continuous	0.8
6	Clarence Ave	30	Free, Lot	Continuous	0.3
7	Church Ave	7	Free, Street	Continuous	0.3
8	Hiern Ave	150	Free, Lot	Continuous	0.3
9	Market St	12	Free, Street	Continuous	0.3
10	Seal Ave	12	Free, Street	Continuous	0.5
11	Donlin Ave	5	Free, Street	Continuous	0.2
12	Courtenay Ave	3	Free, Street	Continuous	0.4
13	Hackett Ln	7	Free, Street	Continuous	0.1
14	Menge Ave	5	Free, Street	Continuous	0.6
15	Espy Ave	18	Free, Street	Continuous	0.9
16	Shadow Lawn Ave	10	Free, Street	Continuous	0.3
17	Least Tern Dr	7	Free, Street	Continuous	0.1
18	Emerald Ave	20	Free, Street	Continuous	0.2
19	Hayden Ave	25	Free, Street	Continuous	0.2
20	Holiday Ave	5	Free, Street	Continuous	0.2
21	White Harbor Rd	7	Free, Street	Continuous	0.3
22	N Seashore Ave	10	Free, Street	Continuous	0.6
23	S Lang Ave	7	Free, Street	Continuous	0.2
24	Oak Gardens Ave	95	Free, Lot	Continuous	0.5
25	Shelter Rock Dr	27	Free, Lot	Continuous	0.3
26	Russell Ave	20	Free, Street	Continuous	0.2
27	Winter Ln	10	Free, Street	Continuous	0.1

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Table C1-2.
Harrison County Parking (continued)

	Location	Spaces	Parking Type	Distance from previous access point	Distance from previous lot (miles)
28	Jeff Davis Ave	180	Free, Lot	Continuous	0.3
29	S Cleveland Ave	190	Free, Lot	Continuous	0.3
30	Gulfview Ave	7	Free, Street	Continuous	0.1
31	N Nicholson Ave	5	Free, Street	Continuous	0.3
32	Beach Park Pl	37	Free, Lot	Continuous	0.1
33	E Azalea Dr	5	Free, Street	Continuous	0.2
34	Richards Ave	5	Free, Street	Continuous	0.1
35	S Ocean Wave Ave	5	Free, Street	Continuous	0.2
36	Rich Ave	32	Free, Lot	Continuous	0.1
37	Ruth Ave	16	Free, Lot	Continuous	0.2
38	Maria Ave	10	Free, Street	Continuous	0.1
39	Fournier Ave	10	Free, Street	Continuous	0.1
40	Camp Ave	49	Free, Lot	Continuous	0.2
41	41st Ave	21	Free, Street	Continuous	0.3
42	38th Ave	45	Free, Street	Continuous	0.2
43	33rd Ave	200	Free, Lot	Continuous	0.2
44	20th Ave	150	Free, Lot	Continuous	1.0
45	Pratt Ave	42	Free, Lot	Continuous	0.4
46	Thornton Ave	35	Free, Lot	Continuous	0.1
47	Hill Pl	5	Free, Street	Continuous	0.2
48	Kelly Ave	10	Free, Street	Continuous	0.2
49	Bert Ave	30	Free, Street	Continuous	0.1
50	Evans Ln	7	Free, Street	Continuous	0.1
51	Gulf Ave	5	Free, Street	Continuous	0.1
52	Roberts Ave	5	Free, Street	Continuous	0.2
53	Alfonso Dr	5	Free, Street	Continuous	0.2
54	Midway Ave	5	Free, Street	Continuous	0.1
55	Oak Ave	5	Free, Street	Continuous	0.1
56	Oask Ave #2	65	Free, Lot	Continuous	0.2
57	Arkansas Ave	50	Free, Lot	Continuous	0.2
58	Texas Ave	5	Free, Street	Continuous	0.1
59	Courthouse Rd	100	Free, Lot	Continuous	0.1
60	Palmetto Ln	3	Free, Street	Continuous	0.1
61	Tegarden Rd	7	Free, Street	Continuous	0.4
62	Paradise Ave	20	Free, Street	Continuous	0.2
63	Oleander Dr	5	Free, Street	Continuous	0.1
64	E Cedar Dr	5	Free, Street	Continuous	0.1
65	Cowan Rd	5	Free, Street	Continuous	0.3
66	Anniston Ave	5	Free, Street	Continuous	0.6
67	Southern Cir	10	Free, Street	Continuous	0.1
68	Mockingbird Ln	5	Free, Street	Continuous	0.1

Table C1-2.
Harrison County Parking (continued)

	Location	Spaces	Parking Type	Distance from previous access point	Distance from previous lot (miles)
69	Gateway Dr	20	Free, Street	Continuous	0.7
70	Eisenhower Dr	35	Free, Street	Continuous	0.4
71	Edgewater Dr	5	Free, Street	Continuous	0.4
72	Grande View Dr	7	Free, Street	Continuous	0.1
73	Oakmont Pl	60	Free, Street	Continuous	0.2
74	Beauvoir Ave	3	Free, Street	Continuous	0.1
75	Sadler Beach Dr	10	Free, Street	Continuous	0.6
76	Sadler Beach Dr 2	25	Free, Street	Continuous	0.1
77	Camellia St	25	Free, Street	Continuous	0.2
78	Treasure Bay Casino	275	Free, Lot	Continuous	0.3
79	Rodenberg Ave	108	Free, Lot	Continuous	0.9
80	Saint Peter Ave	5	Free, Street	Continuous	0.8
81	Saint Francis St	15	Free, Street	Continuous	0.3
82	Saint Paul St	3	Free, Street	Continuous	0.2
83	Morrison Ave	30	Free, Lot	Continuous	0.3
84	Azalea Dr	18	Free, Lot	Continuous	0.2
85	Porter Ave	61	Free, Lot	Continuous	0.3
86	Main St	70	Free, Lot	Continuous	1.0
87	Holley St	15	Free, Street	Continuous	0.5
88	Oak St	20	Free, Lot	Continuous	0.5
89	Cedar St	32	Free, Lot	Continuous	0.3

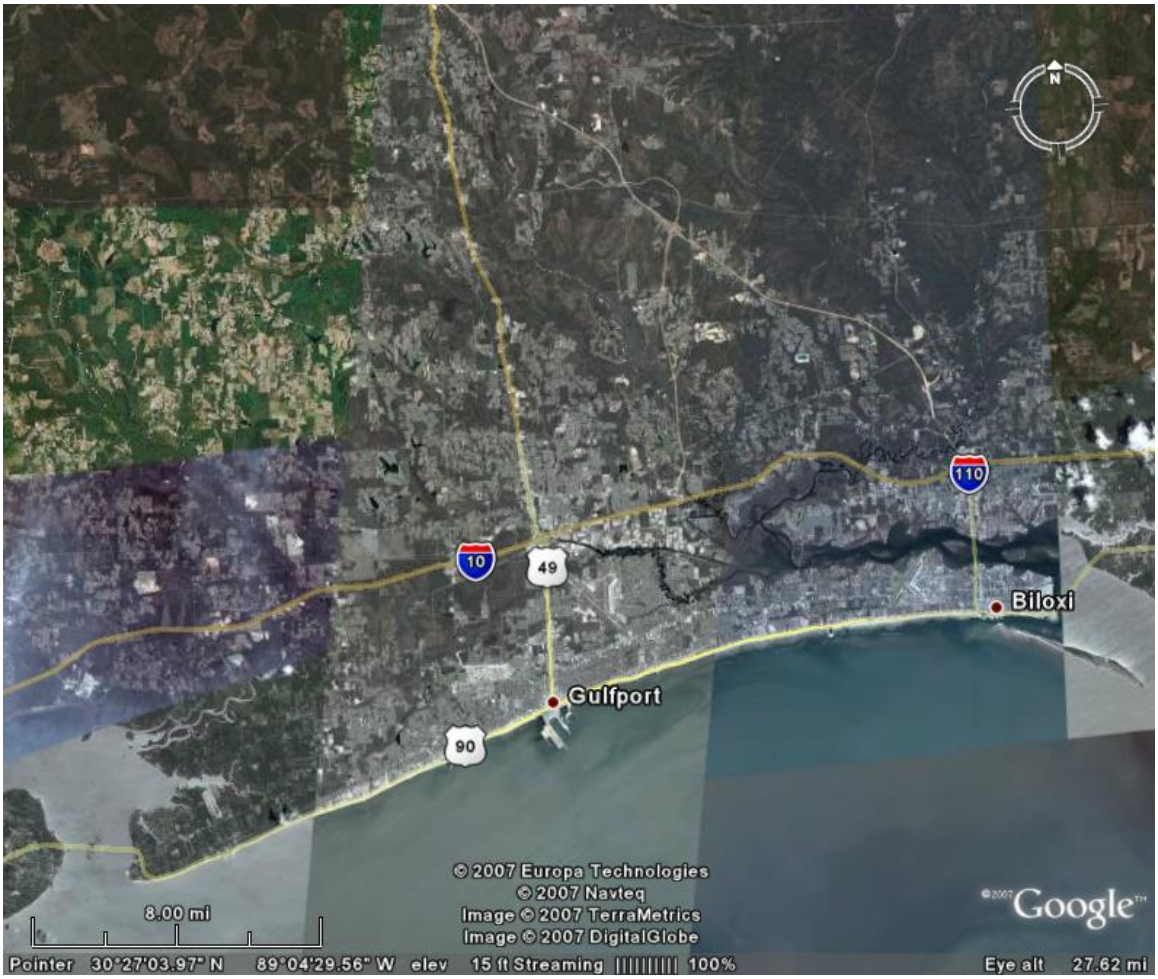
Table C1-3.
Jackson County Parking

	Location	Spaces	Parking Type	Distance from previous lot (miles)
1	Hillandale Ave	225	Free, Street	0.0
2	Shearwater Dr	25	Free, Street	1.7
3	Lake Mars Ave	25	Free, Lot	3.0



Source: Google Earth

Figure C1-1. Hancock County Map



Source: Google Earth

Figure C1-2. Harrison County Map



Source: Google Earth

Figure C1-3. Jackson County Map



Figure C1-4. Hancock County Parking Lot



Figure C1-5. Example of Harrison County Parking Lot.



Figure C1-6. Example Jackson County Parking Lot.

C-1.2 Access

Sufficient access to the public beach exists throughout the three planning units. Under both future without-project and future with-project conditions, the three planning units have access points that run along the entire length of beach in either the form of a board walk or a step down directly from the seawall. These access points are all on the right-of-way for the major road that abuts the beaches including North and South Beach Boulevard in planning unit one and U.S. Highway 90 in planning unit two. Planning unit three contains a combination of direct step downs from the seawalls that run along various sections and walkovers for those sections of beach that require them. All of the access points are on public and are accessible to all visitors on an equal basis at no charge. Figures 1-7, 1-8, and 1-9 illustrate examples of access points to the public beaches in the three planning units.

C-1.3 User Fees

User fees are sometimes charged to the public at beaches in order to recoup the costs of maintaining the beach. Per ER 1165-2-130, “A reasonable beach fee, uniformly applied to all, for use in recovery of the local share of project costs is allowable. Normal charges made by concessionaires and municipalities for use of facilities such as bridges, parking areas, bathhouses, and umbrellas are not construed as a charge for the use of the Federal beach project, if they are commensurate with the value of the service they provide and return only a reasonable profit. Fees for such services must be applied uniformly to all concerned and not as a prerequisite to beach use.” For the beaches in the three planning units in the MsCIP Comprehensive Plan, no fees are anticipated to be charged by the local community.

C-1.4 Conclusion

The results of the analysis indicate that the project meets the requirements of being open 'to all users on an equal basis', and there is sufficient parking and access for the entire length of shoreline protection projects within the three planning units in Mississippi to warrant federal participation. The analysis showed that there are 592 available parking spaces in Hancock County, 2,788 parking spaces in Harrison County, and 350 parking spaces in Jackson County. All spaces are located within a quarter mile of an access point and there is sufficient access to the public beaches either through boardwalk/seawall direct access (planning units one and two) or carefully located access points/crossovers (planning unit 3) along the entire length. User fees are not currently charged to anyone for use and are not anticipated should a project be constructed.

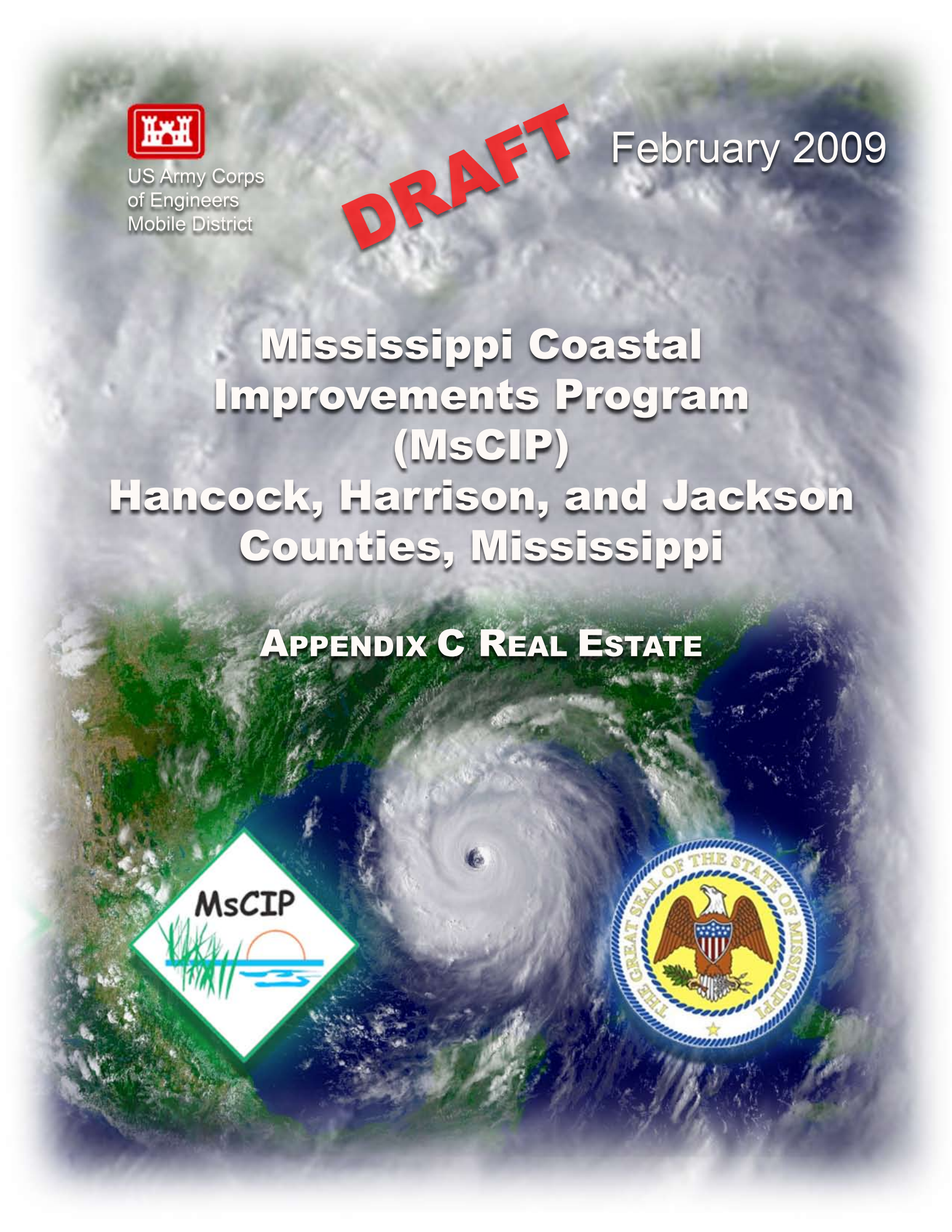
US Army Corps
of Engineers
Mobile District

DRAFT

February 2009

Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

Appendix C Real Estate



FOREWORD

This document is one of a number of technical appendices to the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Feasibility Report and Environmental Impact Statement.

The Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Integrated Feasibility Report and Environmental Impact Statement provides systems-based solutions and recommendations that address: hurricane and storm damage reduction, ecosystem restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion. The recommendations contained in the Main Report/EIS also provide measures that aid in: greater coastal environmental and societal resiliency, regional economic re-development, and measures to reduce long-term risk to the public and property, as a consequence of hurricanes and coastal storms. The recommendations cover a comprehensive package of projects and activities that treat the environment, wildlife, and people, as an integrated system that requires a multi-tiered and phased approach to recovery and risk reduction, irrespective of implementation authority or agency.



Figure 1. The MsCIP Study Area

The purpose of the Comprehensive Plan Report is to present, to the Congress of the United States, the second of two packages of recommendations (i.e., the first being the “interim” recommendations funded in May 2007, and this “final” response, as directed by the Congress), directed at recovery of vital water and related land resources damaged by the hurricanes of 2005, and development of recommendations for long-term risk reduction and community and environmental resiliency, within the three-county, approximately 70 mile-long coastal zone, including Mississippi Sound and its barrier islands, of the State of Mississippi.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and an External Peer Review (EPR). Both review processes will have been conducted in accordance with the Corps “Peer Review of Decision Documents” process, has been reviewed by Corps staff outside the originating office, conducted by a Regional and national team of experts in the field, and coordinated by the National Center of Expertise in Hurricane and Storm Damage Protection, North Atlantic Division, U.S. Army Corps of Engineers.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing recommendations directed at assisting the people of the State of Mississippi in recovery, recommended actions and projects that would assist in the recovery of the physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

This appendix contains detailed technical information used in the analysis of existing and future without-project conditions, in the development of problem-solving measures, and in the analysis, evaluation, comparison, screening, and selection of alternative plans, currently presented as tentatively-selected recommendations contained in the Main Report/EIS.

Each appendix functions as a complete technical document, but is meant to support one particular aspect of the feasibility study process. However, because of the complexity of the plan formulation process used in this planning study, the information contained herein should not be used without parallel consideration and integration of all other appendices, and the Main Report/EIS that summarizes all findings and recommendations.

The Real Estate Appendix identifies and describes the lands, easements and rights-of-way (LER) required for construction, operation and maintenance of the proposed projects. Further, the Real Estate Appendix describes the estimated LER value, together with the estimated administrative and incidental costs attributable to providing project LER, and the acquisition process.

The report is not written to the full feasibility level of detail and defers issues pertaining to borrow and disposal sites and facility/utility relocations for further study during Pre-Construction, Engineering and Design (PED) Phase when more specific information is available. At that time those Real Estate Plans for projects recommended for further study will be revised to incorporate new data and information.

REAL ESTATE SUMMARY

The Real Estate Appendix is written to support the Mississippi Coastal Improvements Program (MsCIP) - Comprehensive Report. The Real Estate Appendix discusses the land requirements associated with each of the different alternatives studied for long term protection of the Mississippi Coastline that includes portions of Hancock, Harrison and Jackson counties. The alternatives under consideration which have real estate requirements are identified as Lines of Defense 1, 2, 3, and 4 along with Nonstructural Acquisition and Ecosystem Restoration areas. It is noted that the Bayou Cumbest and Turkey Creek Ecosystem Restoration areas lay completely or partially within the proposed buy out areas. Although included in the buy out estimates, a separate real estate cost estimate is provided for each of these alternatives in the event a stand alone ecosystem restoration project is recommended.

Table RES-1 identifies the alternatives evaluated by Real Estate, and provides a cost for real estate acquisition for the given alternative. The total cost for each alternative includes an estimated cost for land/improvements, relocation payments, and administrative costs to acquire lands and provide relocation assistance services. Mobile District obtained land records tax data bases for 2005 from the tax assessors' offices in Jackson, Harrison, and Hancock Counties, and provided the data bases to Savannah District Real Estate. Mobile District also provided digital shape files of the various alternatives included in the study. From the counties' data bases and the digital shape files, the Savannah District Spatial Engineering Section designed a web based GIS program which includes a footprint for each alternative. Spatial Engineering wrote a program to generate a data base that includes the tax information for each parcel impacted by a given alternative.

Due to the magnitude of the project and the vast amount of data considered, a number of assumptions were made in compiling the Real Estate costs. The numbers of impacted parcels for the LOD 4 Option A, B & C alternatives varied. The process began by looking at parcels individually to make a determination of approximately what percentage of the parcel may be impacted by the footprint for construction of the berm or levee. As changes in the alternatives occurred, it became apparent that it was not feasible to continue the analysis on a parcel by parcel basis.

Based on the first parcel by parcel analysis completed on more than 2,000 parcels, a determination was made to estimate subsequent real estate takings based on a percentage factor. The total number of properties impacted for a given alternative was firm. However, an assumption was made that the land/improvements valuation would be based on a take of approximately 65% after allowing for the partial takings for those properties impacted by the alternative. While costs are based on assessed values from the 2005 tax year, an appraiser completed a market study using approximately 135 comparable sales from the three coastal counties. All sales used occurred in the first quarter of 2007. From these sales an "adjustment factor" for each county was established. The sales indicated post Katrina real estate values were approximately double the pre-Katrina values and the adjustment factors for each county ranged from 1.75 - 2.50 percent. For planning purposes, this adjustment factor was used to bring the assessed values more in line with 2007 "market values".

An assumption was also made that there would be no relocation cost included for those landowners or tenants where there were structures valued at less than $3,000. It was considered likely that in most cases any structure under $3,000 may be an outbuilding or carport so these should not be included. There may be some mobile homes with an assessed valued under $3,000, but this is thought to be a minimal number. For those parcels where the 2005 tax data indicated there was an improvement valued over $3,000, the value of that improvement and a relocation cost for a displacee are included even though the improvement may have been destroyed by Katrina. This was

based on the assumption that the improvement would likely be rebuilt by the time acquisition for the project is implemented.

A clear distinction could not be made in all cases as to whether a benefit cost for residential or business relocation may apply, so an average cost of $28,000 is used as a "relocation payment" for parcels that were identified with pre Katrina improvements across all alternatives. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

The Acquisition alternative included 34 separate reaches and a total of 33,191 impacted parcels for all the reaches. The Ecosystem Restoration areas for the Turkey Creek and Bayou Cumbest pilot projects have a total of 74 parcels. For these alternatives no adjustments for partial takings were made. One hundred percent of the adjusted values for the land and improvements was used for estimating cost. Relocation costs were considered for every landowner/tenant where there was a structure valued at $3,000 or greater with the same reasoning as stated above and the average "relocation payment" of $28,000 was used.

Administrative costs for land acquisition are based on a cost of $22,500 per parcel. This includes both Federal and Non-Federal Costs. Administrative cost for relocation assistance under Public Law 91-646 is $7,500 per displaced family/business. Total Real Estate acquisition costs for each measure are rounded to the nearest thousand, and include land costs, relocation costs and administrative costs.

It is likely that costs can be refined during the Pre-Construction, Engineering and Design Phase when plans and specifications are available for a recommended plan. A Real Estate Supplement (RES) will be prepared for each authorized component once the real estate requirements have been sufficiently identified during PED. The RES will be submitted to CESAD-PDS-R for approval. The RES will provide updated information as to final real estate requirements for a particular component and will include updated data on the real estate values and costs since the majority of the costs and values contained herein should not be relied upon beyond calendar year 2008. A Real Estate Relocation Plan should also be prepared during PED for each authorized component requiring relocations or displacement of individuals and/or businesses. The Relocation Plan will investigate the availability of replacement housing within a specified radius and any unique or unusual problems that should be considered.

Table RES-1.
Real Estate Summary of Costs

Alternative	Purpose	County	Impacted Parcels	RE Costs
LOD1 Offshore Barrier Islands Options A-G	Off-shore Breakwater		5	$19,000
LOD2 Beach/Dune Construction	HSDR	Hancock		$19,000
LOD2 Beach/Dune Construction	HSDR	Harrison		$19,000
LOD2 Beach/Dune Construction	HSDR	Jackson		$19,000
LOD3 Pearlington Ring- Option A 20	Flood Damage Reduction	Hancock	111	$8,883,000
LOD3 Pearlington Ring - Option B 30	Flood Damage Reduction	Hancock	120	$9,340,000
LOD3 Bay St. Louis Ring Option A 20	Flood Damage Reduction	Hancock	42	$120,246,000
LOD3 Bay St. Louis Ring Option B 30	Flood Damage Reduction	Hancock	576	$156,364,000
LOD3 Elevated Roadway	Flood Damage Reduction	Hancock	427	$44,939,000
LOD3 Elevated Roadway	Flood Damage Reduction	Harrison	1,031	$502,215,000
LOD3 Forrest Heights Levee Option A 17	HSDR Flood Damage Reduction	Harrison	67	$2,571,000
LOD3 Forrest Heights Levee Option B 21	HSDR Flood Damage Reduction	Harrison	67	$2,649,000
LOD3 Elevated Roadway	Flood Damage Reduction	Jackson	137	$39,005,000
LOD3 Ocean Springs Ring Option A 20	Flood Damage Reduction	Jackson	197	$43,609,000
LOD3 Ocean Springs Ring Option B 30	Flood Damage Reduction	Jackson	576	$119,542,000
LOD3 Gulf Park Estates Ring Option A 20	Flood Damage Reduction	Jackson	354	$31,458,000
LOD3 Gulf Park Estates Ring Option B 30	Flood Damage Reduction	Jackson	399	$34,051,000
LOD3 Gulf Park Estates Ring Option C 20	Flood Damage Reduction	Jackson	521	$55,002,000
LOD3 Gulf Park Estates Ring Option D 30	Flood Damage Reduction	Jackson	561	$58,603,000
LOD3 Belle Fontaine Ring Option A 20	Flood Damage Reduction	Jackson	228	$19,366,000
LOD3 Belle Fontaine Ring Option B 30	Flood Damage Reduction	Jackson	297	$25,774,000
LOD3 Belle Fontaine Ring Option C 20	Flood Damage Reduction	Jackson	286	$26,711,000
LOD3 Belle Fontaine Ring Option D 30	Flood Damage Reduction	Jackson	359	$33,260,000
LOD3 Gautier Ring Option A 20	Flood Damage Reduction	Jackson	313	$56,977,000
LOD3 Gautier Ring Option B 30	Flood Damage Reduction	Jackson	354	$66,585,000

Table RES-1.
Real Estate Summary of Costs (continued)

Alternative	Purpose	County	Impacted Parcels	RE Costs
LOD3 Pascagoula Ring Option A 20	Flood Damage Reduction	Jackson	1,075	$237,004,000
LOD3 Pascagoula Ring Option B 30	Flood Damage Reduction	Jackson	1,203	$256,517,000
LOD3 Pascagoula Ring Option C 20	Flood Damage Reduction	Jackson	1,175	$278,147,000
LOD3 Pascagoula Ring Option D 30	Flood Damage Reduction	Jackson	1,321	$297,899,000
LOD3 Pascagoula Ring Option E.20	Flood Damage Reduction	Jackson	2,964	$520,145,000
LOD3 Pascagoula Ring Option F 30	Flood Damage Reduction	Jackson	3,076	$533,059,000
LOD3 Pascagoula Ring Option G 20	Flood Damage Reduction	Jackson	3,138	$574,040,000
LOD3 Pascagoula Ring Option H 30	Flood Damage Reduction	Jackson	3,253	$584,742,000
LOD4 Inland Barrier Option A 20	Flood Damage Reduction	Hancock	426	$66,177,000
LOD4 Inland Barrier Option B 30	Flood Damage Reduction	Hancock	484	$74,262,000
LOD4 Inland Barrier Option C 40	Flood Damage Reduction	Hancock	537	$81,107,000
LOD4 St Louis Bay Surge Barrier Options A-C	Flood Damage Reduction	Hancock & Harrison	8	$1,110,000
LOD4 Inland Barrier Option A 20	Flood Damage Reduction	Harrison	1,512	$253,268,000
LOD4 Inland Barrier Option B 30	Flood Damage Reduction	Harrison	1,688	$271,797,000
LOD4 Inland Barrier Option C 40	Flood Damage Reduction	Harrison	1,927	$300,446,000
LOD4 Inland Barrier Option D 20	Flood Damage Reduction	Harrison	568	$58,266,000
LOD4 Inland Barrier Option E 30	Flood Damage Reduction	Harrison	1,916	$298,748,000
LOD4 Inland Barrier Option F 20	Flood Damage Reduction	Harrison	76	$8,917,000
LOD4 Inland Barrier Option G 30	Flood Damage Reduction	Harrison	189	$20,801,000
LOD4 Inland Barrier Option H 40	Flood Damage Reduction	Harrison	209	$28,271,000
LOD4 Inland Barrier Option I 20	Flood Damage Reduction	Harrison	225	$23,938,000
LOD4 Inland Barrier Option J 30	Flood Damage Reduction	Harrison	171	$25,351,000
LOD4 Back Bay of Biloxi Surge Barrier Options A-C	Flood Damage Reduction	Harrison & Jackson	8	$1,767,000
LOD4 Inland Barrier Option A 20	Flood Damage Reduction	Jackson	323	$58,506,000
LOD4 Inland Barrier Option B 30	Flood Damage Reduction	Jackson	361	$66,571,000
LOD4 Inland Barrier Option C 40	Flood Damage Reduction	Jackson	404	$76,231,000
Nonstructural Acquisition	Flood Damage Reduction	Hancock	17,845	$4,241,808,000
Nonstructural Acquisition	Flood Damage Reduction	Harrison	10,912	$2,722,752,000
Nonstructural Acquisition	Flood Damage Reduction	Jackson	4,434	$775,345,000
Ecosystem Turkey Creek Option A	Ecosystem Restoration	Harrison	13	$1,101,000
Ecosystem Turkey Creek Option B	Ecosystem Restoration	Harrison	8	$752,000
Ecosystem Turkey Creek Option C	Ecosystem Restoration	Harrison	5	$350,000
Ecosystem Bayou Cumbest	Ecosystem Restoration	Jackson	61	$4,807,000

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Comment [K1]: Added Tables to Section 5.1.15 and 5.1.17 that are not listed.

CHAPTER 1. GENERAL

1.1 Guidance

1.1.1 Engineer Regulations

1. ER 405-1-12, Chapter 5 - Acquisition, 5 September 1978, Draft Revision, 9 June 2003
2. ER 405-1-12, Chapter 6 - Relocation Assistance Program, 23 March 1979, Draft Revision, 2 May 2003
3. ER 405-1-12, Chapter 12 - Real Estate Roles and Responsibilities for Civil Works: Cost Shared and Full Federal Projects, 1 May 1998, Draft Revision, 8 March 2003

1.1.2 Engineer Circulars

1. EC 405-1-11, Real Estate Acquisition, 30 December 2003

1.1.3 United States Code

1. Robert T Stafford Disaster Relief and Emergency Assistance Act, as amended, 42 USC § 5121et seq. (Stafford Act)
2. 42 USC, Chapter 61 - Uniform Relocation Assistance and Real Property Acquisition Policies for Federal and Federally Assisted Programs

1.1.4 Code of Federal Regulations

1. Code of Federal Regulations, Title 49, Part 24 - Uniform Relocation Assistance and Real Property Acquisition for Federal and Federally-Assisted Programs

CHAPTER 2. THE REAL ESTATE REPORT

2.1 Statement of Purpose

This report is tentative in nature and is to be used for planning purposes only. The report is written based on specific data from Mobile District and the tax assessors' offices in Hancock, Harrison and Jackson Counties, MS. There may be modifications to the plans that occur during Pre-Construction, Engineering and Design phase, thus changing the final acquisition area(s) and/or administrative and land cost. The Real Estate Appendix is intended to support the Comprehensive Report for the Mississippi Coastal Improvements Program. Due to the scale of the project, the Real Estate Appendix is formatted to include a separate Real Estate Plan (REP) for each of the different measures that are formulated. The Statement of Purpose will not be repeated in each REP. The author of this report has viewed the general Project areas. The State of Mississippi is the non-Federal sponsor for the project. Date of this report is November 2007.

2.2 Study Authority

The Coastal Mississippi Comprehensive Study was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states: "For an additional amount for "Investigations" to expedite studies of flood and storm damage reduction related to the consequences of hurricanes in the Gulf of Mexico and Atlantic Ocean in 2005, $37,300,000 to remain available until expended: ***Provided,*** **That using $10,000,000 of the funds provided, the Secretary shall conduct an analysis and design for comprehensive improvements or modifications to existing improvements in the coastal area of Mississippi in the interest of hurricane and storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resource purposes at full Federal expense: *Provided further,* That the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project recommendations based upon maximizing net national economic development benefits; *Provided further*, That interim recommendations for near term improvements shall be provided within 6 months of enactment of this act with final recommendations within 24 months of this enactment:"**

2.3 Authorization for Entry for Construction

After the non-Federal sponsor completes its acquisition effort and prior to issuance of the solicitation for each construction contract, an informed, authorized, and accountable official of the non-Federal sponsor must execute and provide the district a written Authorization for Entry to all land, easements or rights -of-way (LER) that the Government determined the non-Federal sponsor must provide for that contract. The authorization form must also recite that the non-Federal sponsor is vested with sufficient title and interest in such LER. Further, the non-Federal sponsor must also provide the district with a Certificate of Authority that recites that the official signing the Authorization for Entry form on behalf of the non-Federal sponsor has the authority to furnish such authorization to the Government. Again, rather than including the form in each REP, the form will be included in the Real Estate Appendix as Exhibit "A", and the exhibit will be referenced in the REP.

2.4 Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability

For cost shared projects, a thorough assessment of the non-Federal sponsor's legal and professional capability and experience to acquire and provide the LER for the construction, operations and maintenance of the project, including its condemnation authority and quick-take capability is required. The Capability Assessment checklist must be completed and included as part of the REP. Rather than including the checklist in each REP, the checklist will be included in the Real Estate Appendix as Exhibit “B”, and the exhibit will be referenced in the REP. For this study, this assessment will be made during PED.

2.5 Acquisition Schedule and Management Plan

2.5.1 Acquisition Implementation/Management Plan

The acquisition of lands required for a cost shared project is the responsibility of the Non-Federal Sponsor. It is recommended that an Acquisition Implementation and Management Plan (AIMP) be prepared. This plan should outline the necessary steps required to successfully implement and execute the acquisitions. It should include staffing requirements, field office requirements, contracting requirements and schedules identifying milestones to meet completion dates. This plan should be developed jointly with participation from real estate division, the non-federal sponsor and the project manager to ensure adequate time for acquisition and to meet the schedule for advertisement for construction. A lead time of at least six to nine months prior to the estimated date for the availability of the appropriations should be allowed for preparation of the AIMP. It should be noted that on fast track acquisitions, there are several preliminary acquisition activities that can be accomplished during the PED phase such as surveys, title and appraisal requirements. If these activities are scheduled correctly, the acquisitions can be initiated as soon as the appropriations are made available thus saving 6 – 12 months from the acquisition schedule.

2.5.2 Title/Ownership of Lands Acquired

In cost shared projects, the project sponsor is responsible for acquiring real estate required for the project. Since the Non-Federal Sponsor would be required to operate and manage all lands acquired for the project, title to these lands would be acquired in the named of the sponsor. In the event the Federal Government performs the acquisition of lands, the lands would be acquired in the name of the sponsor. In this instance acquisition of LER by the Government on behalf of the sponsor will be by written agreement between the Government and the non-Federal sponsor.

2.6 Mitigation Lands

Implementation of structural plans would require placement of fill within parts of wetlands in Coastal Mississippi. Overall, structural measures have been developed in ways that avoid or minimize wetland impacts. See section 4.1.7, Mitigation Measures in the Environmental Appendix for a discussion on project impacts and measures for mitigation. Land costs for mitigation are not reflected in the Real Estate Appendix as the plan is to purchase credits from a mitigation bank. the cost of the mitigation credits is included in the Environmental Appendix. The cost presented in the Environmental Appendix does not include real estate administrative costs; these costs would be minimal since the purchase of credits from mitigation banks does not involve acquiring a real interest in land. There could be administrative costs incurred for document preparation. Although specific

mitigation sites have not been selected, for estimation purposes a cost of $5,500 per acre is based on costs to buy credits from established mitigation banks in the Mississippi coastal area. It is noted that LERRD credit is not given for mitigation credits that may be purchased for a project. The cost to purchase mitigation credits is considered as a construction cost.

2.7 Zoning

Title 17 of the Mississippi Code is legislation that enables the counties and municipalities within the proposed project area to establish land use zoning ordinances for their jurisdictions to fulfill the goals and objectives of their comprehensive plans. Potential relocations and redevelopment being considered in the project may affect some current residential and commercial zoning in the counties and may require variances or re-zoning of those areas for project implementation. Zoning ordinances can be used to limit development in certain high-hazard areas or areas with sensitive environmental resources. In areas where no development has taken place (vacant land) or where development has been largely removed (total loss areas), zoning or rezoning of the property could accomplish project objectives by limiting or prohibiting future development. Property devoid of structures only retains its basic land value as dictated by market forces. That land value is influenced to some extent by the natural hazards that may endanger any development that would be constructed on the property. In the case of the study area, there are vast numbers of privately-owned tracts where the structure has been totally destroyed leaving only a concrete slab or wood pilings from the previous foundation. In these cases, rezoning the property for other land uses more adaptable to and compatible with the natural hazards may accomplish program objectives. Zoning of high-risk properties bordering the coast and some of the inlet areas could be used to reduce the incidence of damages to certain types of development or all development.

Any rezoning of vacant land after purchase of at-risk properties for the project would be entirely up to the local jurisdictions in accordance with the floodplain ordinances and any executed agreements for project cooperation. Section 4.5.4 in the Nonstructural Appendix provides an in-depth discussion on Land Use Regulation and Zoning for those counties and municipalities in the project areas.

2.8 Borrow Areas

Section 1.5 in the Engineering Appendix gives detailed information on the borrow sites being considered for use in construction of the project. Section 1.5.5 discusses the on-shore borrow areas which are permitted sites. A table is given for each county that lists the sites and type materials available. A map shows the general location of the sites. Section 1.5.6 describes the offshore borrow areas proposed for use. Section 1.5.7 describes the inland river system sand (dredged material) that is in disposal areas. Diked disposal areas along the Black Warrior - Tombigbee River system and the Tennessee-Tombigbee Waterway are available for use. A map of the disposal areas and tables listing the sites and type real estate interest acquired in the sites are included. In summary the proposed borrow sites are a mix of permitted commercial sites and disposal sites for which the Government either owns or holds an easement interest. Current estimates for borrow material indicate that sufficient sources are available for construction without having to acquire additional sites from private landowners. However should any requirements be identified for acquisition of additional borrow or disposal sites from private landowners, they would be considered part of the LER, and the responsibility of the non-federal sponsor to acquire. The sponsor would have to comply with any approval processes required by the respective county governments for using lands for new borrow or disposal sites.

2.9 Induced Flooding

Lines of Defense 3 and 4 incorporate the use of levees and barriers in the structural measures proposed for storm damage reduction. When it rains, excess rainfall can be trapped behind the levees and can induce flooding even in the absence of a hurricane. During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. The design of the levees includes flap gates, culverts, pumping stations and drainage ditches to aid in water drainage and to channel excess runoff to either gated culverts or pumping stations which will transfer the excess flow to the outside of the levee thereby minimizing induced damages. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report; therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. The design rationale is based on the minimum facility concept, and economic tradeoffs between induced flooding and pumping provisions were not examined. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas. No induced flooding is anticipated as a result of any of the tentatively selected plans. However, should there be a later determination that there will be induced damages for a given measure, a takings analysis will be prepared, the appropriate real estate interest to be acquired will be identified and the real estate estimate will be revised accordingly.

2.10 Utility/Facility Relocations

The term “relocation” shall mean providing a functionally equivalent facility to the owner of an existing utility, cemetery, highway or other public facility or town when such action is authorized in accordance with applicable legal principles of just compensation or as otherwise provided by Federal statute or any project report or House or Senate document referenced therein. Providing a functionally equivalent facility may take the form of adjusting, altering, lowering, raising, or replacement and attendant removal of the affected facility or part thereof. It is important to note that relocation assistance under Public Law 91-646 relates specifically to displaced persons, and should be distinguished from the separate concept of facility or utility relocations

The REP normally contains a description of the facility or utility relocations that must be performed including information regarding the general nature of the impact to each facility or utility; the identity of the owners of the affected facilities and utilities; the purpose of the affected facilities and utilities; whether the owners have compensable real property interests in the land on which the impacted portion of the facility or utility is located; the conclusions reached in an identified Preliminary or Final Attorney's Opinion of Compensability prepared in support of the relocations determinations; whether special legal authority or direction affects relocation classification [for example, the project's authorizing legislation or reports referenced therein; Section 111 of the River and Harbor and Flood Control Act of 1958 (33 U.S.C. §633)]; and other information relevant to the proper identification and performance of relocations necessitated by construction, operation, or maintenance of the project.

Due to level of study in this project, information about specific "relocations" is unknown. In general, it is known that roads would have to be ramped up at intersections for the proposed ring levee projects and that some public utility lines will have to be relocated. The Town of Moss Point in Jackson County has some municipal facilities that would need to be relocated. Each potential utility/facility relocation will be evaluated to determine relocation requirements and possible problems associated with the relocation. Once this assessment is made, the LERRD cost can be adjusted to reflect addition of the utility/faculty relocation cost which are currently included as a construction cost. Any

relocation requirements will be identified during PED along with the required supporting documentation and estimated cost. Utility/facility relocations can add cost to the project and need to be factored into the acquisition schedule timeline.

2.11 Navigation Servitude

For those lands required for construction that lay below the mean high water mark, navigation servitude will apply. Navigation servitude is the dominant right of the Government under the Commerce Clause of the U.S. Constitution (U.S. CONST. Art.I,§8,cl.3) to use, control and regulate the navigable waters of the United States and the submerged lands hereunder for various commerce-related purposes including navigation and flood control. In tidal areas, the servitude extends to all lands below the, mean high water mark. In non-tidal areas, the servitude extends to all lands within the bed and banks of a navigable stream that lie below the ordinary high water mark. The determination of the availability of the navigation servitude should be made on a case by case basis and consists of a two -step process. First the government must determine whether the project serves a purpose that has a nexus to navigation. Purposes recognized by the courts to have the nexus include navigation, flood control and hydroelectric power. If determined that such a nexus exists, then the second step is to determine whether the land at issue is located below the mean or ordinary high water mark of a navigable watercourse. As a general rule, the Government does not acquire interests in real property that it already possesses or over which its use or control is or can be legally exercised. Therefore, if the navigation servitude is found to be available as a result of application of the process described in subparagraph b of this paragraph, then the Government will generally exercise its rights hereunder and, to the extent of such rights, will not acquire a real property interest in the land to which the navigation servitude applies. Generally, it is the policy of the U.S. Army Corps of Engineers (USACE) to utilize the navigation servitude in all situations where available, for cost shared and full Federal projects. The determination of availability will be made during PED.

CHAPTER 3. LINES OF DEFENSE (LOD)

3.1 Line of Defense 1 - Offshore Barrier Islands

3.1.1 Project Description

The barrier islands of Mississippi are located 10 to 15 miles south of the mainland. Currently, there are five islands in the chain that extends for 45 miles west from a point south of the Alabama – Mississippi state line along the coast as shown in Figure 3.1.1-1. Currently, Ship Island exists as two islands separated by a shallow sand bar. It was breached during Hurricane Camille in 1969 and remains today as West and East Ship Island. Two maintained navigation channels pass through the chain of islands. The Gulfport channel passes near the west end of West Ship Island and the Pascagoula channel passes near the west end of Petit Bois Island. The present day location of the channels prevents any further westward migration of either island. All of Petit Bois, Horn, and Ship Islands and part of Cat Island are within the boundaries of the Gulf Islands National Seashore under jurisdiction of the National Park Service (NPS) as shown in Figure 3.1.1-2. The approximate western two thirds of the island is owned by the United Sates of America. The remaining portion of the island is in private ownership among multiple owners of record. In most cases, the boundary extends one mile from the shore of the island. Petit Bois and Horn Islands have also been designated as Wilderness Areas by the U.S. Department of the Interior and have a higher degree of protection than the other islands. Project construction will be on those lands within the boundaries of the Gulf Islands National Seashore and will not impact private lands.

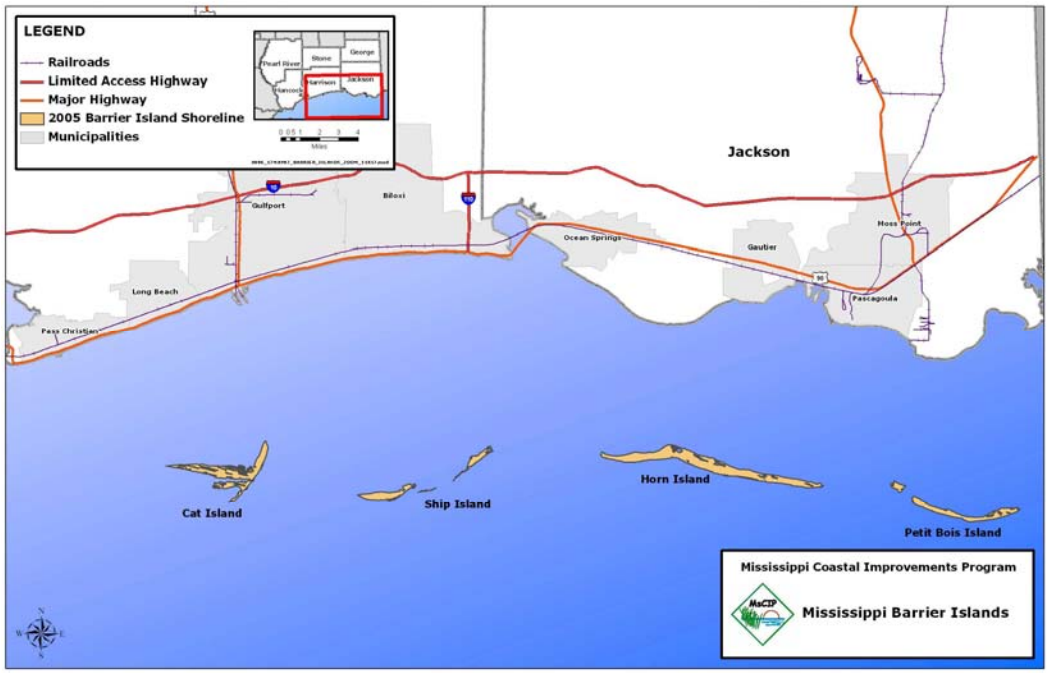


Figure 3.1.1-1. Location of the Mississippi Barrier Islands



Figure 3.1.1-2. Boundaries of the Gulf Islands National Seashore

Data shows that the islands have lost approximately 20 to 25 percent of their land mass since pre-Camille times. Figures 3.1.2.1-1 through 3.1.2.1-4 in the Engineering Appendix illustrate the changes in the footprints of the islands from pre-Camille to post-Katrina. The islands have been heavily influenced by the various hurricanes including even the lower intensity ones. Hurricane George, in 1998, even though a small hurricane, proved to be devastating to the islands due to heavy erosion from waves. Many of the higher dune systems on the islands were destroyed and much of the elevation the islands once had is gone. Most of the islands are now very susceptible to over-wash during storms. Another result of being submerged during Hurricane Katrina was the loss of much of the maritime pine forest that existed on the islands. The trees, mostly now dead from the salt water submergence, played a major role in preventing erosion both from wind and any surges against the islands. Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. The options considered for restoration of the offshore barrier islands are listed in Table 3.1.1-1.

Table 3.1.1-1.
Options for Offshore Barrier Islands

Option	Measure
Option A	Restore Island Footprint
Option B	Replenish Sand in Littoral Zone, Inland Source
Option C	Replenish Sand in Littoral Zone, Inland & Offshore Sources
Option D	Environmental Restoration w/2-foot Dune
Option E	Environmental Restoration w/6-foot dune
Option F	Environmental Restoration of Sea Grass Beds
Option G	Restoration of Ship Island Breach

Several approaches to restoration of the islands were considered. Option A proposes to add new land mass to the islands by using sand dredged and transported from an off-shore location. This sand would come from the St. Bernard Shoals located about 45 miles south of the barrier islands. The shaping of the sand into beaches, dunes and marsh areas will not affect the existing islands other than that narrow strip of land that will form the boundary between the existing island and the new land mass. This option can be used in combination with other options under this line of defense should it be desired to restore habitat on the existing islands. Restoration of Ship Island to a pre-Camille configuration includes closing the post-Katrina, 4-mile long breach to a 2000-foot width and with elevation 20.0 dunes, along with some rebuilding of the other islands to a larger land area. As the new land mass is added to the existing islands, portions of the new island will be planted with various types of vegetation to provide habitat and to aid against erosion.

To increase the size of the footprint of each island and restore them back to a pre-Camille footprint will involve several different operations, some of which can take place concurrently. The source of sand that has been designated as the potential borrow area will require additional investigation using both geophysical techniques and physical sampling. The sand is expected to be in submerged shoals that will have to be located and mapped prior to any removal of the sand. This will be completed during design and before the construction begins.

Each of the islands will require that a “dump basin” be excavated by dredging before any sand is transported from the borrow areas which are located offshore about 45 miles south of the islands. These basins are required due to the depth of the water which is too shallow for the dredges to approach the islands. The basins will typically be located about one mile from the beach of the respective island where sand is being added to surrounding waters. These basins will be of sufficient size to allow a large quantity of sand to be stored after being bottom dumped from a hopper dredge. The material dredged from these basins is anticipated to be unsuitable for placement on the islands and is expected to be transported to permitted disposal areas. As each basin is completed, a hopper dredge can begin to remove sand from the borrow area and transport it to the basin where it can be quickly dumped, allowing the dredge to have minimal delays between trips. When the sand in a basin reaches a set capacity, a cutter head, suction dredge will move the sand from the basin to the area where the sand is needed. Where needed, booster pumps will be utilized. The discharge from the suction dredge will be moved over the areas where the size of the island is being increased. As an area is filled to the desired grade, the sand will be shaped into dunes, basins and beaches. As this earthwork is completed for a given area, planting can begin. The suction dredge will be moved as needed to accommodate the excavation of the basins and the transfer of the sand from the basins to the islands. It is anticipated that the suction dredge will be moved, and then remobilized several times during the entire process for completing an islands enlargement.

Option B and Option C propose to restore the islands by supplementing the sand in the littoral system through the use of inland and off-shore sand sources. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system. The construction of inland waterways in Alabama and Mississippi has resulted in continuing maintenance dredging to maintain the channel depths and alignments. This dredged material is now accumulated in disposal areas along the banks of the river. Dredging of some of the areas along the river has produced large quantities of sand that have potential use for replenishment of littoral zones such as are found along the Mississippi Barrier Islands. An inventory of current disposal sites indicates that approximately 30,000,000 cubic yards of sand is available. Only disposal sites that contain a minimum of 100,000 cubic yards of sand were included in the inventory. Of interest to this study are disposal sites that are located along the Black Warrior – Tombigbee River system and the Tennessee – Tombigbee Waterway. Material from these sites could easily be transported by barge down the river system for use among the islands littoral zone. To add off-site sand into the littoral system under Option B, material from inland dredged material disposal sites would be transported by barge down the river system for use among the islands littoral zones.

Each of the areas designated for adding sand will require that a staging area where barges could be unloaded and the sand spread over the selected area. The sand would be transported from each of numerous disposal sites located up the river systems. The size of the locks on the river systems and the depth of associated channels will dictate the size of barges that can be used. As the barges are unloaded at each site, the sand would be pumped to spreader barges that would be able to cover an area sufficient to control the depth of sand placement.

Option C would help restore the islands by supplementing the sand in select littoral system zones with sand obtained from both inland river and offshore borrow areas. Like Option B, this could be accomplished by adding sand in specific locations based on sediment transport modeling. This option would limit addition of sand to the areas east of Ship Island and Petit Bois Island. These two areas were selected based on cooperation between the National Park Service (NPS, 2007) and the Corps of Engineers and is based on restoration policy of natural resources with the NPS. Both of these islands are affected by the presence of navigation channels that limit westward migration. Placement of sand into these two areas would add sediment into the system and would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. The sand that could be used in this option may come from the same offshore borrow area as Option A, the St. Bernard Shoals located about 45 miles south of the barrier islands and the lower inland river sand described in Option B. The sand from the inland river sources would be from the lower-most areas.

Options D and E involve environmental restoration of the islands consisting of shaping existing sand into dunes on the beaches with planted vegetation and planting of maritime forests on the existing islands where they were mostly destroyed by Hurricane Katrina. For Option D the dune would be shaped from sand that would be removed from the surface between the constructed dune and the edge of the vegetation north of the dune. The dune would have height of 2-feet with a 1v to 3h slopes and a crest width of 6 feet. The dune would be continuous for the length of the gulf-side, south beach. While not designed as a structural defense against storms, the dune would be used as a platform to establish a line of sea oats that in turn would help in the natural process of creating larger and more pronounced sand dunes. The dunes would build with time as wind driven deposits of sand become trapped by the vegetation. For Option E, the dune would have height of 6-feet with a 1v to 3h slopes and a crest width of 6 feet. The sand required to construct a dune of this size would be more than could be removed from the existing beach berm and would come from the same offshore borrow area as the sand used in Option A. Placement of the sand would require moving the sand from a hopper dredge to a staging area on the beach, then moving the sand to the area of placement along the beach.

Option F involves environmental restoration of the sea grass beds that have historically existed on the north side of the islands in the Mississippi Sound. Despite continual changes that occur, the barrier islands remain to buffer the mainland from storms and provide habitat for the rich, diverse wildlife residing within the area. The amount of acres of sea grasses to be planted at each island, based on 50 percent of pre-Camille acreage, is as follows: Cat – 210 acres, Ship – 760 acres, Horn – 2,650 acres, and Petit Bois – 780 acres. This option will involve only the planting of various types of marine aquatic vegetation in selected areas around the islands. No actual construction activities will take place.

Option G proposes to the fill the Ship Island breach. The pre-Camille footprint of Ship Island was obtained from historical records, and showed the area that was breached during Hurricane Camille forming two separate islands. West and East Ship Island has two major historic sites that are in danger from the continuing erosion of the barrier islands. Current studies by the Corps indicate that restoring the two islands to a single island, pre-Camille condition may prevent the rapid erosion of the beaches that is now occurring as well as helping to provide wave erosion on the mainland. Estimates indicated that the restoration of Ship Island to a single land mass off the Mississippi coast will involve approximately 21 million cubic yards of sand. Fort Massachusetts was originally built on the western tip of Ship Island. The westward migration of sand along the southern shore and erosion of the northern shore now has put the fort almost a mile from the western tip of the island, but dangerously close to being in the Sound. Several emergency beach re-nourishments have taken place over the last 35 years through use of operations and maintenance material from the federally authorized Gulfport Harbor Navigation Project to protect the fort from wave action during winter

storms. At present, the NPS is again requesting that the Corps place sand along the shore near the fort in conjunction with dredging operations at the Federal Gulfport Harbor navigation channel. This emergency placement of sand is being repeated about every five to six years. The immediate erosion problem will require re-nourishment of the beach adjacent to the fort similar to the past protection projects. The problem of a long-term fix may be tied to closing the three mile wide breach known as Camille Pass between West and East Ship Island. As well as the sand placement, the plan would include sculpting the sand into beaches, dunes, swales, and marshes. Different types of vegetation planting would also be included to restore habitat on the newly created land. The filling of Camille Pass will also provide a designation of a Federal Beach that would be subject to long term maintenance if needed.

Review of literature indicates that suitable sand can be obtained from St. Bernard Shoals which is located about 45 miles south of Ship Island. This sand should be very high quality material and could be used in the island reconstruction. If this offshore sand source is used, a basin would be dredged near each of the islands to discharge the sand being transported from the borrow area. Using this procedure, the hopper dredge could enter the basin and bottom dump the sand. This would be much faster than pumping off the sand. Doing this would also allow the basin to be placed outside the boundaries of the National Seashore. As the basin is filled, a suction dredge would be mobilized to the site and using this type of the equipment, the sand could be moved to the area where the material is needed to create additional land mass. As the sand is placed on the new land mass, it would be sculpted into dunes and swales which would vary from sea level up to heights of 20 feet.

Another source of sand could be sand from inland river systems as discussed in Option B. Material from these sites could easily be transported by barge down the river system for use as replacement sand in the littoral system of the barrier islands. The offshore sand source and the sand from the inland river systems sites provide sufficient sand for the project construction. The anticipated amount of sand required for each island is as follows:

Cat Island – 14,600,000 cubic yards

Ship Island – 21,240,000 cubic yards

Horn Island – 21,240,000 cubic yards

Petit Bois Island – 9,300,000 cubic yards

3.1.2 Real Estate Requirements

Real Estate requirements for Line of Defense 1 will include a Permit from DOI/NPS to allow for beach re-nourishment, dune construction and plantings to include submerged aquatic vegetation. It will also be necessary to obtain a license from the Minerals Management Agency for mining of sand from those offshore borrow areas in the outer continental shelf, and also to create the “dump basins” needed at each island during construction. It is noted that the Engineering Appendix suggests the use of “permitted disposal areas” for borrow and disposal activity. An assumption is made that some type of permit will be required for borrow/disposal of materials in these areas. This will be investigated further in the next phase, Pre-Construction, Engineering and Design.

3.1.3 Utility/Facility Relocation

There are no utility or facility relocations in any of the options for the offshore barrier islands.

3.1.4 Existing Projects/Studies

Several emergency beach re-nourishments have taken place over the last 35 years on Ship Island to protect Fort Massachusetts from wave action during winter storms. This emergency placement of sand is being repeated about every five to six years. Sand has come from dredging of the federally authorized Gulfport Harbor Navigation Project. Other relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.1.5 Environmental Impacts

None of the options described for the offshore barrier islands are expected to cause negative impacts to the surrounding environment. See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.1.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Since the project will be constructed on lands in the Outer Continental Shelf, any new lands created as a result of the project will be considered lands of the United States of America. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.1.7 Government Owned Property

All of Petit Bois, Horn, and Ship Islands and the western two thirds of Cat Island are within the boundaries of the Gulf Islands National Seashore under jurisdiction of the NPS. In most cases, the boundary extends one mile from the shore of the island. The remaining portion of Cat Island is in private ownership held among multiple owners of record.

3.1.8 Historical Significance

The breach of Ship Island has created problems for the National Park Service due to the location of two historically important sites. Fort Massachusetts is located on the northern shore of West Ship and the French Warehouse is located on the northern shore of East Ship Island. Both of these sites are endangered by on-going erosion of the shoreline with Mississippi Sound. Another site, known as the Quarantine Station, has already been lost to erosion. These sites are shown in Figure 3.1.8-1. See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

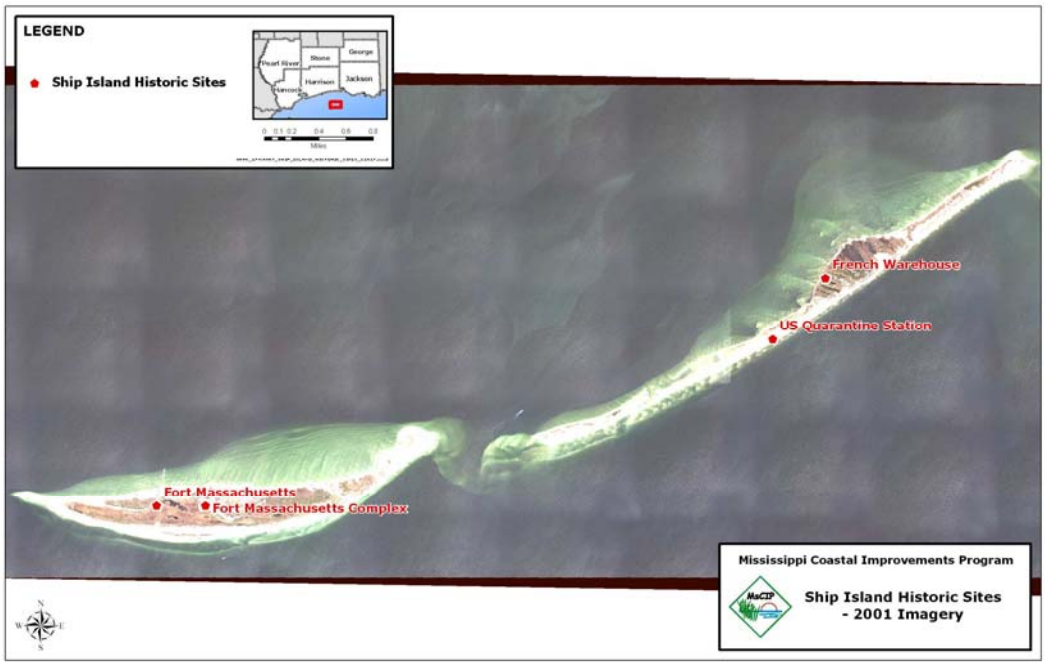


Figure 3.1.8-1. Aerial photo of West and East Ship Island taken in 2001 showing historic sites

3.1.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.1.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.1.11 Public Law 91-646, Relocation Assistance Benefits

Not Applicable

3.1.12 Attitude of Property Owners

There are no known objections to the proposed project.

3.1.13 Acquisition Schedule

All permits must be obtained prior to advertisement for construction. This could be accomplished in 90 - 120 days. An acquisition schedule will be made during PED and will be a joint effort of the NFS, the project manager and Real Estate.

3.1.14 Estates for Proposed Project

No estates are required for the project. All work will be done by permit from the appropriate agency.

3.1.15 Real Estate Estimate

The real estate cost estimate at Table 3.1.15-1 includes a cost for Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. With the exception of a portion of Cat Island that is privately owned, the project will be constructed on offshore barrier islands owned by the Federal Government, so no additional land costs are anticipated. That portion of Cat Island that is privately owned will not be impacted by the project. No cost is included for upland borrow sites as sites have been identified where it will be advantageous to remove fill to make room for future disposal. All costs are for obtaining permits. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estate. Due to the ownership of the islands, the same administrative cost is projected for any individual option or combinations of options.

Table 3.1.15-1.
Offshore Barrier Islands Estimate

a. Lands and Improvements/Permits				0
			Subtotal	0
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs				0
e. Administrative Cost				15,000
	Relocation	Acquisition	Total	
Federal	0	7,500	7,500	
Non-Federal	0	7,500	7,500	
	0	15,000	15,000	
Subtotal				15,000
Contingencies (25%)				3,750

	Totals	**18,750**
	Rounded	**19,000**

3.1.16 Summary of Potential Real Estate Issues

The requirement for using borrow material from the "permitted" sites will be further investigated during PED. Typically if borrow sites are required, this would be considered as part of the LERRD requirements. Real estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should an upland borrow site become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with an upland site and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared and provided to CESAD-PDS-R for review and approval.

Requirements for long term O&M and any associated real estate interests will be identified during PED.

3.1.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.1.17-1 shows the CWBS for real estate activities.

Table 3.1.17-1.
Chart of Accounts - Offshore Barrier Islands

01B	Lands and Damages / Permits	Federal	Non Federal	Total
01B40	Acquisition/Review of NFS	7,500		7,500
01B20	Acquisition by NFS		7,500	7,500
01BX	Contingencies (25%)	1,875	1,875	3,750
	Subtotal	9,375	9,375	18,750
01F	PL 91-646 Assistance			
01F20	By NFS			
01FX	Contingencies (25%)			
	Subtotal			
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS			
01R2B	PL91-646 Relocation Payment by NFS			
01R2D	Review of NFS			
01RX	Contingencies (25%)			
	Subtotal			
	Totals	**9,375**	**9,375**	**18,750**
	Rounded			**19,000**

3.2 Line of Defense 2 - Beach/Dune Construction

The Mississippi Mainland shoreline extends approximately 68 miles, and is divided into three coastal counties: Jackson, Harrison, and Hancock Counties, Figure 3.2-1. The Mississippi coast beaches are a valuable asset and provide vital environmental, cultural, recreational, and economic resources; they assist in maintaining the health and productivity of adjacent waters and provide for diverse cultural and recreational activities.

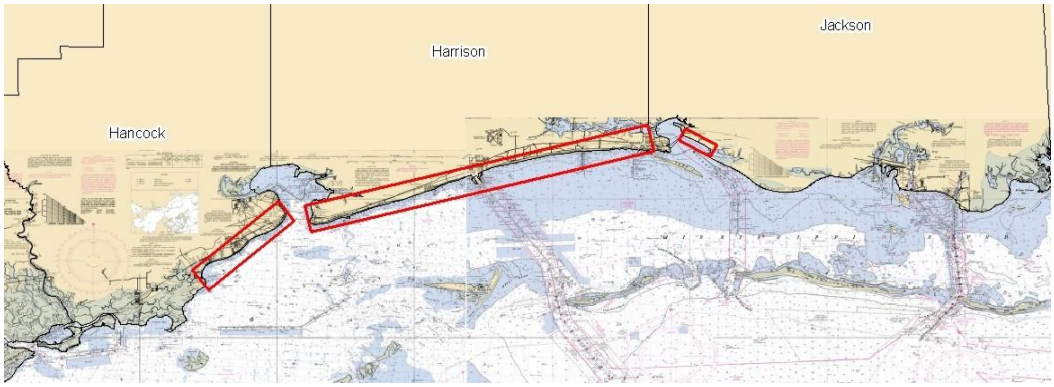


Figure 3.2-1. Mississippi Beaches

Essentially all the beaches along coastal Mississippi are man-made. Harrison County has the most beach-front with 26-miles extending from Biloxi Bay to St. Louis Bay. Hancock County has several miles of beach and Jackson County only a short length. In total, the beaches extend along less than half of the Mississippi coastline. Most of the dunes that previously existed along these beaches were destroyed by Katrina and much of the beach was damaged. Reconstruction of the dunes, where beaches exist, will provide reduction of damaging wave action from smaller storms. A project to restore the beaches in Harrison County has been funded and is underway. Other projects to construct dunes to a height of 5-feet in Harrison County and to 2-feet in Hancock and Jackson County have been proposed as an interim projects, have been designed and are awaiting funding.

Dunes are consistent with a more natural appearing defense than a hard structure. Construction of dunes will include adding vegetation and sand fencing to help stabilize the dunes. The dunes would be a sacrificial barrier, but could also be important by providing additional protection for the toe of the existing roadway, especially in an elevated seawall or roadway configuration as LOD-3. Placement of the dunes directly against a raised seawall or roadway would also serve aesthetically to mask the appearance of a structural barrier.

3.2.1 Hancock County Beaches

3.2.1.1 Project Description

The purpose of this project is to provide hurricane storm damage reduction and restoration of the shoreline to six miles of public beaches along the Hancock County, MS coastline which was impacted by tidal flooding during Hurricane Katrina in August 2005.

Hancock County is the western-most coastal county in Mississippi and is located approximately 95 miles west of Mobile, Alabama and approximately 40-miles east of New Orleans, Louisiana. Hancock County is bordered to the east by Harrison County, MS, and to the west by the Mississippi-

Louisiana state line. The County consists of two municipalities: Bay St. Louis and Waveland. The beaches along the Hancock County shoreline, shown in Figure 3.2.1.1-1, are separated in two sections: the reach extending approximately 6-miles from Grand Bayou in Waveland to the US 90 bridge in Bay St Louis, and the reach extending northeastward approximately 1-mile from Cadet Bayou.

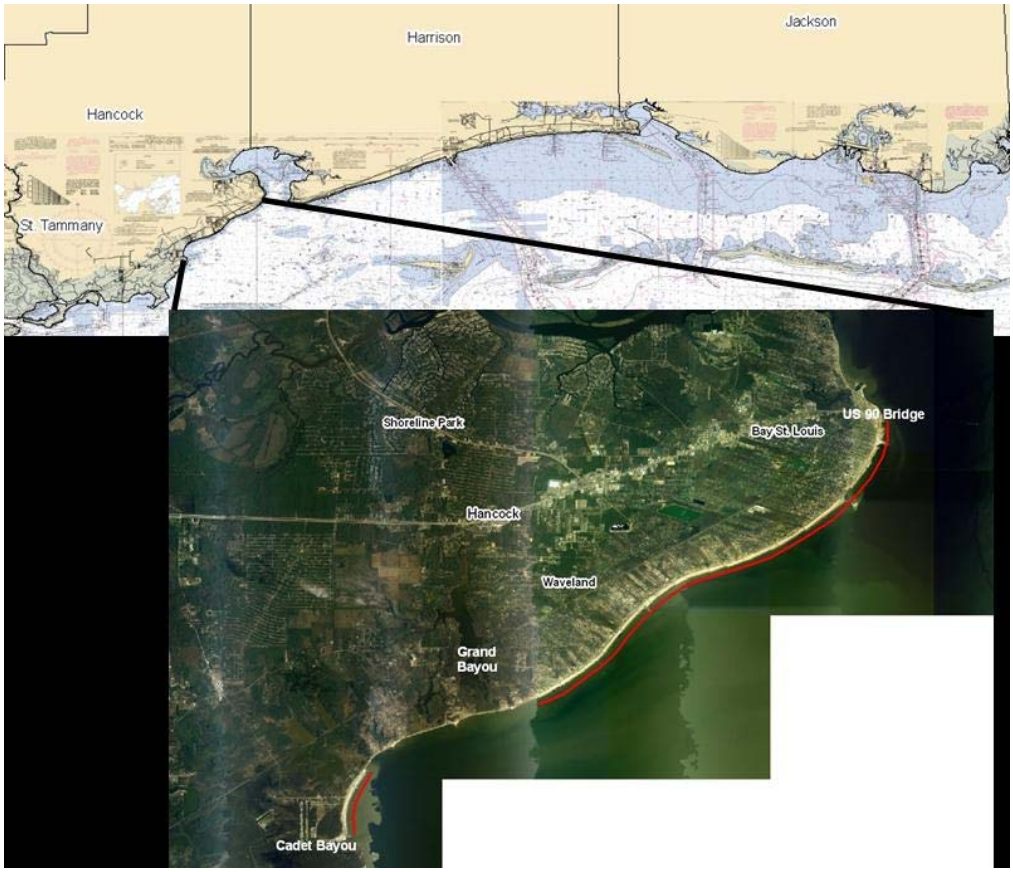


Figure 3.2.1.1-1. Hancock County Beaches

The Hancock County shoreline south of the US 90 bridge is protected by an 8 mile long seawall extending from the US 90 bridge to Cadet Bayou. The Hancock County beaches were constructed for shore protection; however, the area provides added outdoor recreation and environmental benefits. The project was a local project constructed by Hancock County. The area experiences wave and wind erosion and is therefore periodically maintained or re-nourished with sand. The elevation of the seawall ranges between +3.8 and +5.0 feet National Geodetic Vertical Datum (NGVD). The seawall fronting the downtown Bay St Louis beaches is significantly higher. A sand beach was constructed along approximately 6 miles of the seawall in 1967 as part of the emergency repair and protection following Hurricane Betsy (September 1965). The approximately 1 mile section of beach fronting the downtown Bay St Louis area was constructed during the construction of the US 90 Bridge. The 1 mile section extending from Bayou Cadet was constructed in 2005.

The Hancock County beaches were re-nourished in 1994 with material from a borrow area located approximately 1000 feet offshore. The beaches fronting downtown Bay St Louis, the northeast section of the beaches, were again re-nourished in 1996 with material from a borrow area located on the north side of the US 90 bridge. The existing Hancock County beach profile consists of a berm only feature which extends approximately 150 ft from the seawall to the Mississippi Sound. The berm elevation varies from approximately 5.0 ft at the seawall to 3.5 ft at the slope break to the Mississippi Sound. The downtown Bay St Louis area beaches include a bluff with an elevation of about +12 feet.

The project includes evaluation of eleven options in Hancock County as listed in Table 3.2.1.1-1.

Table 3.2.1.1-1.
Hancock County LOD2 Options

Option	Description					
	Dune			Berm		
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing
A*	10	40	1:3	80		
B*	8	50	1:3	80		
C*	10	20	1:3	100		
D*	8	30	1:3	80		
E*	10	40	1:3	80	X	X
F*	8	50	1:3	80	X	X
G*	10	20	1:3	100	X	X
H*	8	30	1:3	100	X	X
I**	10	55	1:3	Extend to accommodate		X
J**	10	55	1:3	Extend to accommodate	X	X
K**				Add 2ft, 60 ft width	X	X

* Options are in conjunction with the LOD3 Seawall

** Options are without a seawall

The future with-project evaluations for Hancock County included 11 options which were evaluated for environmental restoration and enhancement of environmental habitat and hurricane storm damage reduction. Options A through D include four design cross-sections with varying dune and berm configurations. The berm and dune options would be constructed adjacent to the seawall along the length of the beach. For environmental and economic purposes, Options E through H further evaluated the four design cross-sections to include sand fencing and plantings on the dune to provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms. The wider dune features would provide for a larger spatial extent with which to create environmental habitat. Options A through H were evaluated in conjunction with the Line of Defense 3 seawall. Typical cross sections for Options A through D are shown in Figure 3.2.1.1-2. The same cross sections were used for Options E through H. For Options E through H, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.

Options I and J are comparative with-project options, for future evaluation, consisting of a design cross-section which includes a dune and berm constructed as a stand alone project which does not incorporate the Line of Defense 3 seawall. Option I consists of a dune feature constructed approximately 50 ft seaward of the seawall. The berm width would be extended to accommodate the placement of the dune feature. Sand fencing would be placed on the dunes to reduce sand transport due to the strong winds which frequently occur during storms. The cross section for Option J is the

same as Option I; however the dune would be planted to provide for additional environmental habitat. For Option J, sea oats would be planted on both the landward and seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the landward and seaward toes of the dune. The dunes will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Options I and J is shown in Figure 3.2.1.1-3.

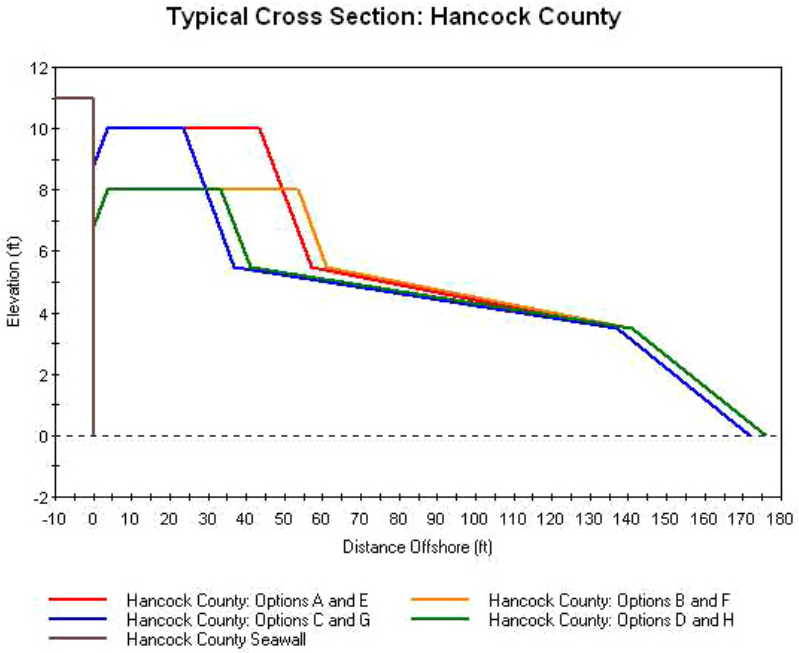


Figure 3.2.1.1-2. Typical Cross Sections, Hancock County Options A-D and E-H

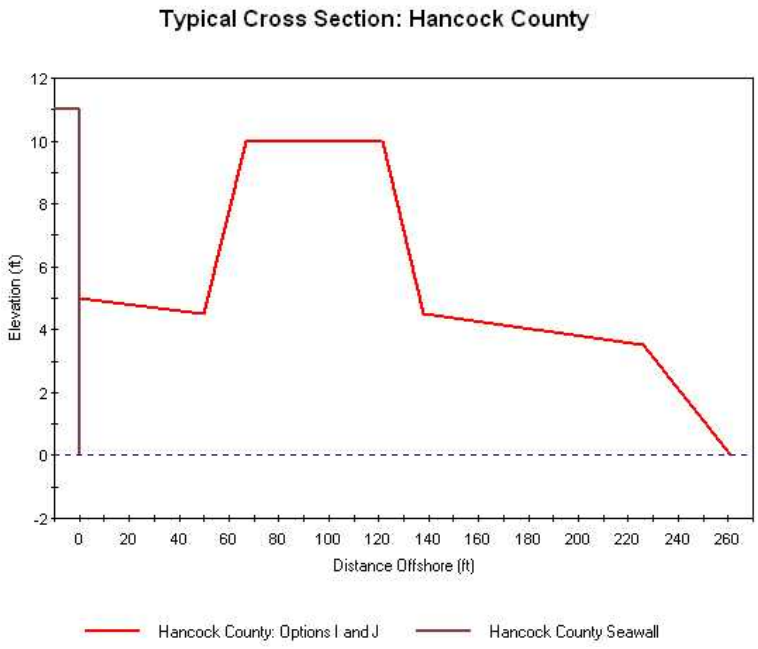


Figure 3.2.1.1-3. Typical Cross Section, Hancock County Comparative Dune Options I and J

Option K is also an option for future evaluation which consists of an elevated berm section constructed primarily for the creation of environmental habitat. Option K would be constructed as a stand alone option which does not incorporate the Line of Defense 3 seawall. The elevated berm section would be constructed approximately 50 ft seaward of the existing seawall to an elevation 2 ft above the existing berm with a width of approximately 60 ft. The berm width would not be extended to accommodate the placement of the elevated berm feature. The new feature would be vegetated and sand fencing would be placed to create environmental habitat and to reduce sand transport due to the strong winds which frequently occur during storms. For Option K, sea oats would be planted in a 30 by 30 inch grid pattern over the entire elevated berm area. The new feature will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Option K is shown in Figure 3.2.1.1-4.

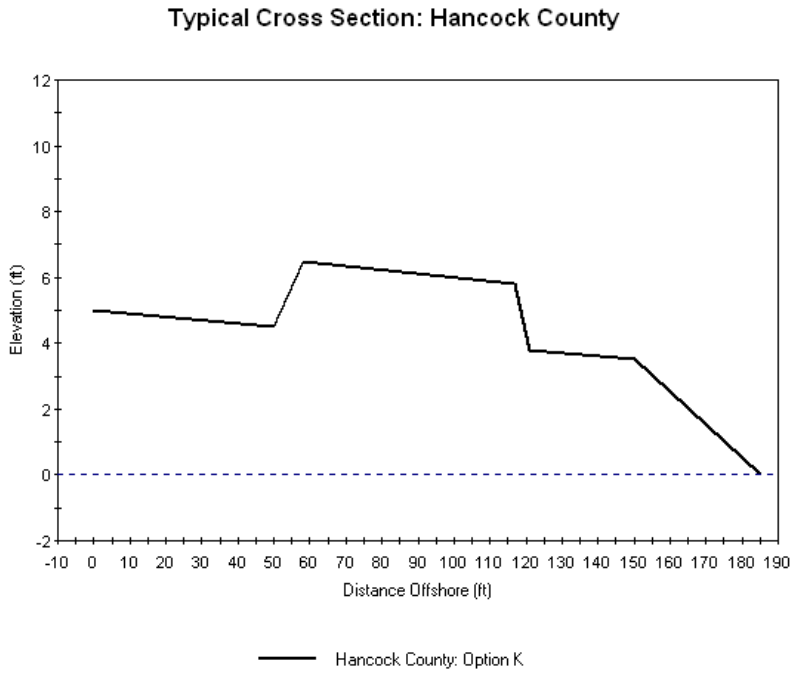


Figure 3.2.1.1-4. Typical Cross Section, Hancock County Option K

3.2.1.2 Real Estate Requirements

Real Estate requirements for Line of Defense 2 for Hancock County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), the right to construct a dune atop the existing beach along with a fence and dune vegetation. Hancock County Tax Maps show parcels under private ownership that are seaward of Beach Boulevard and the seawall. However, under statutory authority, the State claims ownership of all lands seaward of the seawall, and an assumption is made that no further easements will be needed on those lands. An assumption is made that a real estate interest would have been obtained to allow for the original construction of the beaches and subsequent re-nourishment activity. This will be confirmed upon further analysis during PED.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the dune. See Section 2.8 Borrow Areas on page 5. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. Access to the project will be along public roadways and staging is expected to be on sponsor owned lands if required. Addendum C of the Economics Appendix discusses the availability of public parking and access for all three counties. No public access issues have been identified. However, if additional public beach access or parking is required, the sponsor will be responsible for acquiring those real estate interests. Acquisition of additional interests for access and parking are considered as requirements for participation in a Federal project and are not considered as creditable items toward project cost.

3.2.1.3 Utility/Facility Relocation

Some temporary rework of the storm drainage system may be necessary during construction of the project. See Chapter 2 Section 2.10 for more detailed discussion.

3.2.1.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.2.1.5 Environmental Impacts

None of the options described for LOD2 are expected to cause negative impacts to the surrounding environment. See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.2.1.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.2.1.7 Government Owned Property

There are no known Government owned lands within the proposed project.

3.2.1.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.2.1.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.2.1.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.2.1.11 Public Law 91-646, Relocation Assistance Benefits

Not Applicable.

3.2.1.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.2.1.13 Acquisition Schedule

An assumption is made that the sponsor holds an interest in all lands required for the project. Certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. This can be accomplished within 30 days. However, if a borrow area or temporary work area easements become a requirement, 6-12 months should be allowed for easement acquisition of the sites. An acquisition schedule will be made during PED and will be a joint effort of the NFS, the project manager and Real Estate.

3.2.1.14 Estates for Proposed Project

An assumption is made that no easements will be required on lands seaward of the seawall. Should a borrow site be required, the Borrow Easement should be used. The Temporary Work Area Easement will be used for any staging or temporary work areas if required. The estates recommended are standard estates.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____,

beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.2.1.15 Real Estate Estimate

The real estate cost estimate at Table 3.2.1.15-1 includes a cost for Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. The State claims ownership of those lands seaward of the seawall, so no additional land costs are anticipated. No cost is included for an upland borrow site. The requirement, if any, for an upland borrow site will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate. The same administrative cost is projected for any individual option or combinations of options.

Table 3.2.1.15-1.
LOD2 Hancock County Estimate

a. Lands and Improvements/Permits					0
				Subtotal	0
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs					0
e. Administrative Cost					15,000
		Relocation	Acquisition	Total	
	Federal	0	7,500	7,500	
	Non-Federal	0	7,500	7,500	
		0	15,000	15,000	
Subtotal					15,000
Contingencies (25%)					3,750
	Totals				**18,750**
	Rounded				**19,000**

3.2.1.16 Summary of Potential Real Estate Issues

The requirement for borrow areas or temporary work areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should borrow areas or temporary work areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Specific requirements for long term O&M and any associated real estate interests will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

3.2.1.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.2.1.17-1 shows the CWBS for real estate activities.

Table 3.2.1.17-1.
Chart of Accounts - LOD2 Hancock County

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages / Permits			
01B40	Acquisition/Review of NFS	7,500		7,500
01B20	Acquisition by NFS		7,500	7,500
01BX	Contingencies (25%)	1,875	1,875	3,750
	Subtotal	9,375	9,375	18,750
01F	PL 91-646 Assistance			
01F20	By NFS			
01FX	Contingencies (25%)			
	Subtotal			
01R	Real Estate Land Payments			

01A	Project Planning	Federal	Non-Federal	Totals
01R1B	Land Payments by NFS			
01R2B	PL91-646 Relocation Payment by NFS			
01R2D	Review of NFS			
01RX	Contingencies (25%)			
	Subtotal			
	Totals	**9,375**	**9,375**	**18,750**
	Rounded			**19,000**

3.2.2 Harrison County Beaches

3.2.2.1 Project Description

The purpose of this project is to provide hurricane storm damage reduction and restoration of the shoreline to 26 miles of public beaches along Harrison County, MS coastline which was impacted by tidal flooding during Hurricane Katrina in August 2005.

The Mississippi mainland shoreline is divided into three coastal counties: Jackson, Harrison, and Hancock Counties. Harrison County, extends approximately 26-miles, has the largest population, and the greatest number of municipalities. It is bordered on the east by industrialized Jackson County, on the west by Hancock County and the John C. Stennis Space Center and to the north by primarily rural Stone County. The County consists of five municipalities: Biloxi, D'Iberville, Gulfport, Long Beach, and Pass Christian. The Harrison County Federal Shore Protection Project shown in Figure 3.2.2.1-1 extends approximately 26-miles from Biloxi on the east to Henderson Point on the west.

As a result of the 1915 hurricane which destroyed half of U.S. 90, a seawall was constructed to protect the roadway and beach front property. After the hurricane in 1947 and due to ongoing loss of sediment, the Harrison County, Mississippi Federal Beach Erosion Control Project was constructed in 1952 under the Section 2 authority of the River and Harbor Act .The project was constructed to protect the seawall and US 90, which provides an evacuation route for residents. The non-federal sponsor was Harrison County.

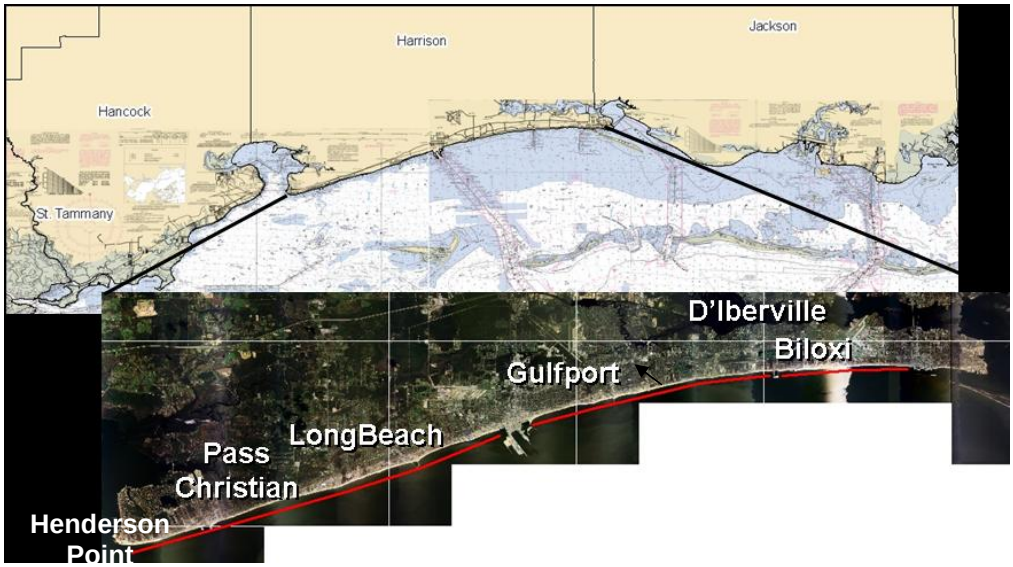


Figure 3.2.2.1-1. Project Location, Harrison County Beaches

The authorized Harrison County project provides for a beach profile consisting of a berm only feature which extends approximately 265 ft from the seawall to mean sea level (MSL). The berm elevation varies from an elevation of approximately 7.2 ft (NAVD 88) at the seawall to 3.5 ft at the slope break to the Mississippi Sound. Storm water culverts pass beneath US 90 to the shoreline to drain sections of Biloxi, Long Beach, and Pass Christian. The Harrison County beaches were last re-nourished in 2001, which placed approximately 1.1 million CY of beach quality sand obtained from borrows sites located about 1,500 ft offshore of the Harrison County shoreline. During Hurricane Katrina on 29 August 2005, the project experienced erosional damage due to wind driven waves, debris scour, storm surge and subsequent return flow after the hurricane.

The project includes the evaluation of eleven options in Harrison County as listed in Table 3.2.2.1-1.

Table 3.2.2.1-1.
Harrison County LOD2 Options

Option	Description					
	Dune			Berm		
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing
A*	15	35	1:3	160		
B*	13	45	1:3	160		
C*	15	25	1:3	170		
D*	13	15	1:3	160		
E*	15	35	1:3	160	X	X
F*	13	45	1:3	80	X	X
G*	15	25	1:3	170	X	X
H*	13	15	1:3	160	X	X
I**	15	55	1:3	Extend to accommodate		X
J**	15	55	1:3	Extend to accommodate	X	X
K**				Add 2ft, 60 ft width	X	X

* Options are in conjunction with the LOD3 Seawall

** Options are without a seawall

The future with-project evaluations for Harrison County included 11 options which were evaluated for environmental restoration and enhancement of environmental habitat and for hurricane and storm damage reduction. Options A through D included four design cross-sections with varying dune and berm configurations. The berm and dune options would be constructed adjacent to the seawall along the length of the beach. For environmental and economic purposes, Options E through H further evaluated the four design cross-sections to include sand fencing and plantings on the dune to provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms. The wider dune features would provide for a larger spatial extent with which to create environmental habitat. Options A through H were evaluated in conjunction with the Line of Defense 3 seawall. The dunes will be constructed to accommodate the approximately 10 ft wide boardwalk which extends along most of the Harrison County seawall. Typical cross sections for Options A through D are shown in Figure 3.2.2.1-2. The same cross sections were used for Options E through H. For Options E through H, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.

Options I and J are comparative with-project options, for future evaluation, consisting of a design cross-section which includes a dune and berm constructed as a stand alone project which does not incorporate the Line of Defense 3 seawall. Option I consists of a dune feature constructed approximately 50 ft seaward of the seawall at an elevation of 15 ft (NAVD 88), with a crest width of 55 ft, and a dune slope of 1:3. The berm width would be extended to accommodate the placement of the dune feature. Sand fencing would be placed on the dunes to reduce sand transport due to the strong winds which frequently occur during storms. The cross section for Option J is the same as Option I; however the dune would be planted to provide for additional environmental habitat. For Option J, sea oats would be planted on both the landward and seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the landward and seaward toes of the dune. The dunes will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Options I and J is shown in Figure 3.2.2.1-3.

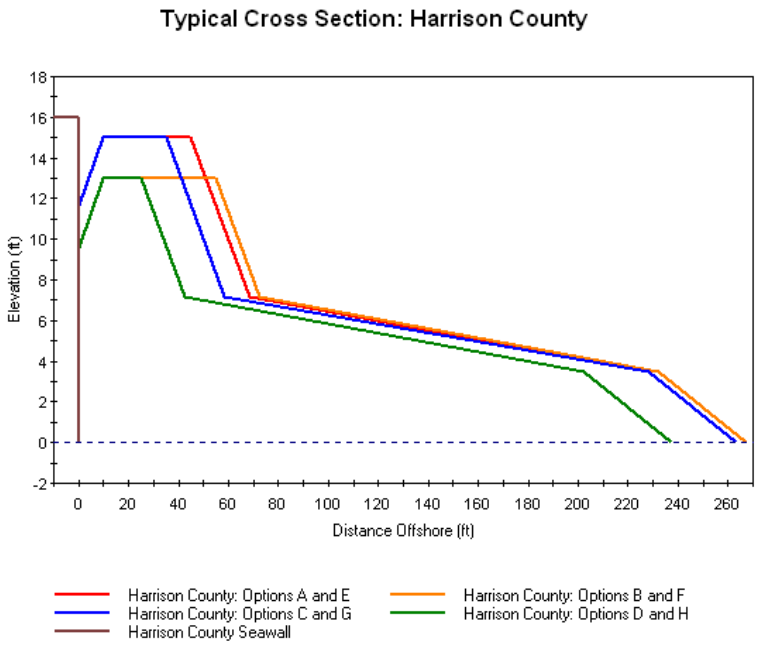


Figure 3.2.2.1-2. Typical Cross Sections, Harrison County Options A-D and E-H

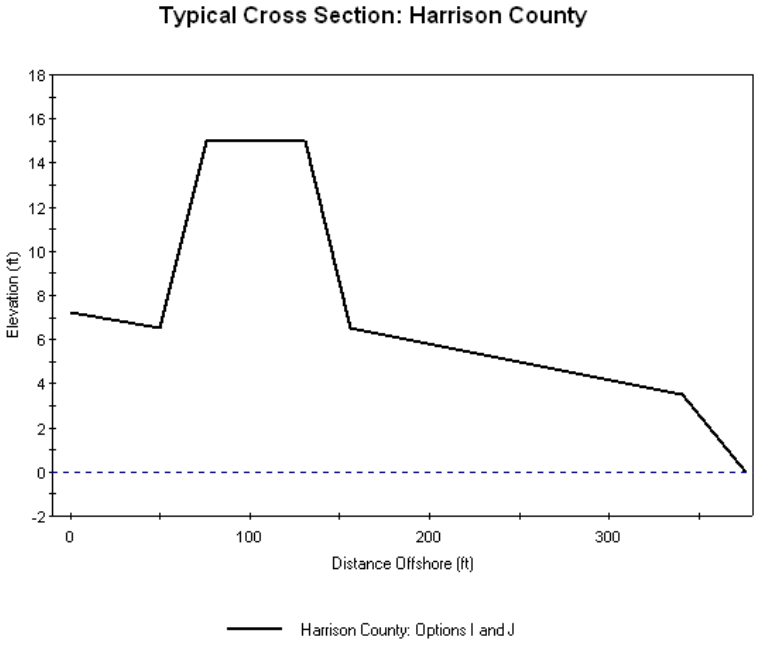


Figure 3.2.3.1-3. Typical Cross Section, Harrison County Comparative Dune Options I and J

Option K is also an option for future evaluation which consists of an elevated berm section constructed primarily for the creation of environmental habitat. Option K would be constructed as a stand alone option which does not incorporate the Line of Defense 3 seawall. The elevated berm section would be constructed approximately 50 ft seaward of the existing seawall to an elevation 2 ft above the existing berm with a width of approximately 60 ft. The berm width would not be extended to accommodate the placement of the elevated berm feature. The new feature would be vegetated and sand fencing would be placed to create environmental habitat and to reduce sand transport due to the strong winds which frequently occur during storms. For Option K, sea oats would be planted in a 30 by 30 inch grid pattern over the entire elevated berm area. The new feature will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Option K is shown in Figure 3.2.2.1-4.

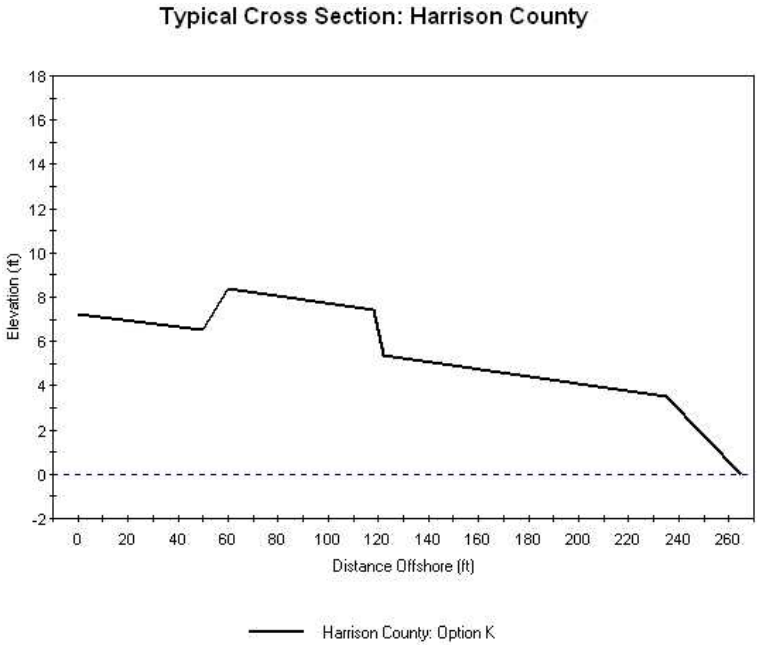


Figure 3.2.2.1-4. Typical Cross Section, Harrison County Option K

3.2.2.2 Real Estate Requirements

Real Estate requirements for Line of Defense 2 for Harrison County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), the right to construct a dune atop the existing beach along with a fence and dune vegetation. Harrison County Tax Maps show parcels under private ownership that are seaward of Beach Boulevard and the seawall. However, the State claims ownership of all lands seaward of the seawall, and an assumption is made that no further easements will be needed on those lands. An assumption is made that a real estate interest would have been obtained to allow for the original construction of the beaches and subsequent re-nourishment activity. This will be confirmed upon further analysis during PED. The sand used for project construction is expected to come from established off shore sources within one mile of the work area. Appropriate permitting will be required to borrow from the off shore sites.

Access to the project will be along public roadways and staging is expected to be on sponsor owned lands if required. Addendum C of the Economics Appendix discusses the availability of public parking and access for all three counties. No public access issues have been identified. However, if additional public beach access or parking is required, the sponsor will be responsible for acquiring those real estate interests. Acquisition of additional interests for access and parking are considered as requirements for participation in a Federal project and are not considered as creditable items toward project cost.

3.2.2.3 Utility/Facility Relocation

There are no known utility or facility relocations in any of the options for the berm and dune construction.

3.2.2.4 Existing Projects/Studies

The Harrison County Shore Protection Project was completed in June 1952 and provided for the repair of the existing 24 mile long Harrison County seawall and its protection by the construction of a beach from Biloxi Lighthouse to Henderson point near Pass Christian. The beach has been maintained by Harrison County since then. During PED a determination will be made of what interest was acquired for the project. Other relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.2.2.5 Environmental Impacts

None of the options described for LOD2 are expected to cause negative impacts to the surrounding environment. See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.2.2.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the

non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.2.2.7 Government Owned Property

There are no known Government owned lands within the proposed project.

3.2.2.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.2.2.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.2.2.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.2.2.11 Public Law 91-646, Relocation Assistance Benefits

Not Applicable

3.2.2.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.2.2.13 Acquisition Schedule

An assumption is made that the sponsor holds an interest in all lands required for the project. Certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. This can be accomplished within 30 days. However, if temporary work area easements become a requirement, 6-12 months should be allowed for an easement acquisition of the sites. An acquisition schedule will be made during PED and will be a joint effort of the NFS, the project manager and Real Estate.

3.2.2.14 Estates for Proposed Project

An assumption is made that no easements will be required on lands seaward of the seawall. The standard estate Temporary Work Area Easement will be used for any staging or temporary work areas if required.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.2.2.15 Real Estate Estimate

The real estate cost estimate at Table 3.2.2.15-1 includes a cost for Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. The State claims ownership of those lands seaward of the seawall, so no additional land costs are anticipated. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate. The same administrative cost is projected for any individual option or combinations of options.

Table 3.2.2.15-1.
LOD2 Harrison County Estimate

a. Lands and Improvements/Permits					0
				Subtotal	0
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs					0
e. Administrative Cost					15,000
		Relocation	Acquisition	Total	
	Federal	0	7,500	7,500	
	Non-Federal	0	7,500	7,500	
		0	15,000	15,000	
Subtotal					15,000
Contingencies (25%)					3,750
	Totals				**18,750**
	Rounded				**19,000**

3.2.2.16 Summary of Potential Real Estate Issues

If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Should temporary work areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Specific requirements for long term O&M and any associated real estate interests will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

3.2.2.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.2.2.17-1 shows the CWBS for real estate activities.

Table 3.2.2.17-1.
Chart of Accounts - LOD2 Harrison County

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages / Permits			
01B40	Acquisition/Review of NFS	7,500		7,500
01B20	Acquisition by NFS		7,500	7,500
01BX	Contingencies (25%)	1,875	1,875	3,750
	Subtotal	9,375	9,375	18,750
01F	PL 91-646 Assistance			
01F20	By NFS			
01FX	Contingencies (25%)			
	Subtotal			
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS			
01R2B	PL91-646 Relocation Payment by NFS			
01R2D	Review of NFS			
01RX	Contingencies (25%)			
	Subtotal			
	Totals	**9,375**	**9,375**	**18,750**

Rounded	**19,000**

3.2.3 Jackson County Beaches

3.2.3.1 Project Description

The purpose of this project is to provide hurricane storm damage reduction and restoration of the shoreline to 7 miles of public beaches along the Jackson County, MS coastline which was impacted by tidal flooding during Hurricane Katrina in August 2005.

The Mississippi mainland shoreline is divided into three coastal counties: Jackson, Harrison, and Hancock Counties. Jackson County is the eastern-most coastal county in Mississippi and is bordered on the east by the Mississippi-Alabama state line and on the west by Harrison County. Jackson County consists of four municipalities: Pascagoula, Moss Point, Gautier, and Ocean Springs. The beaches along the Ocean Springs shoreline are divided into two reaches: Front Beach extending approximately 1 mile southeastward from US 90 along Front Beach drive to the Ocean Springs Harbor, and East Beach extending approximately 1 mile from the Ocean Springs Harbor to Halstead Road, Figure 3.2.3.1-1.

Seawalls were constructed along the shoreline fronting the developed sections of Ocean Springs in the late 1920s. Two decades later, beach nourishment projects created sand beaches in front of two seawall segments, and the modern shoreline reaches of Front Beach and East Beach became named. Front Beach, more exposed to wave and tidal forces, experienced greater levels of erosion, and re-nourishment with dredged material was conducted in the 1970s. At wave-sheltered East Beach, marsh vegetation colonized the beachfront intertidal zone and thus assisted in the stabilization of the shoreline. Both Front Beach and East Beach systems only consist of a berm with landward elevations ranging from approximately 2.5 to 5 ft and berm widths of about 100 ft.

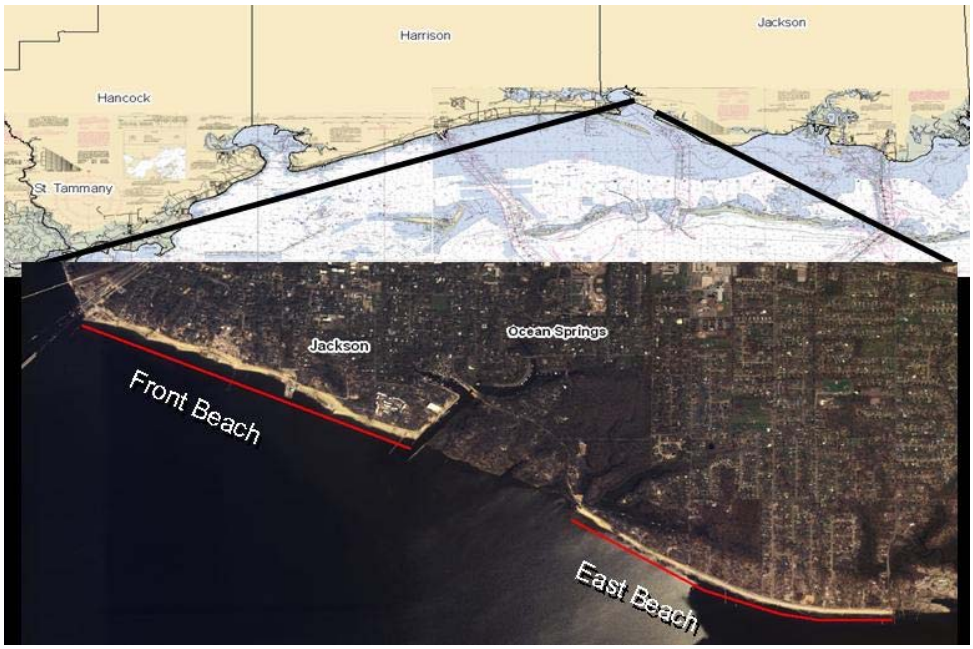


Figure 3.2.3.1-1. Project Location, Jackson County Beaches

The project includes evaluation of eleven options in Jackson County as listed in Table 3.2.3.1-1. Evaluation of the Jackson County beaches was based on the analysis of the Hancock County beaches. The Jackson County beach options are the same design as the Hancock County beaches; therefore the reader is referred to Section 3.2.1.1 for information regarding the Hancock County future with project options.

Table 3.2.3.1-1.
Jackson County LOD2

Option	Description					
	Dune			Berm		
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing
A*	10	40	1:3	80		
B*	8	50	1:3	80		
C*	10	20	1:3	100		
D*	8	30	1:3	80		
E*	10	40	1:3	80	X	X
F*	8	50	1:3	80	X	X
G*	10	20	1:3	100	X	X
H*	8	30	1:3	100	X	X
I**	10	55	1:3	Extend to accommodate		X
J**	10	55	1:3	Extend to accommodate	X	X
K**				Add 2ft, 60 ft width	X	X

* Options are in conjunction with the LOD3 Seawall

** Options are without a seawall

3.2.3.2 Real Estate Requirements

Real Estate requirements for Line of Defense 2 for Jackson County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), the right to construct a dune atop the existing beach along with a fence and dune vegetation. Jackson County Tax Maps show parcels under private ownership that are seaward of the beach boulevards. However, the State claims ownership of all lands seaward of the seawall, and an assumption is made that no further easements will be needed on those lands. An assumption is made that a real estate interest would have been obtained to allow for the original construction of the beaches and subsequent re-nourishment activity. This will be confirmed upon further analysis during PED.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the project. The sources are within ten miles of the work area. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. Access to the project will be along public roadways and staging is expected to be on sponsor owned lands if required. Addendum C of the Economics Appendix discusses the availability of public parking and access for all three counties. No public access issues have been identified. However, if additional public beach access or parking is required, the sponsor will be responsible for acquiring those real estate interests. Acquisition of additional interests for access and parking are considered as requirements for participation in a Federal project and are not considered as creditable items toward project cost.

3.2.3.3 Utility/Facility Relocation

There are no known utility or facility relocations in any of the options for the berm and dune construction.

3.2.3.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.2.3.5 Environmental Impacts

None of the options described for LOD2 are expected to cause negative impacts to the surrounding environment. See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.2.3.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.2.3.7 Government Owned Property

There are no known Government owned lands within the proposed project.

3.2.3.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.2.3.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.2.3.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.2.3.11 Public Law 91-646, Relocation Assistance Benefits

Not Applicable.

3.2.3.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.2.3.13 Acquisition Schedule

An assumption is made that the sponsor holds an interest in all lands required for the project. Certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. This can be accomplished within 30 days. However, if borrow or temporary work area easements become a requirement, 6-12 months should be allowed for an easement acquisition of the sites. An acquisition schedule will be made during PED and will be a joint effort of the NFS, the project manager and Real Estate.

3.2.3.14 Estates for Proposed Project

An assumption is made that no easements will be required on lands seaward of the seawall. Should a borrow site be required, the Borrow Easement should be used. The Temporary Work Area Easement will be used for any staging or temporary work areas if required. The estates recommended are standard estates.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.2.3.15 Real Estate Estimate

The real estate cost estimate at Table 3.2.3.15-1 includes a cost for Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. The State claims ownership of those lands seaward of the seawall, so no additional land costs are anticipated. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate. The same administrative cost is projected for any individual option or combinations of options.

Table 3.2.3.15-1.
LOD2 Jackson County Estimate

a. Lands and Improvements/Permits				0
			Subtotal	0
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs				0
e. Administrative Cost				15,000
	Relocation	Acquisition	Total	
Federal	0	7,500	7,500	
Non-Federal	0	7,500	7,500	
	0	15,000	15,000	
Subtotal				15,000
Contingencies (25%)				3,750
	Totals			**18,750**
	Rounded			**19,000**

3.2.3.16 Summary of Potential Real Estate Issues

The requirement for borrow areas or temporary work areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should borrow areas or temporary work areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Specific requirements for long term O&M and any associated real estate interests will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

3.2.3.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.2.3.17-1 shows the CWBS for real estate activities.

Table 3.2.3.17-1.
Chart of Accounts - LOD2 Jackson County

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages / Permits			
01B40	Acquisition/Review of NFS	7,500		7,500
01B20	Acquisition by NFS		7,500	7,500
01BX	Contingencies (25%)	1,875	1,875	3,750
	Subtotal	9,375	9,375	18,750
01F	PL 91-646 Assistance			
01F20	By NFS			
01FX	Contingencies (25%)			
	Subtotal			
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS			
01R2B	PL91-646 Relocation Payment by NFS			
01R2D	Review of NFS			
01RX	Contingencies (25%)			
	Subtotal			
	Totals	**9,375**	**9,375**	**18,750**
	Rounded			**19,000**

3.3 Line of Defense 3 - Elevated Roadways, Seawall, and Ring Levees

All of the beaches described in the LOD-2 alternative have a roadway landward of the beach. The roads vary from local or county roads to US Highway 90, a major, four-lane highway that extends across the entire Harrison County coast. The existing roadways vary in elevation from four to five feet in Jackson and Hancock County and up to about 15 feet above sea level in Harrison County. All of these roads are evacuation routes and all have been damaged in past hurricanes. In a damaged or destroyed condition, these roads make re-entry to the area difficult after a hurricane has passed. Raising and using these roadways as barriers with an associated seawall defines a portion of the 3rd line of defense, LOD-3. This would be the first hard engineered structure that will not be affected by erosion from a storm such as a dune system.

Initial strategy was to study three elevations, 12.0, 18.0 and 24.0 feet. This coastal barrier will coincide with the beaches where they exist. Raising the beach-front road does present some engineering challenges due to the numerous intersections with other streets and roads. With any significant increase in elevation, the intersecting roads would require ramps that would be extremely long to have a reasonable grade. Each of these ramps would also create areas where rainfall would collect and have to be removed during a storm. It also became apparent that public opinion was against any structure that would block the view of the beaches and water from the adjoining properties immediately north of the roads. This was voiced in public meetings and also from agencies that were involved in the study. To maintain some level of support for this defense, it was decided to raise the roadways an average of six feet. This allowed reasonable road intersection

construction while maintaining the aesthetic view of the water and would not be perceived as a high seawall along the coast. A review of the typical roadway elevations allowed raising the roadways in Jackson and Hancock County to Elevation 11.0 and Highway 90 in Harrison County to Elevation 16.0. It was decided to study these elevations without other options as the main part of LOD-3 with the understanding that these structures would not provide protection from large storms. As described above, the LOD-2 dunes could also be constructed against the elevated roadway to help protect the toe of the structural wall associated with the road.

This line of defense would be connected to LOD-4, described below, at the mouth of Biloxi Bay and St. Louis Bay. It would also extend northward to higher ground or to LOD- 4 in Jackson County and Hancock County. The bays are an inlet for storm surge that would be controlled by surge gates as part of LOD- 4. It was also recognized that if LOD-3 was constructed without LOD-4, surge gates across the bays would have to be included as part of LOD-3.

As the first structural defense, LOD-3 will exclude some areas that may be considered potential areas of retreat or have other non-structural solutions. This may be due to low population density, ecological sensitivity, areas that contain numerous waterway crossings or areas that could not function with a structural barrier in place. In Jackson County, LOD-3 will encompass the southern portion of Ocean Springs, but due to extended marshes and streams, it will extend northeastward from near the eastern end of East Beach Road to higher ground. Areas east of this location contain numerous marshes, streams, and scattered development. Ring levees will be evaluated for housing developments in some areas. Further east in Jackson County are the cities of Gautier, Pascagoula and Moss Point. The presence of numerous streams and inlets will make a continuous barrier very difficult and these areas are also envisioned to have individual ring levees. While alignments were selected that provided the maximum protection for the most developed areas, some portions could be excluded due to cost and technical issues with closing off drainages. Redrawing the alignments would place some areas into a non-structural solution and could be considered as potential options for further study. These alternate alignments were drawn for Pascagoula/Moss Point, Bell Fontaine, and Gulf Park Estates.

At the western end of LOD-3, the barrier will extend down North Beach Boulevard for several miles to near Bayou Caddy and then turn north to tie in with higher ground. By following this path, the existing roadway will provide an alignment and it will encompass much of the developed waterfront from Bay St. Louis to Waveland, MS. Further west, the town of Pearlington will be evaluated for construction of a ring levee.

As with the main portion of LOD-3, the ring levees were initially considered with the same three elevations of 12.0, 18.0 and 24.0. Closer study revealed that in many cases, the elevation 12.0 was too low based on existing ground surfaces and the elevation 24.0 may not be high enough to be certified by FEMA for a 100-year storm event. The elevations to be studied for the ring levees then was changed to 20.0 and 30.0 with the assumption that the 100-year event would fall between these elevations and that the elevation 30.0 design would be sufficiently high for even a 500-year event. A 100-year minimum event is necessary for levee certification by FEMA.

While many options were reviewed for the type of structure to be used along the roadways, a simple elevated roadway associated with an extension of the existing seawall was chosen for reliability reasons. A structure that did not mainly rely on powered systems or with multiple moving systems was deemed more suitable for the purposes of this line of defense. Numerous conceptual designs were considered including inflatable barriers, concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall, sliding panel gates within a seawall, and structural concrete seawalls. The ring levees were all designed as earthen structures. It should be understood that all of these LOD-3 structures would provide less protection than would be required for a Camille

or Katrina-like storm. LOD-3 storm damage reduction levels are limited and will be determined based on public and local government acceptance and the amount of risk that Mississippi is willing to accept.

As previously mentioned, this LOD-3 is dependent on having the ability of closure across the two bays to prevent the storm surge from running inside the mouths of the bays. While the plan calls for surge gates to be associated with LOD-4, surge gates would also have to be incorporated with LOD-3 if LOD-4 is not selected as an alternative. The top elevation of surge gates used solely for LOD-3 would be of an elevation that would be compatible with the rest of that barrier.

Interior drainage behind these barriers must be considered. Any large rainfall event would require that the water trapped behind the barrier have a means to drain or even be mechanically pumped. The amount of storage that a given watershed could provide behind a barrier during surge conditions will vary. The means to block surge but allow drainage as the surge passes may include conduits with flap valves or gated culverts up to surge gates across large bodies of water. The areas where pumping is required are numerous, but necessary to prevent residual damages associated with this blockage of normal drainage.

The pumping stations, where required, must survive any storm damage and continue to operate until the storm event has passed. This will require hardened structures to house the pumps and power systems, and be constructed to a height that corresponds to the risk associated with that line of defense.

3.3.1 Hancock County Ring Levees, Pearlington

Pearlington is a small town located in the western part of Hancock County as shown in Figure 3.3.1-1. The town lies on the bank of the Pearl River about 5 miles from the Mississippi Sound. Ground elevations over most of the residential and business areas are very low between elevations 6-10 ft NAVD88. Pearlington was an extremely hard hit area during the 2005 hurricane season. Water reached a depth of 10-14 feet over the whole community. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A and Option B.



Figure 3.3.1-1. Vicinity Map, Pearlington

3.3.1.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the most densely populated areas of Pearlington along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 ft NAVD88 with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.1.2 Option B - elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 ft NAVD88. The difference between the description of this option and the preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.1.3 Project Description

Figure 3.3.1.3-1 shows the location of the proposed project alternatives. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.1.3-2 shows the proposed location of the pump/culvert sites. During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Further

studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

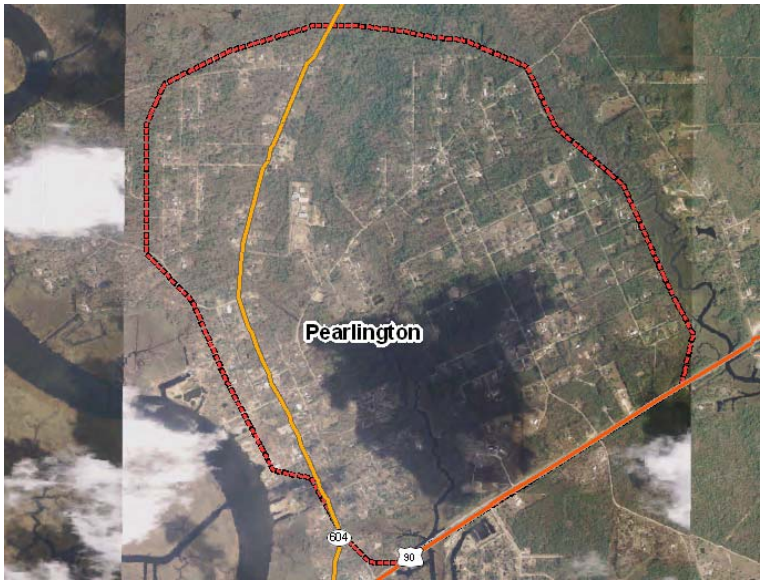


Figure 3.3.1.3-1. Pearlington Ring Levee

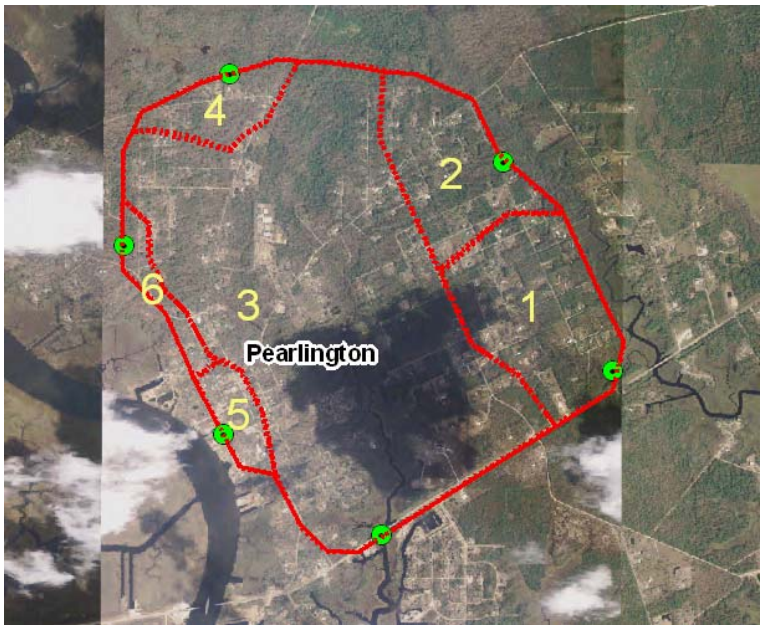


Figure 3.3.1.3-2. Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site borrow sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. Pump facilities will be required at 6 locations.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around the Pearlington area, 18 roadway intersections would have to be accommodated. For this study it was estimated that all 18 would require swing gate structures.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills or rivulets will be filled and damaged revetment will be repaired.

3.3.1.4 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Pearlington Ring Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches, and 6 culvert/pump station facilities.

Based on the footprint of the Option A 20.0 foot elevation, it was determined that approximately 111 parcels and 28 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 6 pump stations will require approximately 0.23 of an acre each for a total of 1.38 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 28 relocations. For cost purposes, the relocations are assumed to be residential.

Based on the footprint of the Option B 30.0 foot elevation, it was determined that 120 parcels and 30 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 6 pump stations will require approximately 0.23 of an acre each for a total of 1.38 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 30 relocations. For cost purposes, the relocations are assumed to be residential.

Ditches that will be constructed to provide drainage for the interior of the ring levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Any modifications to the roadways will most probably need to be accomplished under a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.1.5 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.1.6 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.1.7 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.1.8 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project. Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.1.9 Government Owned Property

There are no known Government owned lands in the proposed project.

3.3.1.10 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.1.11 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.1.12 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.1.13 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person

may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 28 relocations in Option A and approximately 30 relocations in Option B. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.1.14 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.1.15 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.1.16 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all

such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.1.17 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.1.17-1. The real estate cost estimates at Table 3.3.1.17-2 and Table 3.3.1.17-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.1.17-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	111	28	8,883,000
Option B - 30.0	120	30	9,340,000

Table 3.3.1.17-2.
LOD3 Hancock County Ring Levee, Pearlington - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
111 Ownerships, 28 Improvements					3,527,608
(6 Pump Stations)					87,399
				Subtotal	3,615,007
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 28 relocations					784,000
e. Administrative Cost					2,707,500
		Relocation	Acquisition	Total	
	Federal	42,000	277,500	319,500	
	Non-Federal	168,000	2,220,000	2,388,000	
		210,000	2,497,500	2,707,500	
Subtotal					7,106,507
Contingencies (25%)					1,776,627
	Totals				**8,883,134**
	Rounded				**8,883,000**

Table 3.3.1.17-3.
LOD3 Hancock County Ring Levee, Pearlington - Option B 30.0 Estimate

a. Lands and Improvements/Permits					
120 Ownerships, 30 Improvements					3,630,995
(6 Pump Stations)					87,399
				Subtotal	3,718,394
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 30 relocations					828,800
e. Administrative Cost					2,925,000
		Relocation	Acquisition	Total	
	Federal	45,000	300,000	345,000	
	Non-Federal	180,000	2,400,000	2,580,000	
		225,000	2,700,000	2,925,000	
Subtotal					7,472,194
Contingencies (25%)					1,868,049
	Totals				**9,340,243**
	Rounded				**9,340,000**

3.3.1.18 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A Real Estate Relocation Plan should be prepared during PED to address potential relocation activity under PL.91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.1.19 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.1.19-1 and 3.3.1.19-2 shows the CWBS for real estate activities.

Table 3.3.1.19-1.
Chart of Accounts - LOD3 Hancock County Ring Levee, Pearlington - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	277,500		277,500
01B20	Acquisition by NFS		2,220,000	2,220,000
01BX	Contingencies (25%)	69,375	555,000	624,375
	Subtotal	346,875	2,775,000	3,121,875
01F	PL 91-646 Assistance			
01F20	By NFS		168,000	168,000
01FX	Contingencies (25%)		42,000	42,000
	Subtotal		210,000	210,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		3,615,007	3,615,007
01R2B	PL91-646 Relocation Payment by NFS		784,000	784,000
01R2D	Review of NFS	42,000		42,000
01RX	Contingencies (25%)	10,500	1,099,752	1,110,252
	Subtotal	52,500	5,498,759	5,551,259
	Totals	**399,375**	**8,483,759**	**8,883,134**
	Rounded			**8,883,000**

Table 3.3.1.19-2.
Chart of Accounts - LOD3 Hancock County Ring Levee, Pearlington - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	300,000		300,000
01B20	Acquisition by NFS		2,400,000	2,400,000
01BX	Contingencies (25%)	75,000	600,000	675,000
	Subtotal	375,000	3,000,000	3,375,000
01F	PL 91-646 Assistance			
01F20	By NFS		180,000	180,000
01FX	Contingencies (25%)		45,000	45,000
	Subtotal		225,000	225,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		3,718,394	3,718,394
01R2B	PL91-646 Relocation Payment by NFS		828,800	828,800
01R2D	Review of NFS	45,000		45,000
01RX	Contingencies (25%)	11,250	1,136,799	1,148,049
	Subtotal	56,250	5,683,993	5,740,243
	Totals	**431,250**	**8,908,993**	**9,340,243**
	Rounded			**9,340,000**

3.3.2 Hancock County Ring Levees, Bay St. Louis

The City of Bay St. Louis is located in the eastern part of Hancock County as shown in Figure 3.3.2-1. The town is bordered by the Mississippi Sound. The Shoreline Park subdivision area to the north of Bay St. Louis is very low at elevations 4-6 ft NAVD88 and subject to frequent flooding from storm surge. During the 2005 hurricane season, water reached a depth of 10-20 ft over the coastal community. For purposes of providing protection to residential and commercial structures for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A and Option B.



Figure 3.3.2-1. Vicinity Map, Bay St. Louis

3.3.2.1 Option A - Elevation 20.0 NAVD88

This option consists of an earthen dike around the most densely populated areas of Bay St. Louis along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.2.2 Option B - Elevation 30.0 NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.2.3 Project Description

Figure 3.3.2.3-1 below shows the location of the proposed project alternatives. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.2.3-2 shows the proposed location of the pump/culvert sites. During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Further

studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.



Figure 3.3.2.3-1. Bay St. Louis Ring Levee



Figure 3.3.2.3-2. Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. Pump facilities are required at 12 locations.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around the Bay St. Louis area to elevation 20.0, 21 roadway intersections would have to be accommodated. For this study it was estimated that of this number, 4 would require swing gate structures, with the rest requiring roller gates of various heights. With the installation of a ring levee around the Bay St. Louis area to elevation 30, 69 roadway intersections would have to be accommodated, and it was estimated that of this number, 62 would require swing gate structures, with the remaining 7 requiring roller gates of various heights.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.2.4 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Bay St. Louis Ring Levees include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and 12 culvert/pump station facilities.

Based on the footprint of the Option A 20.0 foot elevation, it was determined that approximately 442 parcels and 149 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 11 pump stations will require approximately 0.23 of an acre each for a total of 2.53 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 149 relocations.

Based on the footprint of the Option B 30.0 foot elevation, it was determined that 576 parcels and 212 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 12 pump stations will require approximately 0.23 of an acre each for a total of 2.76 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 212 relocations.

Any modifications to the roadways will most probably need to be accomplished under a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.2.5 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee. An assumption is made that this work will be accomplished under a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.2.6 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.2.7 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.2.8 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.2.9 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.2.10 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.2.11 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.2.12 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.2.13 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 149 relocations in Option A and approximately 212 relocations in Option B. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.2.14 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

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3.3.2.16 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.2.17 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.2.17-1. The real estate cost estimates at Table 3.3.2.17-2 and Table 3.3.2.17-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.2.17-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	442	149	120,246,000
Option B - 30.0	576	212	156,364,000

Table 3.3.2.17-2.
LOD3 Hancock County Ring Levee, Bay St. Louis - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
300 Ownerships for Levee, 123 Improvements					71,036,318
131 Ownerships for Ditches, 26 Improvements					9,805,320
11 Pump Stations					160,231
442 Ownerships				Subtotal	81,001,869
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 149 relocations					4,132,800
e. Administrative Cost					11,062,500
	Relocation	Acquisition	Total		
Federal	223,500	1,105,000	1,328,500		
Non-Federal	894,000	8,840,000	9,734,000		
	1,117,500	9,945,000	11,062,500		
Sub-Total					96,197,169
Contingencies (25%)					24,049,292
	Totals				**120,246,461**
	Rounded				**120,246,000**

Table 3.3.2.17-3.
LOD3 Hancock County Ring Levee, Bay St. Louis - Option B 30.0 Estimate

a. Lands and Improvements/Permits					
433 Ownerships for Levee, 186 Improvements					94,636,388
131 Ownerships for Ditches, 26 Improvements					9,805,320
12 Pump Stations					174,798
576 Ownerships				Subtotal	104,616,506
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 212 relocations					5,924,800
e. Administrative Cost					14,550,000
	Relocation	Acquisition	Total		
Federal	318,000	1,440,000	1,758,000		
Non-Federal	1,272,000	11,520,000	12,792,000		
	1,590,000	12,960,000	14,550,000		
Sub-Total					125,091,306
Contingencies (25%)					31,272,827
	Totals				**156,364,133**
	Rounded				**156,364,000**

3.3.2.18 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A Real Estate Relocation Plan should be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.2.19 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.2.19-1 and 3.3.2.19-2 shows the CWBS for real estate activities.

Table 3.3.2.19-1.
Chart of Accounts - LOD3 Hancock County Ring Levee, Bay St. Louis - Option A

01A	Project Planning	Federal	Non-federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acq/Review of NFS	1,105,000		1,105,000
01B20	Acquisition by NFS		8,840,000	8,840,000
01BX	Contingencies (25%)	276,250	2,210,000	2,486,250
	Subtotal	1,381,250	11,050,000	12,431,250
01F	PL 91-646 Assistance			
01F20	By NFS		894,000	894,000
01FX	Contingencies (25%)		223,500	223,500
	Subtotal		1,117,500	1,117,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		81,001,869	81,001,869
01R2B	PL91-646 Relocation Payment by NFS		4,132,800	4,132,800
01R2D	Review of NFS	223,500		223,500
01RX	Contingencies (25%)	55,875	21,283,667	21,339,542
	Subtotal	279,375	106,418,336	106,697,711
	Totals	**1,660,625**	**118,585,836**	**120,246,461**
	Rounded			**120,246,000**

Table 3.3.2.19-2.
Chart of Accounts - LOD3 Hancock County Ring Levee, Bay St. Louis - Option B

01A	Project Planning	Federal	Non-federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acq/Review of NFS	1,440,000		1,440,000
01B20	Acquisition by NFS		11,520,000	11,520,000
01BX	Contingencies (25%)	360,000	2,880,000	3,240,000
	Subtotal	1,800,000	14,400,000	16,200,000
01F	PL 91-646 Assistance			
01F20	By NFS		1,272,000	1,272,000
01FX	Contingencies (25%)		318,000	318,000
	Subtotal		1,590,000	1,590,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		104,616,506	104,616,506
01R2B	PL91-646 Relocation Payment by NFS		5,924,800	5,924,800
01R2D	Review of NFS	318,000		318,000
01RX	Contingencies (25%)	79,500	27,635,327	27,714,827
	Subtotal	397,500	138,176,633	138,574,133
	Totals	**2,197,500**	**154,166,633**	**156,364,133**
	Rounded			**156,364,000**

3.3.3 Hancock County, Elevated Roadway

Residential and business areas along the coast in Hancock County are susceptible to storm surge damage. The beach front road in Hancock County joins the communities of Bay St. Louis and Waveland at the mouth of St. Louis Bay. Drainage at Bay St. Louis and Waveland is to the Mississippi Sound to the south and to tributaries of St. Louis Bay to the north. The Shoreline Park subdivision area to the north of Bay St. Louis is very low at elevations and subject to frequent flooding from storm surge. Impacts from the 2005 hurricanes were devastating to the area. A damage reduction option to raise the beach front road in Hancock County to elevation 11ft NAVD88 was evaluated. The location of the project is shown in Figure 3.3.3-1.

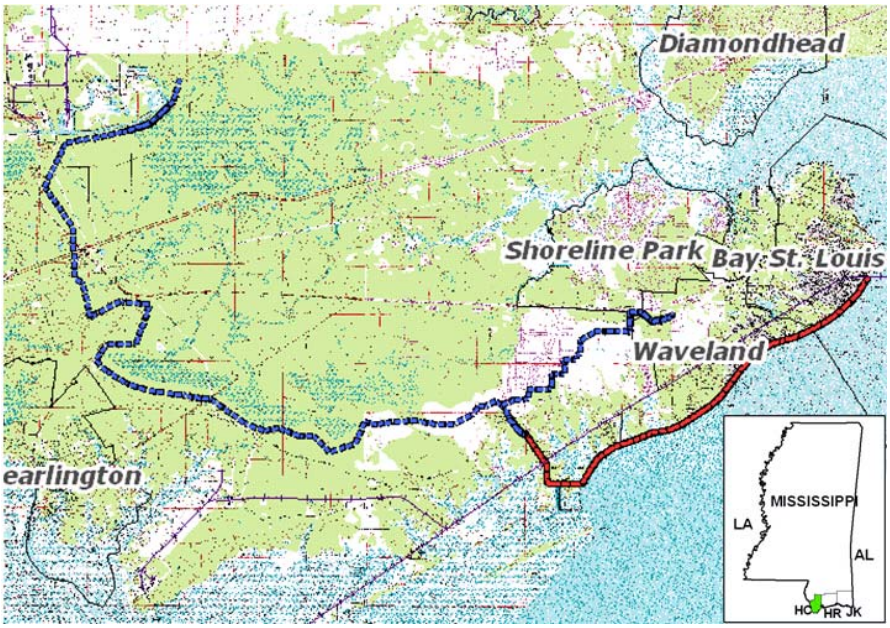


Figure 3.3.3-1. Vicinity Map near Waveland

3.3.3.1 Project Description

The proposed road alignment is shown in red in Figure 3.3.3-1. The option consists of more than one element and function. This option also contains a provision for a levee at elevation 16 ft NAVD88, shown in blue in the above Figure 3.3.3-1. The elevation 16 ft NAVD88 levee functions in coordination with the Harrison County Elevated Hwy 90 Roadway also at elevation 16 ft NAVD and the St. Louis Bay closure structure. This option consists of raising the beach front road to elevation 11 ft NAVD88 in the Bay St. Louis/Waveland area as shown on the following Figure 3.3.3.1-1, along with the internal sub-basins and levee culvert/pump locations. There is one culvert but no pumps associated with the Elevation 16 ft NAVD88 levee as shown on Figure 3.3.3.1-2. This levee runs mostly along the ridge line so the drainage is away from the levee. A small boat access structure is also shown at the mouth of one basin. Rising sector gates will be provided at this gate allowing shallow draft traffic most of the time. The gate will be closed prior to hurricane storm surge.

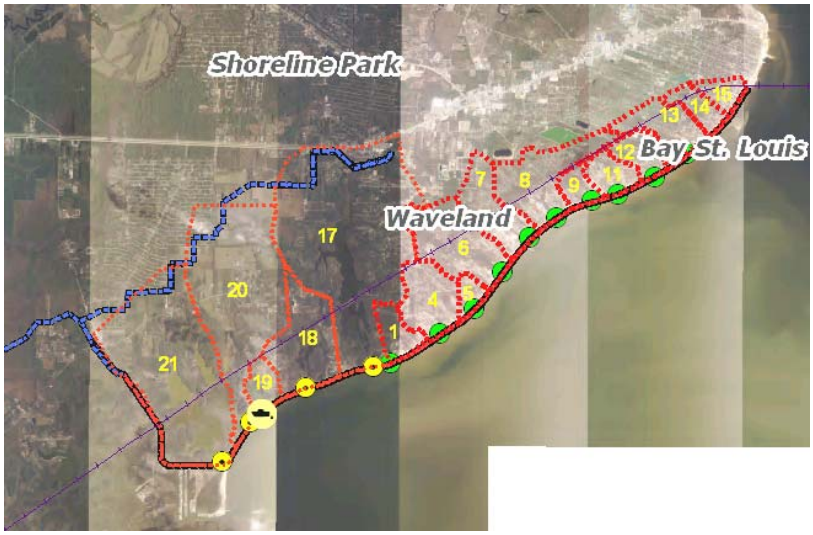


Figure 3.3.3.1-1. Pump/Culvert/Boat Access Site Locations and Sub-basins

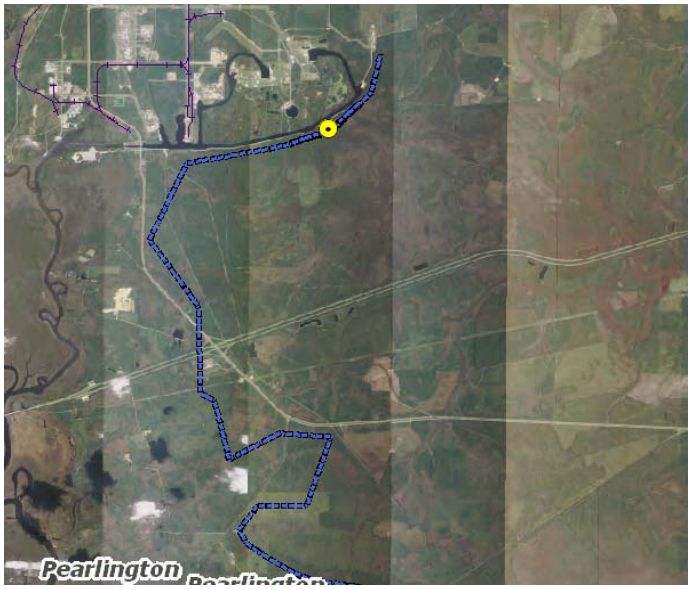


Figure 3.3.3.1-2. Culvert Site Location

The Line 3 defense elevates the roadway and accompanying seawall by extending the seaway at its present slope to grade, creating the roadway sub grade then, sloping the backside to one vertical to three horizontal side slopes with a twenty five foot toe width for access and drainage. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The embankment will be constructed of sand clay materials obtained from off site

commercial sources, trucked to the work area. The final surface on the back side will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the road. All non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate ramping over the embankment where the surface elevation is near that of the crest elevation. Drainage on the interior of the raised roadway would be collected at the highway and channeled to culverts. Drainage ditches along the toe of the highway will be required to assure that smaller basins can be drained to a culvert/pump site. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

The features that require periodic operations will be the raising and lowering of sluice gates and the functioning flap gates, grass cutting of the embankment slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion.

3.3.3.2 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Hancock County Elevated Road measure include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to raise a road and construct an earthen levee and 10 culvert/pump station facilities. Based on the project footprint, it was determined that approximately 427 parcels and 66 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 10 pump stations will require approximately 0.23 of an acre each for a total of 2.3 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 66 relocations.

Ditches that will be constructed to provide drainage for the levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Raising of the roadway will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

In some areas the levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. To allow continued free boat access to areas behind the levee these water courses will be fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay St. Louis. A small boat access structure is shown at the mouth of one basin in the project footprint. Rising sector gates will be provided at this gate allowing shallow draft traffic most of the time. The gate will be closed prior to hurricane storm surge. No additional real estate interest is identified for boat access points as they fall within the footprint of the project and impacted parcels are included in the total that is projected. For those lands required for construction that lay below the mean high water mark, navigation servitude will apply.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with

the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the project. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.3.3 Utility/Facility Relocation

The plan calls for elevation of the beachfront road. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.3.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.3.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.3.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot

receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.3.7 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.3.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.3.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.3.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.3.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 66 relocations in this alternative. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.3.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.3.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.3.14 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.3.15 Real Estate Estimate

The real estate cost estimate at Table 3.3.3.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions,

analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.3.15-1.
LOD3 Hancock County Elevated Road Estimate

a. Lands and Improvements/Permits					
417 Ownerships for Levee, 66 Improvements					23,843,680
10 Pump Stations					145,665
427 Ownerships				Subtotal	23,989,345
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 66 relocations					1,859,200
e. Administrative Cost					10,102,500
		Relocation	Acquisition	Total	
	Federal	99,000	1,067,500	1,166,500	
	Non-Federal	396,000	8,540,000	8,936,000	
		495,000	9,607,500	10,102,500	
Subtotal					35,951,045
Contingencies (25%)					8,987,761
		Totals			**44,938,806**
		Rounded			**44,939,000**

3.3.3.16 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.3.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.3.3.17-1 shows the CWBS for real estate activities.

Table 3.3.3.17-1.
Chart of Accounts - LOD3 Hancock County Elevated Road

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,067,500		1,067,500
01B20	Acquisition by NFS		8,540,000	8,540,000
01BX	Contingencies (25%)	266,875	2,135,000	2,401,875
	Subtotal	1,334,375	10,675,000	12,009,375
01F	PL 91-646 Assistance			
01F20	By NFS		396,000	396,000
01FX	Contingencies (25%)		99,000	99,000
	Subtotal		495,000	495,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		23,989,345	23,989,345
01R2B	PL91-646 Relocation Payment by NFS		1,859,200	1,859,200
01R2D	Review of NFS	99,000		99,000
01RX	Contingencies (25%)	24,750	6,462,136	6,486,886
	Subtotal	123,750	32,310,681	32,434,431
	Totals	**1,458,125**	**43,480,681**	**44,938,806**
	Rounded			**44,939,000**

3.3.4 Harrison County, Elevated Roadway

Residential and business areas along the coast in Harrison County are susceptible to storm surge damage. In Harrison County, ground elevations over most of the residential and business areas vary between elevation 8-12 feet NAVD88 on the coast and rising within 1000 feet to elevation 30-36 along a ridge parallel to the coastline, then decreasing to the north. A damage reduction option to raise Highway 90 to elevation 16 feet NAVD88 was evaluated. The location of the project is shown in Figure 3.3.4-1.



Figure 3.3.4-1. Vicinity Map, Harrison County

3.3.4.1 Project Description

The proposed project is shown in red in Figures 3.3.4.1-1 through Figure 3.3.4.1-4. Highway 90 in Harrison County extends from Biloxi Bay to pass Christian.



Figure 3.3.4.1-1. Pump/Culvert/Sub-basin Site Locations, Harrison County



Figure 3.3.4.1-2. Pump/Culvert/Sub-basin Site Locations, Harrison County



Figure 3.3.4.1-3. Pump/Culvert/Sub-basin Site Locations, Harrison County



Figure 3.3.4.1-4. Pump/Culvert/Sub-basin Site Locations, Harrison County

This option consists of raising US Highway 90 along the coast of Harrison County to elevation 16 feet NAVD88 along with the internal sub-basins and levee culvert/pump locations as shown above. The Line 3 defense elevates the roadway and accompanying seawall by extending the seaway at its present slope to grade, creating the roadway sub grade then, sloping the backside to one vertical to three horizontal side slopes with a twenty five foot toe width for access and drainage. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The embankment will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area. The final surface on the back side will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an

event that overtops the road. All non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate ramping over the embankment where the surface elevation is near that of the crest elevation. Drainage on the interior of the raised roadway would be collected at the highway and channeled to culverts Drainage ditches along the toe of the highway, will be required to assure that smaller basins can be drained to a culvert/pump site. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations.

3.3.4.2 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Harrison County Elevated Road measure include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to raise a road and construct an earthen levee, drainage ditches and 15 culvert/pump station facilities. Based on the project footprint, it was determined that approximately 1031 parcels and 80 structures would be impacted. The acreage to be acquired is unknown. It is known that the 15 pump stations will require approximately 0.23 of an acre each for a total of 3.45 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 80 relocations.

Ditches that will be constructed to provide drainage for the levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Raising of the roadway and relocation of any utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the project. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.4.3 Utility/Facility Relocation

The plan calls for elevation of Highway 90. Some removal/relocation of utilities may be required. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.4.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.4.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.4.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.4.7 Government Owned Property

There 4 Government owned parcels within the footprint of the project. In viewing the footprint, it appears that these parcels will be minimally impacted where they abut Highway 90. Land and structure values are not listed in the public records. Ownership is listed in public records as US Govt, US Veterans Hospital, and United States of America. Specific impacts to Government owned lands will be determined during PED.

3.3.4.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.4.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.4.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.4.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 80 relocations in this alternative. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.4.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.4.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60

days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.4.14 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.4.15 Real Estate Estimate

The real estate cost estimate at Table 3.3.4.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions,

analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.4.15-1.
LOD3 Harrison County Elevated Road Estimate

a. Lands and Improvements/Permits					
1016 Ownerships for Levee, 80 Improvements					375,464,802
15 Pump Stations					270,004
1031 Ownerships				Subtotal	375,734,806
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 80 relocations					2,240,000
e. Administrative Cost					0
		Relocation	Acquisition	Total	
	Federal	120,000	2,577,500	2,697,500	
	Non-Federal	480,000	20,620,000	21,100,000	
		600,000	23,197,500	23,797,500	
Subtotal					401,772,306
Contingencies (25%)					100,443,077
		Totals			**502,215,383**
		Rounded			**502,215,000**

3.3.4.16 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.4.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.3.4.17-1 shows the CWBS for real estate activities.

Table 3.3.4.17-1.
Chart of Accounts - LOD3 Harrison County Elevated Road

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	2,577,500		2,577,500
01B20	Acquisition by NFS		20,620,000	20,620,000
01BX	Contingencies (25%)	644,375	5,155,000	5,799,375
	Subtotal	3,221,875	25,775,000	28,996,875
01F	PL 91-646 Assistance			
01F20	By NFS		480,000	480,000
01FX	Contingencies (25%)		120,000	120,000
	Subtotal		600,000	600,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		375,734,806	375,734,806
01R2B	PL91-646 Relocation Payment by NFS		2,240,000	2,240,000
01R2D	Review of NFS	120,000		120,000
01RX	Contingencies (25%)	30,000	94,493,702	94,523,702
	Subtotal	150,000	472,468,508	472,618,508
	Totals	**3,371,875**	**498,843,508**	**502,215,383**
	Rounded			**502,215,000**

3.3.5 Harrison County Forrest Heights Levee, City of Gulfport

The Forrest Heights community is located in an area known as North Gulfport within the city of Gulfport on the Mississippi Gulf Coast. The residential community lies on the bank of Turkey Creek about 2.6 miles from the mouth at Bernard Bayou, and has frequently been inundated by flood waters due to storm surges from the Mississippi Sound and from inland flooding along the lower Turkey Creek floodplain. Turkey Creek has a tendency to frequently exceed its stream channel capacity and flood adjacent low-lying areas. Water reached a depth of 2-8 feet over the entire community during Hurricane Katrina inundation. Ground elevations over most of the residential area are between elevations 10-14 feet NAVD88. Drainage is mostly along streets and through natural drainage ways to the Turkey Creek. A previous evaluation recommended the construction of an earthen levee to protect this area from storm surge flooding. The Forrest Heights levee is proposed to be constructed as a pilot project for the MsCIP comprehensive plan. The levee will address the combination of storm surge protection and inland surge protection. The levee is intended to be constructed to a height such that the levee might be certified under the National Flood Insurance Program. A preliminary engineering analysis suggests a levee built to approximately elevation 21 ft NAVD88 would satisfy or exceed certification elevation criteria. The location of the levee is shown in Figure 3.3.5-1. The options in this study are identified as Option A and Option B. The levees were evaluated at elevations 17 ft NAVD88 and 21 ft NAVD88. The top width was assumed 12 ft with side slopes of 1 vertical to 3 horizontal.

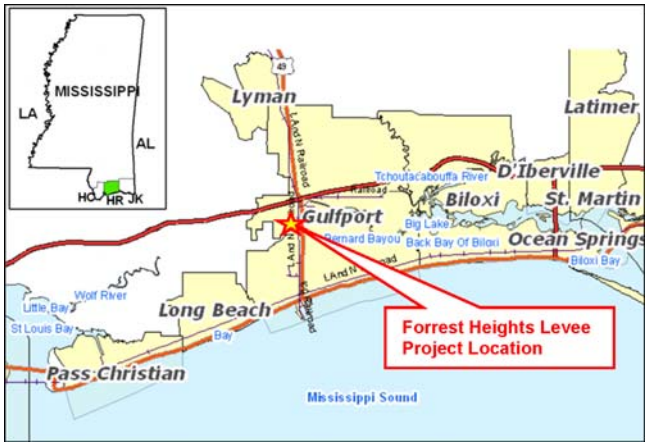


Figure 3.3.5-1. Vicinity Map

3.3.5.1 Option A - Elevation 17.0 ft NAVD88

This option consists of an earthen dike around the Forrest Heights community along with the levee culvert/interior detention location. It generally will be trapezoidal in shape with an elevation of 17.0 feet and a top width of 12 ft and slopes of 1 vertical to 3 horizontal on both sides. The total length of the levee will be approximately 7,900 feet. The recommended plan includes selective clearing and snagging as a measure to prevent increases in water surface elevations upstream that would occur due to the placement of the levees in the floodplain.

3.3.5.2 Option B - Elevation 21.0 ft NAVD88

This option consists of an earthen levee around northern, western, and southern sides of the Forrest Heights community. Because of the height of the levee, the eastern side will be constructed with a concrete “T”-wall structure. The “T” wall will take less space than an earthen levee and encroach less into property along the alignment. Closure gates across the two access roads to the subdivision will be required. The lengths of the levee culverts will be slightly longer than those used in Option A. Other features and methods of analysis are the same.

The levee alignment for both Option A and B is generally the same and is shown in Figure 3.3.5.2-1.

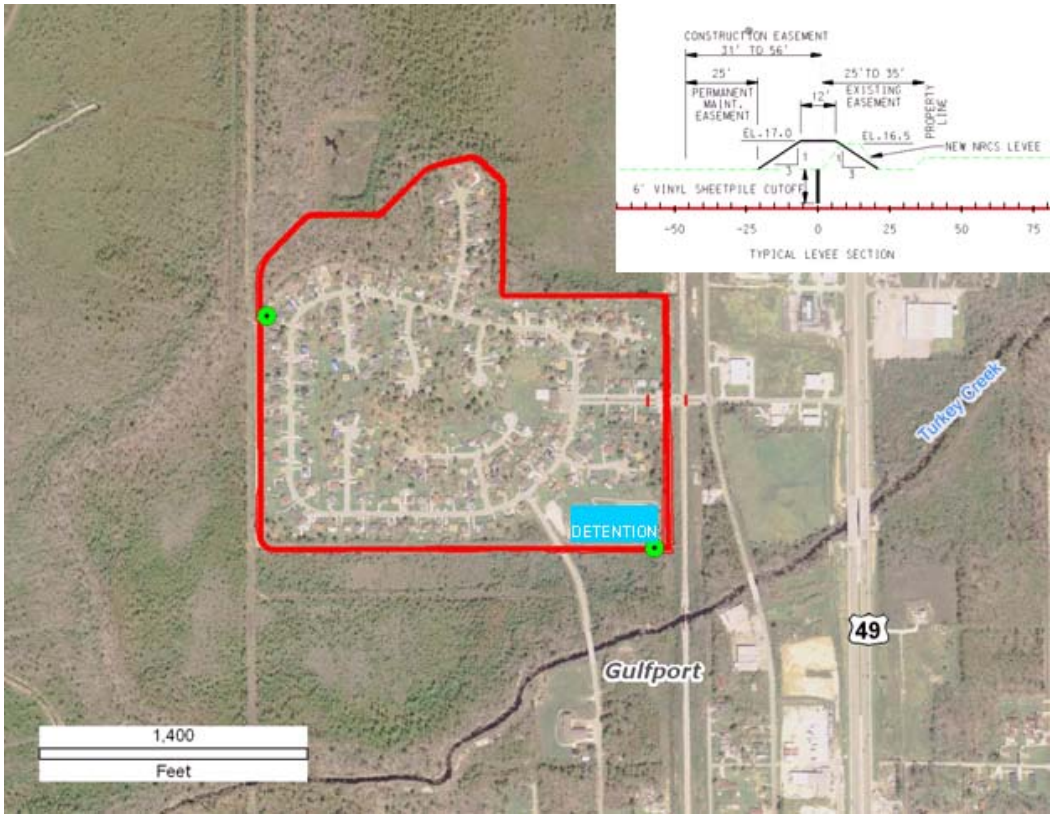


Figure 3.3.5.2-1. Levee Alignment with Detention Site Location

3.3.5.3 Project Description

As described above, the levee will be an earthen berm constructed either at elevation 17.0 feet or 21.0 feet along with culvert/interior detention locations. Interior flooding on the landward side of the levee will be improved by adding a storm water detention basin and pumping facility. The detention area will hold storm water until the creek water level recedes and water can drain through the culvert. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided in the levee for control in the event the flap gate malfunctions.

The detention basin would have an area of approximately 3 acres but would not be excavated. The area is the lowest site in the subdivision and is presently used for recreation facilities such as baseball and tennis.

The Recommended Plan includes selective clearing and snagging for approximately 4.5 miles from the mouth of Turkey Creek at Bernard Bayou to the upstream limits as shown in Figure 3.3.5.3-1. Selective clearing and snagging would remove obstructions such as debris dams and excessive sedimentation that hinders the flow through the Turkey Creek channel. While the selective clearing and snagging component of the plan does not eliminate flooding along Turkey Creek, the plan does reduce flood damages along the creek and at the upper end of the canals at 28th Street. The main purpose of the selective clearing and snagging is to make sure that induced damages do not occur due to the construction of the recommended levees. Only debris, snags and sediment that obstruct the flow will be removed. Material to be removed includes: 1) fine sediment accumulations that obstruct flows and alter flow patterns; 2) Debris blockages that currently or in the near future cause obstructed flow and altered flow patterns; and 3) Rooted trees that obstruct flow or need to be cleared for equipment access. Access areas that are cleared will be reestablished at the conclusion of the selective clearing and snagging activities. Some access points, however, may remain for the non-Federal sponsor to use for maintenance activity of the completed project. The existing bank alignment along the entire reach will not be changed, including the downstream reaches of Turkey Creek along the meander bends. Specific reaches to be cleared and snagged will be identified by an interdisciplinary team prior to construction.



Figure 3.3.5.3-1. Channel Clearing and Snagging Limits

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a twelve foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates and sluice gates to provide protection from high water outside the levee.

With the installation of a ring levee around the Forrest Heights community at Option A, elevation 17.0 or Option B, elevation 21.0, 2 roadway intersections would have to be accommodated. For this study it was estimated that for Option A both roadway entrances could use ramps for crossing the restored levee. For Option B both roadway entrances would use sliding flood gates.

Operation and maintenance activities for this project will be required on an annual basis. All gates will be operated to assure proper working order. Debris and shoaled sediment will be removed from the interior ponding area. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.5.4 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Forrest Heights Levees include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and detention ponding area. Based on the footprint of the Option A 17.0 foot elevation, it was determined that approximately 18 parcels and 2 structures will be impacted. The acreage to be acquired for the levee is unknown. It is known that the detention ponding area would require approximately 3.0 acres. Lands required for construction of the levee and the detention pond will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 2 relocations. Approximately 55 acres will be acquired in Channel Improvement Easements from approximately 48 landowners.

Based on the footprint of the Option B 30.0 foot elevation, it was determined that the same number of parcels and structures will be impacted as for Option A, but the easement area required for the levee will be extended to permit construction of the higher levee.

Ditches that will be constructed to provide drainage for the interior of the ring levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with

the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.5.5 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.5.6 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.5.7 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.5.8 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the

non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.5.9 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.5.10 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.5.11 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.5.12 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.5.13 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 2 relocations in Option A and approximately 2 relocations in Option B. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.5.14 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.5.15 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.5.16 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. The Channel Improvements Easement will be used for clearing and snagging work. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

CHANNEL IMPROVEMENT EASEMENT.

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the purposes as authorized by the Act of Congress approved _____,

including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions there from; to excavate: dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements far public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.5.17 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.5.17-1. The real estate estimates at Tables 3.3.5.17-2 and 3.3.5.17-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.5.17-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 17.0	67	2	$2,571,000
Option B - 21.0	67	4	$2,649,000

Table 3.3.5.17-2.
LOD3 Harrison County Forrest Heights Levee, Gulfport - Option A 17.0 Estimate

a. Lands and Improvements/Permits		
18 Ownerships for Levee, 2 Improvements		219,740
1 Ownerships for Pond, 0 Improvements		13,392
48 Ownerships for Channel Improvement		245,520
67 Ownerships	Subtotal	478,652
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs - 2 relocations		56,000
e. Administrative Cost		1,522,500

	Relocation	Acquisition	Total
Federal	3,000	167,500	170,500
Non-Federal	12,000	1,340,000	1,352,000
	15,000	1,507,500	1,522,500

Sub-Total		2,057,152
Contingencies (25%)		514,288
Totals		**2,571,440**
Rounded		**2,571,000**

Table 3.3.5.17-3.
LOD3 Harrison County Forrest Heights Levee, Gulfport - Option B 21.0 Estimate

a. Lands and Improvements/Permits		
18 Ownerships for Levee, 2 Improvements		281,800
1 Ownerships for Pond, 0 Improvements		13,392
48 Ownerships for Channel Improvement		245,520
67 Ownerships	Subtotal	540,712
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs - 2 relocations		56,000
e. Administrative Cost		1,522,500

	Relocation	Acquisition	Total
Federal	3,000	167,500	170,500
Non-Federal	12,000	1,340,000	1,352,000
	15,000	1,507,500	1,522,500

Sub-Total		2,119,212
Contingencies (25%)		529,803
Totals		**2,649,015**
Rounded		**2,649,000**

3.3.5.18 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with

these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.5.19 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.5.19-1 and 3.3.5.19-2 shows the CWBS for real estate activities.

Table 3.3.5.19-1.
Chart of Accounts - LOD3 Harrison County Forrest Heights Levee, Gulfport - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	167,500		167,500
01B20	Acquisition by NFS		1,340,000	1,340,000
01BX	Contingencies (25%)	41,875	335,000	376,875
	Subtotal	209,375	1,675,000	1,884,375
01F	PL 91-646 Assistance			
01F20	By NFS		12,000	12,000
01FX	Contingencies (25%)		3,000	3,000
	Subtotal		15,000	15,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		478,652	478,652

01R2B	PL91-646 Relocation Payment by NFS		56,000	56,000
01R2D	Review of NFS	3,000		3,000
01RX	Contingencies (25%)	750	133,663	134,413
	Subtotal	3,750	668,315	672,065
	Totals	**213,125**	**2,358,315**	**2,571,440**
	Rounded			**2,571,000**

Table 3.3.5.19-2.
Chart of Accounts - LOD3 Harrison County Forrest Heights Levee, Gulfport - Option B

01A	**Project Planning**	**Federal**	**Non-Federal**	**Totals**
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	167,500		167,500
01B20	Acquisition by NFS		1,340,000	1,340,000
01BX	Contingencies (25%)	41,875	335,000	376,875
	Subtotal	209,375	1,675,000	1,884,375
01F	PL 91-646 Assistance			
01F20	By NFS		12,000	12,000
01FX	Contingencies (25%)		3,000	3,000
	Subtotal		15,000	15,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		540,712	540,712
01R2B	PL91-646 Relocation Payment by NFS		56,000	56,000
01R2D	Review of NFS	3,000		3,000
01RX	Contingencies (25%)	750	149,178	149,928
	Subtotal	3,750	745,890	749,640
	Totals	**213,125**	**2,435,890**	**2,649,015**
	Rounded			**2,649,000**

3.3.6 Jackson County, Elevated Roadway

Residential and business areas along the coast in Jackson County are susceptible to storm surge damage. The city of Ocean Springs lies at the eastern side of the Back Bay of Biloxi. Ground elevations over most of the residential and business areas vary between elevations 16-24 ft NAVD88, with houses along the coast between 8-16 ft NAVD88. This option entails the raising of the Beach Road and the adjoining seawall to Elevation 11.00 from Highway 90 eastward to the Jackson County Marina. The project also provides for all utility infrastructures such as water, sewer, storm drain, gas and electric lines to be removed and reinstalled to meet the new grades. The project location is shown in Figure3.3.6-1 with the roadway in red.

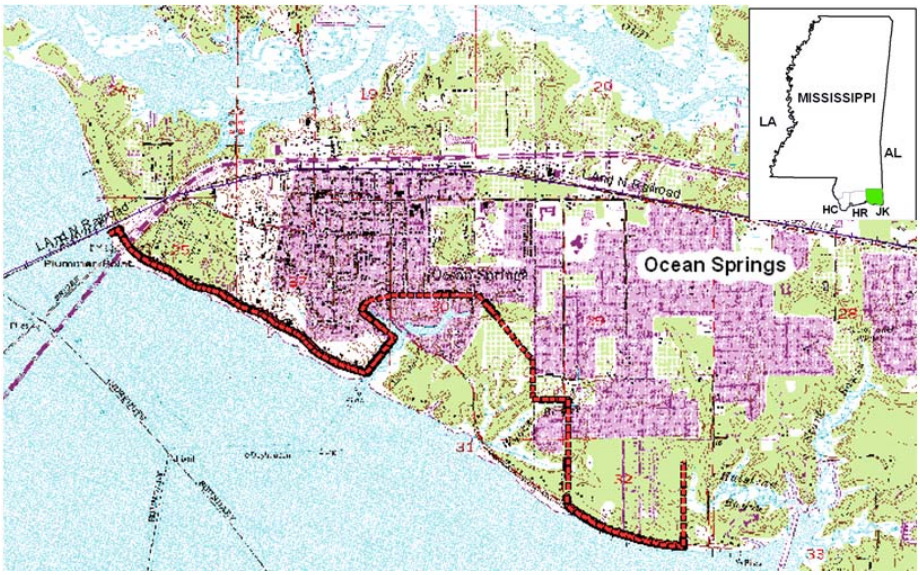


Figure 3.3.6-1. Vicinity Map, Ocean Springs

3.3.6.1 Project Description

This option consists of raising the beach road to elevation 11 feet NAVD88 in Ocean Springs. The internal sub-basins and levee culvert/pump locations are shown on Figure 3.3.6.1-1. Drainage on the interior of the raised highway would be collected at the highway and channeled to culverts placed at locations shown below. Drainage Ditches along the toe of the highway will be required to assure that smaller basins can be drained to a culvert/pump site.



Figure 3.3.6.1-1. Pump/Culvert/Sub-basin Site Location

The Line 3 defense elevates the roadway and accompanying seawall by extending the seaway at its present slope to grade, creating the roadway sub grade then, sloping the backside to one vertical to three horizontal side slopes with a twenty five foot toe width for access and drainage. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The embankment will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area. The final surface on the back side will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the road. All non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate ramping over the embankment where the surface elevation is near that of the crest elevation. Drainage on the interior of the raised roadway would be collected at the highway and channeled to culverts. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations.

3.3.6.2 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Jackson County Elevated Road measure include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to raise a road and construct an earthen levee, drainage ditches and 7 culvert/pump station facilities. Based on the project footprint, it was determined that approximately 137 parcels and 55 structures would be impacted. The acreage to be acquired is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 55 relocations.

Ditches that will be constructed to provide drainage for the levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Raising of the roadway and relocation of any utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the project. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an

upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.6.3 Utility/Facility Relocation

The plan calls for elevation of Highway 90. Some removal/relocation of utilities may be required. An assumption is made that this work will be accomplished under a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.6.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.6.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.6.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.6.7 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.6.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.6.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.6.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.6.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 55 relocations in this alternative. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.6.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.6.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey,

appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.6.14 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.6.15 Real Estate Estimate

The real estate cost estimate at Table 3.3.6.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.6.15-1.
LOD3 Jackson County Elevated Road Estimate

a. Lands and Improvements/Permits					
130 Ownerships for Levee, 55 Improvements					25,914,583
7 Pump Stations					271,308
137 Ownerships				Subtotal	26,185,891
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 55 relocations					1,523,200
e. Administrative Cost					3,495,000
		Relocation	Acquisition	Total	
	Federal	82,500	342,500	425,000	
	Non-Federal	330,000	2,740,000	3,070,000	
		412,500	3,082,500	3,495,000	
Subtotal					31,204,091
Contingencies (25%)					7,801,023
		Totals			**39,005,114**
		Rounded			**39,005,000**

3.3.6.16 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.6.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.3.6.17-1 shows the CWBS for real estate activities.

Table 3.3.6.17-1.
Chart of Accounts - LOD3 Jackson County Elevated Road

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	342,500		342,500
01B20	Acquisition by NFS		2,740,000	2,740,000
01BX	Contingencies (25%)	85,625	685,000	770,625
	Subtotal	428,125	3,425,000	3,853,125
01F	PL 91-646 Assistance			
01F20	By NFS		330,000	330,000
01FX	Contingencies (25%)		82,500	82,500
	Subtotal		412,500	412,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		26,185,891	26,185,891
01R2B	PL91-646 Relocation Payment by NFS		1,523,200	1,523,200
01R2D	Review of NFS	82,500		82,500
01RX	Contingencies (25%)	20,625	6,927,273	6,947,898
	Subtotal	103,125	34,636,364	34,739,489

Totals	**531,250**	**38,473,864**	**39,005,114**
Rounded			**39,005,000**

3.3.7 Jackson County Ring Levees, Ocean Springs

Several high density residential and business areas in Jackson County were identified. They are Ocean Springs, Gulf Park, Belle Fontaine, Gautier and Pascagoula/Moss Point. The city of Ocean Springs is located in the western part of Jackson County and lies at the eastern side of the Back Bay of Biloxi as shown in Figure 3.3.7-1. Ground elevations over most of the residential and business areas vary between elevations 16-24 feet NAVD88, with houses along the coast at between 8-16 feet NAVD88. These areas are subject to damage from storm surges associated with hurricanes. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A and Option B. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with side slopes of 1 vertical to 3 horizontal.

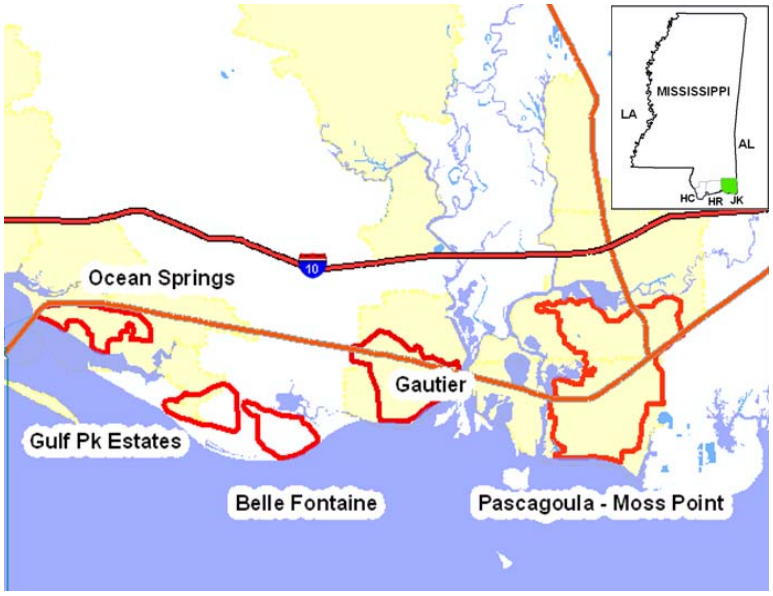


Figure 3.3.7-1. Vicinity Map, Ocean Springs, MS

3.3.7.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the most densely populated areas of Ocean Springs along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.7.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the

height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.7.3 Project Description

Figure 3.3.7.3-1 shows the location of the proposed project alternatives. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.7.3-2 shows the proposed location of the pump/culvert sites. During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.



Figure 3.3.7.3-1. Ocean Springs Ring Levee



Figure 3.3.7.3-2. Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. Pump facilities are required at 14 locations. As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used

including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around the Ocean Springs area at Option A, elevation 20.0, 24 roadway intersections would have to be accommodated. For this study it was estimated that 6 roller gate structures and 18 would require swing gate structures would be required. At Option B, elevation 30.0, 76 roadway intersections would have to be accommodated, and it was estimated that 6 roller gate structures and 70 swing gate structures would be required

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.7.4 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Ocean Spring Ring Levees include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and 14 culvert/pump station facilities.

Based on the footprint of the Option A 20.0 foot elevation, it was determined that approximately 197 parcels and 83 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 14 pump stations will require approximately 0.23 of an acre each for a total of 3.22 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 83 relocations.

Based on the footprint of the Option B 30.0 foot elevation, it was determined that 576 parcels and 312 structures are impacted. The acreage to be acquired for the levee is unknown. It is known that the 14 pump stations would require approximately 0.23 of an acre each for a total of 3.22 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 312 relocations.

Ditches that will be constructed to provide drainage for the interior of the ring levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if

disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.7.5 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.7.6 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.7.7 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.7.8 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the

purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.7.9 Government Owned Property

There 11 Government owned parcels within the footprint of the project. In viewing the footprint, it appears that these parcels will be minimally impacted by construction of the levee for the most part. Three of the parcels may be impacted to a greater degree. Land values are listed in the public records but no improvement values are listed. Ownership is listed in public records as US of America and United States of America. Specific impacts to Government owned lands will be determined during PED.

3.3.7.10 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.7.11 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.7.12 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.7.13 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 83 relocations in Option A and approximately 312 relocations in Option B. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.7.14 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area

to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.7.15 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.7.16 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement

hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.7.17 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.7.17-1. The real estate estimates at Tables 3.3.7.17-2 and 3.3.7.17-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.7.17-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	197	83	$43,609,000
Option B - 30.0	576	312	$119,542,000

Table 3.3.7.17-2.
LOD3 Jackson County Ring Levee, Ocean Springs - Option A 20.0 Estimate

a. Lands and Improvements/Permits		
183 Ownerships for Levee, 83 Improvements		26,959,933
14 Pump Stations		542,617
197 Ownerships	Subtotal	27,502,550
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs – 83 relocations		2,329,600
e. Administrative Cost		5,055,000

	Relocation	Acquisition	Total
Federal	124,500	492,500	617,000
Non-Federal	498,000	3,940,000	4,438,000
	622,500	4,432,500	5,055,000

Subtotal		34,887,150
Contingencies (25%)		8,721,788
	Totals	**43,608,938**
	Rounded	**43,609,000**

Table 3.3.7.17-3.
LOD3 Jackson County Ring Levee, Ocean Springs - Option B 30.0 Estimate

a. Lands and Improvements/Permits				
562 Ownerships for Levee, 312 Improvements				71,055,087
14 Pump Stations				542,617
576 Ownerships			Subtotal	71,597,704
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs – 312 relocations				8,736,000
e. Administrative Cost				15,300,000
	Relocation	Acquisition	Total	
Federal	468,000	1,440,000	1,908,000	
Non-Federal	1,872,000	11,520,000	13,392,000	
	2,340,000	12,960,000	15,300,000	
Subtotal				95,633,704
Contingencies (25%)				23,908,426
	Totals			**119,542,130**
	Rounded			**119,542,000**

3.3.7.18 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.7.19 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.7.19-1 and 3.3.7.19-2 shows the CWBS for real estate activities.

Table 3.3.7.19-1.
Chart of Accounts - LOD3 Jackson County Ring Levee, Ocean Springs - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	492,500		492,500
01B20	Acquisition by NFS		3,940,000	3,940,000
01BX	Contingencies (25%)	123,125	985,000	1,108,125
	Subtotal	615,625	4,925,000	5,540,625
01F	PL 91-646 Assistance			
01F20	By NFS		498,000	498,000
01FX	Contingencies (25%)		124,500	124,500
	Subtotal		622,500	622,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		27,502,550	27,502,550
01R2B	PL91-646 Relocation Payment by NFS		2,329,600	2,329,600
01R2D	Review of NFS	124,500		124,500
01RX	Contingencies (25%)	31,125	7,458,038	7,489,163
	Subtotal	155,625	37,290,188	37,445,813
	Totals	**771,250**	**42,837,688**	**43,608,938**
	Rounded			**43,609,000**

Table 3.3.7.19-2.
Chart of Accounts - LOD3 Jackson County Ring Levee, Ocean Springs - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,440,000		1,440,000
01B20	Acquisition by NFS		11,520,000	11,520,000
01BX	Contingencies (25%)	360,000	2,880,000	3,240,000
	Subtotal	1,800,000	14,400,000	16,200,000
01F	PL 91-646 Assistance			
01F20	By NFS		1,872,000	1,872,000
01FX	Contingencies (25%)		468,000	468,000
	Subtotal		2,340,000	2,340,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		71,597,704	71,597,704
01R2B	PL91-646 Relocation Payment by NFS		8,736,000	8,736,000
01R2D	Review of NFS	468,000		468,000
01RX	Contingencies (25%)	117,000	20,083,426	20,200,426
	Subtotal	585,000	100,417,130	101,002,130
	Totals	**2,385,000**	**117,157,130**	**119,542,130**
	Rounded			**119,542,000**

3.3.8 Jackson County Ring Levees, Gulf Park

Several high density residential and business areas in Jackson County were identified. They are Ocean Springs, Gulf Park, Belle Fontaine, Gautier and Pascagoula/Moss Point. Gulf Park Estates Subdivision is located adjacent to and east of Ocean Springs. The area of study for the ring levee is bounded by Simmons Bayou on the north and the Mississippi Sound on the south. The location of the Gulf Park Estate ring levee is shown in Figure 3.3.8-1. Ground elevations over most of the residential areas vary between elevations 10-20 feet NAVD88. These areas are subject to damage from storm surges associated with hurricanes. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A, Option B, Option C and Option D. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with side slopes of 1 vertical to 3 horizontal.



Figure 3.3.8-1. Vicinity Map, Gulf Park Estates

3.3.8.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the most densely populated areas of Gulf Park Estates along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.8.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.8.3 Option C - Alternate Alignment, Elevation 20.0 ft NAVD88

Option C consists of an earthen levee at elevation 20.0 feet in an alignment slightly different from the alignment for Options A and B. Additionally, the lands that lay between the alignment of Option A and the alternate alignment, Option C will be acquired as a buffer zone in this option.

3.3.8.4 Option D - Alternate Alignment, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option C, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. As above, the buffer zone lands will be acquired.

3.3.8.5 Project Description

Figure 3.3.8.5-1 shows the location of the proposed project alternatives with the alternate alignment representing Options C and D. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.8.5-2 shows the proposed location of the pump/culvert sites. During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.



Figure 3.3.8.5-1. Gulf Park Estates Ring Levee



Figure 3.3.8.5-2. Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study the culverts were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. Pump facilities are required at 8 locations for Options A and B and at 9 locations for Options C and D.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used

including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around Gulf Park Estates at Option A, elevation 20.0, 20 roadway intersections would have to be accommodated. For this study it was estimated that 2 roller gate structures and 18 would require swing gate structures would be required. At Option B, elevation 30.0, 13 roadway intersections would have to be accommodated, and it was estimated that all 13 would require swing gate structures. At Option C, elevations 20.0, 18 roadway gates for intersections would have to be accommodated, and 14 would require swing gate structures with the remaining 4 requiring roller gates of varying heights. For Option D, elevation 30.0**,** 15 roadway intersections would have to be accommodated and all 15 would require swing gate structures.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.8.6 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Gulf Park Estates Ring Levees include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire buffer zone lands, construct an earthen levee, drainage ditches and 8 - 9 culvert/pump station facilities depending on the option.

Based on the footprint of Option A, 20.0 foot elevation, it was determined that approximately 354 parcels and 62 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 8 pump stations will require approximately 0.23 of an acre each for a total of 1.84 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 62 relocations.

Based on the footprint of Option B, 30.0 foot elevation, it was determined that approximately 399 parcels and 66 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 8 pump stations will require approximately 0.23 of an acre each for a total of 1.84 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 66 relocations.

Based on the footprint of Option C, 20.0 foot elevation, it was determined that approximately 521 parcels and 134 structures would be impacted. This number includes acquisition of the buffer zone. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction

of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 134 relocations.

Based on the footprint of Option D, 30.0 foot elevation, it was determined that approximately 561 parcels and 144 structures would be impacted. This number includes acquisition of the buffer zone. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 141 relocations.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.8.7 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.8.8 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.8.9 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.8.10 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.8.11 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.8.12 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.8.13 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.8.14 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.8.15 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a

result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 62 relocations in Option A, 66 relocations in Option B, 134 relocations in Option C, and 144 relocations in Option D. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.8.16 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.8.17 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.8.18 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____,

_____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.8.19 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.8.19-1. The real estate estimates at Tables 3.3.8.19-2 through 3.3.8.19-5 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.8.19-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	354	62	$31,458,000
Option B - 30.0	399	66	$34,051,000
Option C - 20.0	521	134	$55,002,000
Option D - 30.0	561	144	$58,603,000

Table 3.3.8.19-2.
LOD3 Jackson County Ring Levee, Gulf Park - Option A 20.0 Estimate

a. Lands and Improvements/Permits				
312 Ownerships, 60 Improvements				13,792,587
34 Ownerships for Ditches, 2 Improvements				897,419
8 Pump Stations				310,067
354 Ownerships			Subtotal	15,000,073
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 62 relocations				1,736,000
e. Administrative Cost				8,430,000
	Relocation	Acquisition	Total	
Federal	93,000	885,000	978,000	
Non-Federal	372,000	7,080,000	7,452,000	
	465,000	7,965,000	8,430,000	
Sub-Total				25,166,073
Contingencies (25%)				6,291,518
	Totals			**31,457,591**
	Rounded			**31,458,000**

Table 3.3.8.19-3.
LOD3 Jackson County Ring Levee, Gulf Park - Option B 30.0 Estimate

a. Lands and Improvements/Permits				
357 Ownerships for Levee, 64 Improvements				14,712,847
34 Ownerships for Ditches, 2 Improvements				897,419
8 Pump Stations				310,067
399 Ownerships			Subtotal	15,920,333
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 66 relocations				1,848,000
e. Administrative Cost				9,472,500
	Relocation	Acquisition	Total	
Federal	99,000	997,500	1,096,500	
Non-Federal	396,000	7,980,000	8,376,000	
	495,000	8,977,500	9,472,500	
Sub-Total				27,240,833
Contingencies (25%)				6,810,208
	Totals			**34,051,041**
	Rounded			**34,051,000**

Table 3.3.8.19-4.
LOD3 Jackson County Ring Levee, Gulf Park - Option C, Alternate Alignment, Elevation 20.0 Estimate

a. Lands and Improvements/Permits				
365 Ownerships for Levee, 121 Improvements				23,289,789
113 Ownerships for Buffer, 11 Improvements				2,969,418
34 Ownerships for Ditches, 2 Improvements				897,419
9 Ownerships for Pump Stations				348,825
521 Ownerships			Subtotal	27,505,451
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 134 relocations				3,768,800
e. Administrative Cost				12,727,500
	Relocation	Acquisition	Total	
Federal	201,000	1,302,500	1,503,500	
Non-Federal	804,000	10,420,000	11,224,000	
	1,005,000	11,722,500	12,727,500	
Sub-Total				44,001,751
Contingencies (25%)				11,000,438
Totals				**55,002,189**
Rounded				**55,002,000**

Table 3.3.8.19-5.
LOD3 Jackson County Ring Levee, Gulf Park - Option D Alternate Alignment
Elevation 30.0 Estimate

a. Lands and Improvements/Permits				
418 Ownerships for Levee, 135 Improvements				25,624,634
100 Ownerships for Buffer, 7 Improvements				2,271,308
34 Ownerships for Ditches, 2 Improvements				897,419
9 Ownerships for Pump Stations				348,825
561 Ownerships			Subtotal	29,142,186
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 144 relocations				4,037,600
e. Administrative Cost				13,702,500
	Relocation	Acquisition	Total	
Federal	216,000	1,402,500	1,618,500	
Non-Federal	864,000	11,220,000	12,084,000	
	1,080,000	12,622,500	13,702,500	
Sub-Total				46,882,286
Contingencies (25%)				11,720,572
Totals				**58,602,858**
Rounded				**58,603,000**

3.3.8.20 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate

Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.8.21 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.8.21-1 through 3.3.8.21-4 shows the CWBS for real estate activities.

Table 3.3.8.21-1.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gulf Park - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	885,000		885,000
01B20	Acquisition by NFS		7,080,000	7,080,000
01BX	Contingencies (25%)	221,250	1,770,000	1,991,250
	Subtotal	1,106,250	8,850,000	9,956,250
01F	PL 91-646 Assistance			
01F20	By NFS		372,000	372,000
01FX	Contingencies (25%)		93,000	93,000
	Subtotal		465,000	465,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		15,000,073	15,000,073
01R2B	PL91-646 Relocation Payment by NFS		1,736,000	1,736,000
01R2D	Review of NFS	93,000		93,000
01RX	Contingencies (25%)	23,250	4,184,018	4,207,268
	Subtotal	116,250	20,920,091	21,036,341
	Totals	**1,222,500**	**30,235,091**	**31,457,591**
	Rounded			**31,458,000**

Table 3.3.8.21-2.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gulf Park - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	997,500		997,500
01B20	Acquisition by NFS		7,980,000	7,980,000
01BX	Contingencies (25%)	249,375	1,995,000	2,244,375
	Subtotal	1,246,875	9,975,000	11,221,875
01F	PL 91-646 Assistance			
01F20	By NFS		396,000	396,000
01FX	Contingencies (25%)		99,000	99,000
	Subtotal		495,000	495,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		15,920,333	15,920,333
01R2B	PL91-646 Relocation Payment by NFS		1,848,000	1,848,000
01R2D	Review of NFS	99,000		99,000
01RX	Contingencies (25%)	24,750	4,442,083	4,466,833
	Subtotal	123,750	22,210,416	22,334,166
	Totals	**1,370,625**	**32,680,416**	**34,051,041**
	Rounded			**34,051,000**

Table 3.3.8.21-3.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gulf Park - Option C Alternate Alignment

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	1,302,500		1,302,500
01B20	Acquisition by NFS		10,420,000	10,420,000
01BX	Contingencies (25%)	325,625	2,605,000	2,930,625
	Subtotal	1,628,125	13,025,000	14,653,125
01F	PL 91-646 Assistance			
01F20	By NFS		804,000	804,000
01FX	Contingencies (25%)		201,000	201,000
	Subtotal		1,005,000	1,005,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		27,505,451	27,505,451
01R2B	PL91-646 Relocation Payment by NFS		3,768,800	3,768,800
01R2D	Review of NFS	201,000		201,000
01RX	Contingencies (25%)	50,250	7,818,563	7,868,813
	Subtotal	251,250	39,092,814	39,344,064
	Totals	**1,879,375**	**53,122,814**	**55,002,189**
	Rounded			**55,002,000**

Table 3.3.8.21-4.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gulf Park - Option D Alternate Alignment

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	1,402,500		1,402,500
01B20	Acquisition by NFS		11,220,000	11,220,000
01BX	Contingencies (25%)	350,625	2,805,000	3,155,625
	Subtotal	1,753,125	14,025,000	15,778,125
01F	PL 91-646 Assistance			
01F20	By NFS		864,000	864,000
01FX	Contingencies (25%)		216,000	216,000
	Subtotal		1,080,000	1,080,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		29,142,186	29,142,186
01R2B	PL91-646 Relocation Payment by NFS		4,037,600	4,037,600
01R2D	Review of NFS	216,000		216,000
01RX	Contingencies (25%)	54,000	8,294,947	8,348,947
	Subtotal	270,000	41,474,733	41,744,733
	Totals	**2,023,125**	**56,579,733**	**58,602,858**
	Rounded			**58,603,000**

3.3.9 Jackson County Ring Levees, Belle Fontaine

Several high density residential and business areas in Jackson County were identified. They are Ocean Springs, Gulf Park, Belle Fontaine, Gautier, and Pascagoula/Moss Point. The subdivision of Belle Fontaine is located just west of Gautier along the gulf coast on Mississippi Sound. The location of the Belle Fontaine ring levee is shown in Figure 3.3.9-1. The northeastern part of the subdivision is near elevation 10-14 feet NAVD88 and very flat. Ground elevations over the southwestern part of the area vary between elevations 16-20 feet NAVD88. These areas are subject to damage from storm surges associated with hurricanes. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A, Option B, Option C and Option D. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with side slopes of 1 vertical to 3 horizontal.

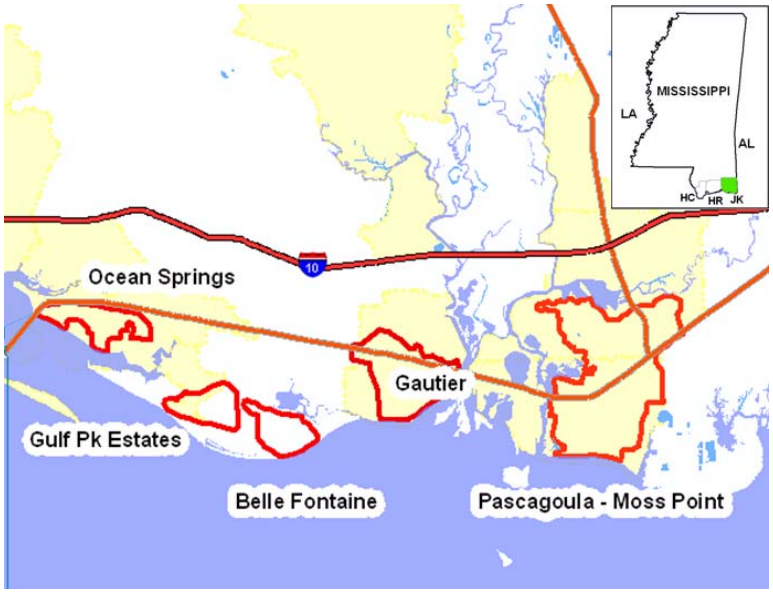


Figure 3.3.9-1. Vicinity Map, Belle Fontaine

3.3.9.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the subdivision of Belle Fontaine along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.9.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.9.3 Option C - Alternate Alignment, Elevation 20.0 ft NAVD88

Option C consists of an earthen levee at elevation 20.0 feet in an alignment slightly different from the alignment for Options A and B. Additionally, the lands that lay between the alignment of Option A and the alternate alignment Option C will be acquired as a buffer zone in this option.

3.3.9.4 Option D - Alternate Alignment, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option C, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. As above, the buffer zone lands will be acquired.

3.3.9.5 Project Description

Figure 3.3.9.5-1 shows the location of the proposed project alternatives with the alternate alignment representing Options C and D. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.9.5-2 shows the proposed location of the pump/culvert sites. During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

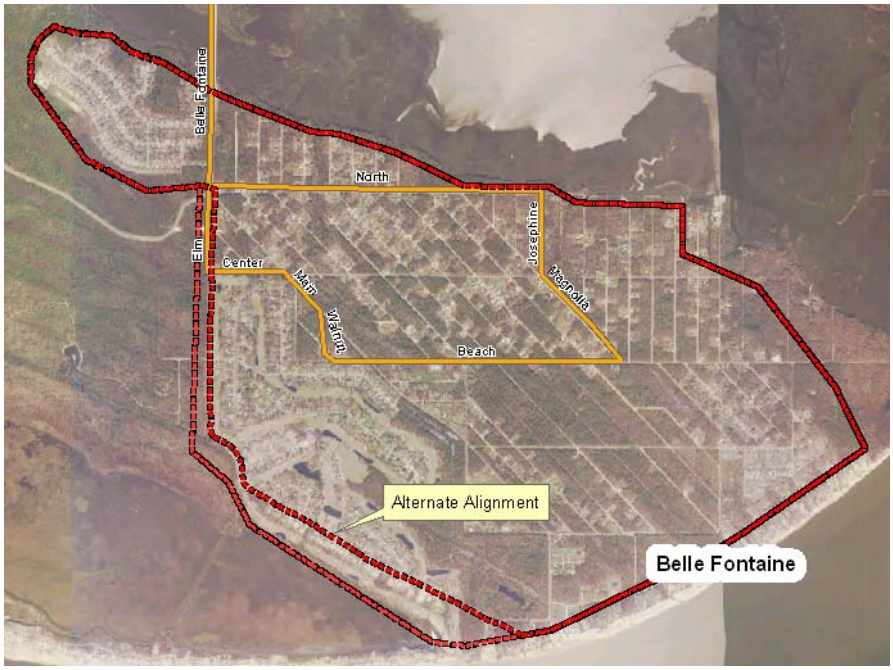


Figure 3.3.9.5-1. Belle Fontaine Ring Levee



Figure 3.3.9.5-2. Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. Pump facilities are required at 7 locations.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used

including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around Belle Fontaine at Option A, elevation 20.0, 10 roadway intersections would have to be accommodated. For this study it was estimated that 5 roller gate structures and 5 swing gate structures would be required. At Option B, elevation 30.0, 13roadway intersections would have to be accommodated, and it was estimated that all 13 would require swing gate structures. At Option C, elevation 20.0, 13 roadway intersections would have to be accommodated and it was estimated that 5 of these would require swing gate structures with the remaining five requiring roller gates of varying heights. At Option D, elevation 30.0, 11 roadway intersections would have to be accommodated and it was estimated that all 11 would require swing gate structures.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.9.6 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Belle Fontaine Ring Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire buffer zone lands, construct an earthen levee, drainage ditches and 7 culvert/pump station facilities.

Based on the footprint of Option A, 20.0 foot elevation, it was determined that approximately 228 parcels and 30 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 30 relocations.

Based on the footprint of Option B, 30.0 foot elevation, it was determined that 297 parcels and 38 structures are impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations would require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 28 relocations.

Based on the footprint of Option C, 20.0 foot elevation, it was determined that 286 parcels and 45 structures would be impacted. This number includes acquisition of the buffer zone lands. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 45 relocations.

Based on the footprint of Option D, 30.0 foot elevation, it was determined that 359 parcels and 54 structures would be impacted. This includes acquisition of the buffer zone lands. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 54 relocations.

Ditches that will be constructed to provide drainage for the interior of the ring levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.9.7 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.9.8 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.9.9 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.9.10 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish

all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.9.11 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.9.12 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.9.13 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.9.14 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.9.15 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic

types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 30 relocations in Option A, 38 relocations in Option B, 45 relocations in Option C, and 54 relocations in Option D. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.9.16 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.9.17 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.9.18 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.9.19 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.9.19-1. The real estate estimates at Tables 3.3.9.19-2 through 3.3.9.19-5 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.9.19-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	228	30	$19,366,000
Option B - 30.0	297	38	$25,774,000
Option C - 20.0	286	45	$26,711,000
Option D - 30.0	359	54	$33,260,000

Table 3.3.9.19-2.
LOD3 Jackson County Ring Levee, Belle Fontaine - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
221 Ownerships for Levee, 30 Improvements					9,015,200
7 Pump Stations					271,308
228 Ownerships					
				Subtotal	9,286,508
b. Mineral Rights					0
c. Damages					0
30 relocations					
d. P.L. 91-646 Relocation costs – 30 relocations					851,200
e. Administrative Cost					5,355,000
		Relocation	Acquisition	Total	
	Federal	45,000	570,000	615,000	
	Non-Federal	180,000	4,560,000	4,740,000	
		225,000	5,130,000	5,355,000	
Subtotal					15,492,708
Contingencies (25%)					3,873,177
		Totals			**19,365,885**
		Rounded			**19,366,000**

Table 3.3.9.19-3.
LOD3 Jackson County Ring Levee, Belle Fontaine - Option B 30.0 Estimate

a. Lands and Improvements/Permits					
290 Ownerships for Levee, 38 Improvements					12,327,474
7 Pump Stations					271,308
297 Ownerships				Subtotal	12,598,782
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 38 relocations					1,052,800
e. Administrative Cost					6,967,500
		Relocation	Acquisition	Total	
	Federal	57,000	742,500	799,500	
	Non-Federal	228,000	5,940,000	6,168,000	
		285,000	6,682,500	6,967,500	
Subtotal					20,619,082
Contingencies (25%)					5,154,771
		Totals			**25,773,853**
		Rounded			**25,774,000**

Table 3.3.9.19-4.
LOD3 Jackson County Ring Levee, Belle Fontaine - Option C Alternate Alignment, Elevation 20.0 Estimate

a. Lands and Improvements/Permits				
251 Ownerships for Levee, 43 Improvements				11,442,807
28 Ownerships for Buffer, 2 Improvements				1,314,250
7 Ownerships for Pump Stations				271,308
286 Ownerships			Subtotal	13,028,365
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 45 relocations				1,568,000
e. Administrative Cost				6,772,500
	Relocation	Acquisition	Total	
Federal	67,500	715,000	782,500	
Non-Federal	270,000	5,720,000	5,990,000	
	337,500	6,435,000	6,772,500	
Sub-Total				21,368,865
Contingencies (25%)				5,342,216
	Totals			**26,711,081**
	Rounded			**26,711,000**

Table 3.3.9.19-5.
LOD3 Jackson County Ring Levee, Belle Fontaine - Option D Alternate Alignment, Elevation 30.0 Estimate

a. Lands and Improvements/Permits				
335 Ownerships for Levee, 54 Improvements				15,586,002
17 Ownerships for Buffer, 0 Improvements				745,255
7 Ownerships for Pump Stations				271,308
359 Ownerships			Subtotal	16,602,565
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 54 relocations				1,523,200
e. Administrative Cost				8,482,500
	Relocation	Acquisition	Total	
Federal	81,000	897,500	978,500	
Non-Federal	324,000	7,180,000	7,504,000	
	405,000	8,077,500	8,482,500	
Sub-Total				26,608,265
Contingencies (25%)				6,652,066
Totals				**33,260,331**
Rounded				**33,260,000**

3.3.9.20 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.9.21 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.9.21-1 through 3.3.9.21-4 shows the CWBS for real estate activities.

Table 3.3.9.21-1.
Chart of Accounts - LOD3 Jackson County Ring Levee, Belle Fontaine - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	570,000		570,000
01B20	Acquisition by NFS		4,560,000	4,560,000
01BX	Contingencies (25%)	142,500	1,140,000	1,282,500
	Subtotal	712,500	5,700,000	6,412,500
01F	PL 91-646 Assistance			
01F20	By NFS		180,000	180,000
01FX	Contingencies (25%)		45,000	45,000
	Subtotal		225,000	225,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		9,286,508	9,286,508
01R2B	PL91-646 Relocation Payment by NFS		851,200	851,200
01R2D	Review of NFS	45,000		45,000
01RX	Contingencies (25%)	11,250	2,534,427	2,545,677
	Subtotal	56,250	12,672,135	12,728,385
	Totals	**768,750**	**18,597,135**	**19,365,885**
	Rounded			**19,366,000**

Table 3.3.9.21-2.
Chart of Accounts - LOD3 Jackson County Ring Levee, Belle Fontaine - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	742,500		742,500
01B20	Acquisition by NFS		5,940,000	5,940,000
01BX	Contingencies (25%)	185,625	1,485,000	1,670,625
	Subtotal	928,125	7,425,000	8,353,125
01F	PL 91-646 Assistance			
01F20	By NFS		228,000	228,000
01FX	Contingencies (25%)		57,000	57,000
	Subtotal		285,000	285,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		12,598,782	12,598,782
01R2B	PL91-646 Relocation Payment by NFS		1,052,800	1,052,800
01R2D	Review of NFS	57,000		57,000
01RX	Contingencies (25%)	14,250	3,412,896	3,427,146
	Subtotal	71,250	17,064,478	17,135,728
	Totals	**999,375**	**24,774,478**	**25,773,853**
	Rounded			**25,774,000**

Table 3.3.9.21-3.
Chart of Accounts - LOD3 Jackson County Ring Levee, Belle Fontaine - Option C Alternate Alignment

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	715,000		715,000
01B20	Acquisition by NFS		5,720,000	5,720,000
01BX	Contingencies (25%)	178,750	1,430,000	1,608,750
	Subtotal	893,750	7,150,000	8,043,750
01F	PL 91-646 Assistance			
01F20	By NFS		270,000	270,000
01FX	Contingencies (25%)		67,500	67,500
	Subtotal		337,500	337,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		13,028,365	13,028,365
01R2B	PL91-646 Relocation Payment by NFS		1,568,000	1,568,000
01R2D	Review of NFS	67,500		67,500
01RX	Contingencies (25%)	16,875	3,649,091	3,665,966
	Subtotal	84,375	18,245,456	18,329,831
	Totals	**978,125**	**25,732,956**	**26,711,081**
	Rounded			**26,711,000**

Table 3.3.9.21-4.
Chart of Accounts - LOD3 Jackson County Ring Levee, Belle Fontaine - Option D Alternate Alignment

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	897,500		897,500
01B20	Acquisition by NFS		7,180,000	7,180,000
01BX	Contingencies (25%)	224,375	1,795,000	2,019,375
	Subtotal	1,121,875	8,975,000	10,096,875
01F	PL 91-646 Assistance			
01F20	By NFS		324,000	324,000
01FX	Contingencies (25%)		81,000	81,000
	Subtotal		405,000	405,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		16,602,565	16,602,565
01R2B	PL91-646 Relocation Payment by NFS		1,523,200	1,523,200
01R2D	Review of NFS	81,000		81,000
01RX	Contingencies (25%)	20,250	4,531,441	4,551,691
	Subtotal	101,250	22,657,206	22,758,456
	Totals	**1,223,125**	**32,037,206**	**33,260,331**
	Rounded			**33,260,000**

3.3.10 Jackson County Ring Levees, Gautier

Several high density residential and business areas in Jackson County were identified. They are Ocean Springs, Gulf Park, Belle Fontaine, Gautier and Pascagoula/Moss Point. Gautier is located on the west side of the Pascagoula River delta at the mouth of the West Pascagoula River at the Mississippi Sound. The location of the Gautier ring levee is shown in Figure 3.3.10-1. Ground elevations over most of the residential and business areas vary between elevations 10-20 feet NAVD88. These areas are subject to damage from storm surges associated with hurricanes. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A and Option B. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with side slopes of 1 vertical to 3 horizontal.

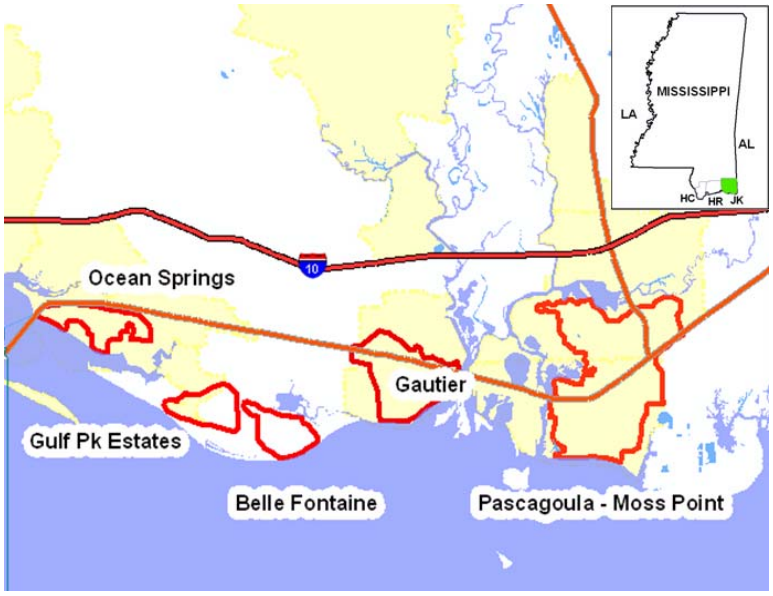


Figure 3.3.10-1. Vicinity Map, Gautier

3.3.10.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the most densely populated areas of Gautier along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.10.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.10.3 Project Description

Figure 3.3.10.3-1 shows the location of the proposed project alternatives. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. The culverts would have tidal gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for manual control in the event the tidal gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.10.3-2 shows the proposed location of the pump/culvert sites. During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

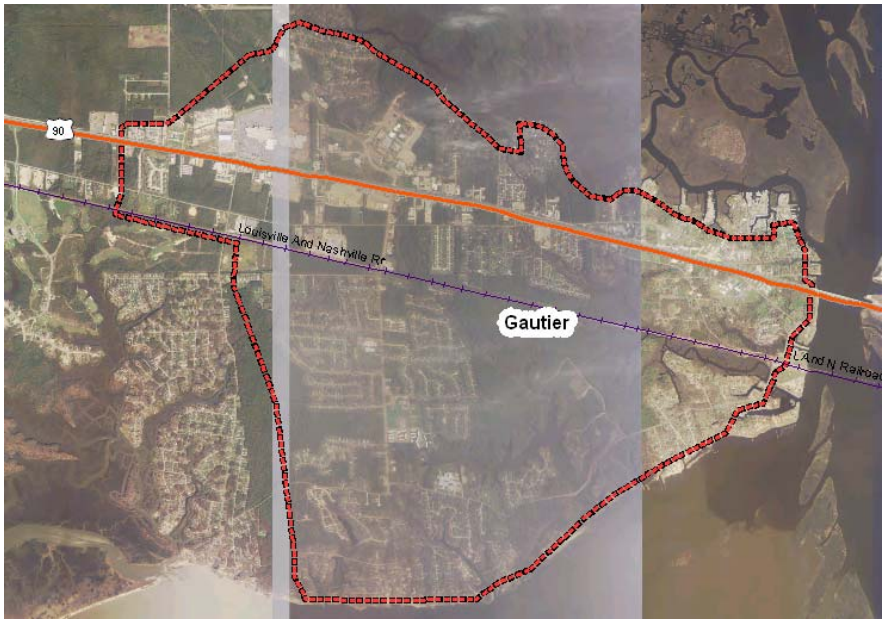


Figure 3.3.10.3-1. Gautier Ring Levee



Figure 3.3.10.3-2. Pump/Culvert/Sub-basin/Boat Access Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study the culverts were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide closure when needed. Pump facilities are required at 11 locations.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around Gautier at Option A, elevation 20.0, 20 roadway intersections would have to be accommodated. For this study it was estimated that 11 roller gate structures and 11 swing gate structures would be required. At Option B, elevation 30.0, 23 roadway intersections would have to be accommodated, and it was estimated that all 23 would require swing gate structures.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.10.4 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Gautier Ring Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and 11 culvert/pump station facilities.

Based on the footprint of the Option A 20.0 foot elevation, it was determined that approximately 313 parcels and 139 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 11 pump stations will require approximately 0.23 of an acre each for a total of 2.53 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 139 relocations.

Based on the footprint of the Option B 30.0 foot elevation, it was determined that 354 parcels and 161 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 11 pump stations will require approximately 0.23 of an acre each for a total of 2.53 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 161 relocations.

Ditches that will be constructed to provide drainage for the interior of the ring levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

In some areas the levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. To allow continued free boat access to areas behind the levee these water courses will be fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay St. Louis. A small boat access structure is shown at the mouth of multiple basins in the project footprint. Rising sector gates will be provided at these gates allowing shallow draft traffic most of the time. The gates will be closed prior to hurricane storm surge. No additional real estate interest is identified for boat access points as they fall within the footprint of the project and impacted parcels are included in the total that is projected. For those lands required for construction that lay below the mean high water mark, navigation servitude will apply.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report.

Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.10.5 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.10.6 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.10.7 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.10.8 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.10.9 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.10.10 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.10.11 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.10.12 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.10.13 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 139 relocations in Option A and approximately 161 relocations in Option B. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.10.14 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.10.15 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the

NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.10.16 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.10.17 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.10.17-1. The real estate estimates at Table 3.3.10.17-2 and 3.3.10.17-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.10.17-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	313	139	$56,977,000
Option B - 30.0	354	161	$66,585,000

Table 3.3.10.17-2.
LOD3 Jackson County Ring Levee, Gautier - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
302 Ownerships for Levee, 139 Improvements					33,172,344
11 Pump Stations					426,342
313 Ownerships				Subtotal	33,598,686
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 139 relocations					3,897,600
e. Administrative Cost					8,085,000
		Relocation	Acquisition	Total	
	Federal	208,500	782,500	991,000	
	Non-Federal	834,000	6,260,000	7,094,000	
		1,042,500	7,042,500	8,085,000	
Subtotal					45,581,286
Contingencies (25%)					11,395,322
		Totals			**56,976,608**
		Rounded			**56,977,000**

Table 3.3.10.17-3.
LOD3 Jackson County Ring Levee, Gautier - Option B 30.0 Estimate

a. Lands and Improvements/Permits					
343 Ownerships for Levee, 161 Improvements					39,166,820
11 Pump Stations					426,342
354 Ownerships				Subtotal	39,593,162
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 161 relocations					4,502,400
e. Administrative Cost					9,172,500
		Relocation	Acquisition	Total	
	Federal	241,500	885,000	1,126,500	
	Non-Federal	966,000	7,080,000	8,046,000	
		1,207,500	7,965,000	9,172,500	
Subtotal					53,268,062
Contingencies (25%)					13,317,016
		Totals			**66,585,078**
		Rounded			**66,585,000**

3.3.10.18 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.10.19 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.10.19-1 and 3.3.10.19-2 shows the CWBS for real estate activities.

Table 3.3.10.19-1.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gautier - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	782,500		782,500
01B20	Acquisition by NFS		6,260,000	6,260,000
01BX	Contingencies (25%)	195,625	1,565,000	1,760,625
	Subtotal	978,125	7,825,000	8,803,125
01F	PL 91-646 Assistance			
01F20	By NFS		834,000	834,000
01FX	Contingencies (25%)		208,500	208,500
	Subtotal		1,042,500	1,042,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		33,598,686	33,598,686
01R2B	PL91-646 Relocation Payment by NFS		3,897,600	3,897,600
01R2D	Review of NFS	208,500		208,500
01RX	Contingencies (25%)	52,125	9,374,072	9,426,197
	Subtotal	260,625	46,870,358	47,130,983
	Totals	**1,238,750**	**55,737,858**	**56,976,608**
	Rounded			**56,977,000**

Table 3.3.10.19-2.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gautier - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	885,000		885,000
01B20	Acquisition by NFS		7,080,000	7,080,000
01BX	Contingencies (25%)	221,250	1,770,000	1,991,250
	Subtotal	1,106,250	8,850,000	9,956,250
01F	PL 91-646 Assistance			
01F20	By NFS		966,000	966,000
01FX	Contingencies (25%)		241,500	241,500
	Subtotal		1,207,500	1,207,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		39,593,162	39,593,162
01R2B	PL91-646 Relocation Payment by NFS		4,502,400	4,502,400
01R2D	Review of NFS	241,500		241,500
01RX	Contingencies (25%)	60,375	11,023,891	11,084,266
	Subtotal	301,875	55,119,453	55,421,328
	Totals	**1,408,125**	**65,176,953**	**66,585,078**
	Rounded			**66,585,000**

3.3.11 Jackson County Ring Levees, Pascagoula/Moss Point

Several high density residential and business areas in Jackson County were identified. They are Ocean Springs, Gulf Park, Belle Fontaine, Gautier and Pascagoula/Moss Point. The cities of Moss Point and Pascagoula lie at the confluence of the Escatawpa and Pascagoula Rivers along the gulf coast on Mississippi Sound as shown on Figure 3.3.11-1. Both the northern part of Moss Point and the southern Part of Pascagoula are very flat. Ground elevations over most of the residential and business areas vary between elevations 10-12 feet NAVD88 in the southern part of the area (Pascagoula) and 14-20 feet NAVD88 in the northern part (Moss Point). These areas are subject to damage from storm surges associated with hurricanes. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Options A through H. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with side slopes of 1 vertical to 3 horizontal.

3.3.11.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the most densely populated areas of Moss Point and Pascagoula along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal. This is the basic alignment and is the most extensive, covering the main residential areas in Pascagoula and Moss Point.

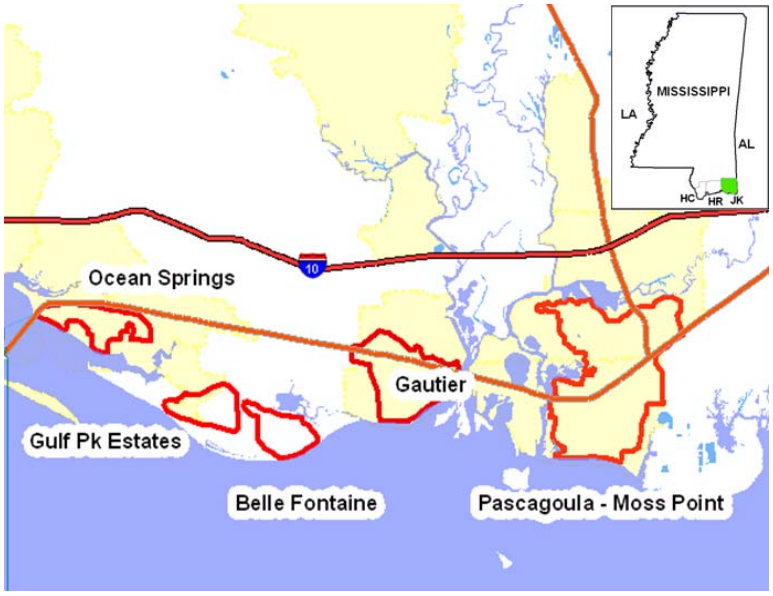


Figure 3.3.11-1. Vicinity Map, Pascagoula/Moss Point

3.3.11.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.11.3 Option C - Washington Avenue Alternate Alignment, Elevation 20.0 ft NAVD88

The alignment of the Option C levee is the same as Option A, except that it follows Washington Avenue on the southernmost leg of the levee. Additionally the lands that lay between the alignment of Option A and the alternate alignment Option C will be acquired as buffer zone in this option.

3.3.11.4 Option D - Washington Avenue Alternate Alignment, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option C above. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. As above, the buffer zone lands will be acquired

3.3.11.5 Option E - Moss point Alternate Alignment, Elevation 20.0 ft NAVD88

The alignment of the Option E levee is the same as Option A, except that it follows a modified alignment through Moss Point along higher ground on the north leg of the levee. Additionally the lands that lay between the alignment of Option A and the alternate alignment Option E will be acquired as a buffer zone in this option.

3.3.11.6 Option F - Moss Point Alternate Alignment, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option E above. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. As above, the buffer zone lands will be acquired.

3.3.11.7 Option G - Combined Washington Avenue and Moss Point Alterative Alignments, Elevation 20.0 ft NAVD88

The alignment of the levee is the same as Option A, above, except that is follows the same modified alignment along Washington Ave as for Options C and D on the south, and the modified alignment in Moss Point as for Options E and F along the north leg of the levee. Additionally, the lands that lay between the alignment of Option A and the alternate alignments Option C and Option E will be acquired as buffer zones in this option.

3.3.11.8 Option H - Combined Washington Avenue and Moss Point Alterative Alignments, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option G above. The only difference between the description of this option and preceding description of Option G is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. As above, the buffer zone lands will be acquired.

3.3.11.9 Project Description

Figure 3.3.11.9-1 shows the location of the proposed project alternatives with the alternate alignments representing Options C-H. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.11.9-2 shows the proposed location of the pump/culvert sites. During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box

structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. Pump facilities are required at 23-28 locations with variance depending on the option.

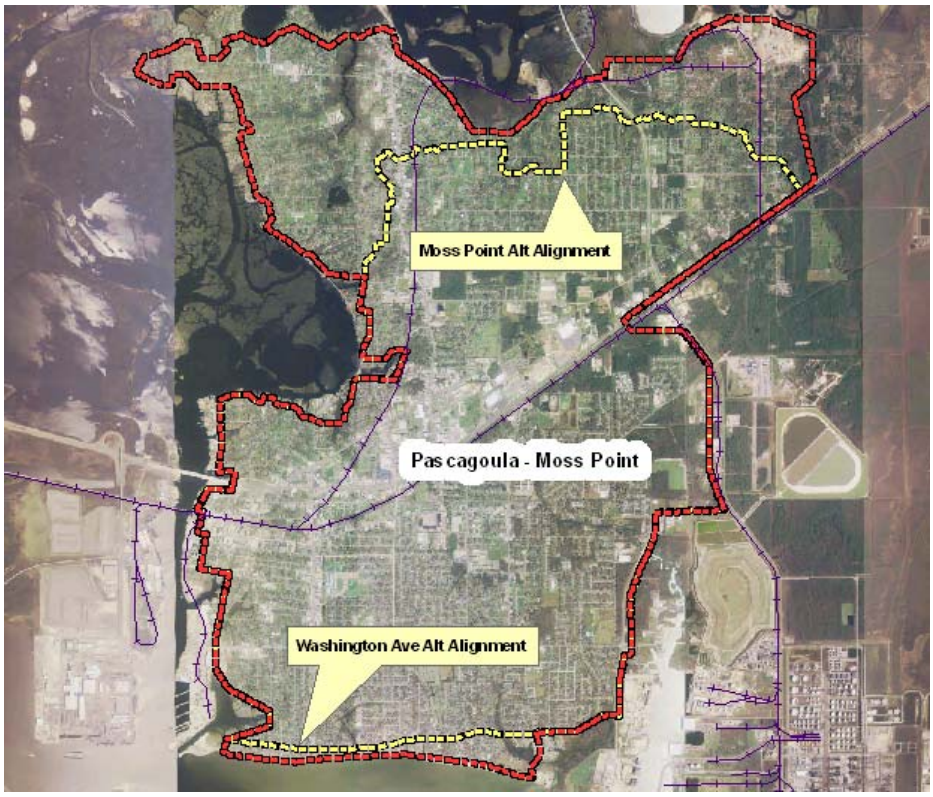


Figure 3.3.11.9-1. Pascagoula/Moss Point Levee

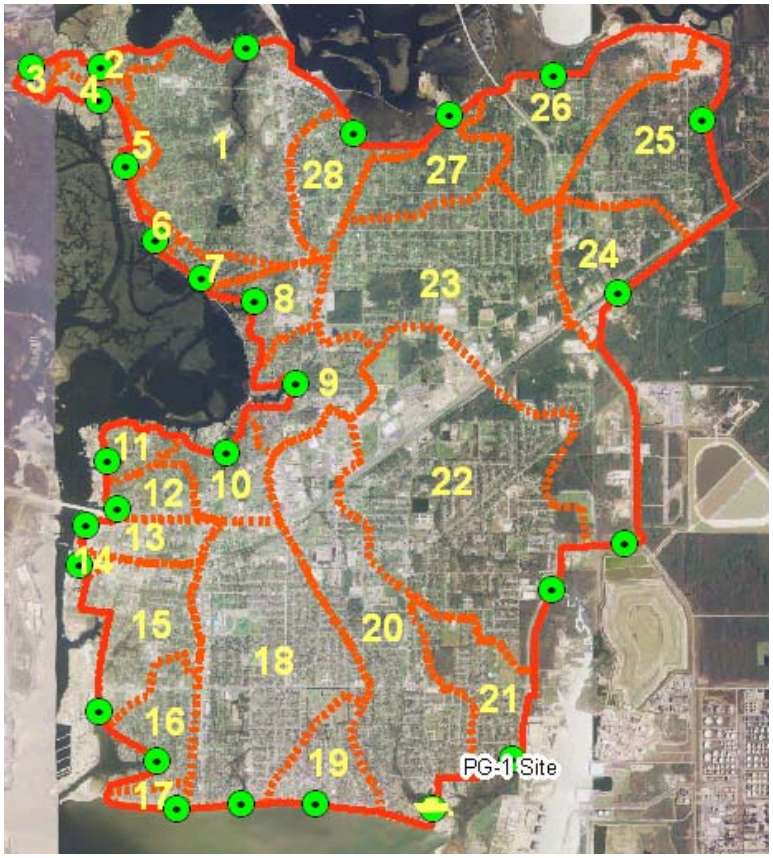


Figure 3.3.11.9-2. Pump/Culvert/Sub-basin/Boat Access Site Locations

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

Table 3.3.11.9-1 summarizes the number of roadway/railway intersections impacted by the various options. The number of roller gate, swing gate and railroad gate structures are listed for each option.

Table 3.3.11.9-1.
Levee and Roadway/Railway Intersections

Option	Roadway/Railway Intersections	Roller Gates	Swing Gates	Railroad Gates
Option A	68	29	35	8
Option B	79	1	73	5
Option C	76	24	108	14
Option D	87	1	180	18
Option E	43	15	56	10
Option F	75		75	14
Option G	48	15	72	10
Option H	79		79	14

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.11.10 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Pascagoula/Moss Point Ring Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire buffer zone lands, construct an earthen levee, drainage ditches and 23 - 28 culvert/pump station facilities depending on the option.

Based on the footprint of the Option A, 20.0 foot elevation, it was determined that approximately 1075 parcels and 536 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 28 pump stations will require approximately 0.23 of an acre each for a total of 6.44 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 536 relocations.

Based on the footprint of the Option B, 30.0 foot elevation, it was determined that 1203 parcels and 602 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 28 pump stations will require approximately 0.23 of an acre each for a total of 6.44 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 602 relocations.

Based on the footprint of the Option C, 20.0 foot elevation, it was determined that 1175 parcels and 550 structures would be impacted. Lands for the buffer zone are included in this number. The acreage to be acquired for the levee is unknown. It is known that the 27 pump stations will require approximately 0.23 of an acre each for a total of 6.21 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 550 relocations.

Based on the footprint of the Option D, 30.0 foot elevation, it was determined that 1321 parcels and 623 structures would be impacted. Lands for the buffer zone are included in this number. The acreage to be acquired for the levee is unknown. It is known that the 27 pump stations will require approximately 0.23 of an acre each for a total of 6.21 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 623 relocations.

Based on the footprint of the Option E, 20.0 foot elevation, it was determined that 2964 parcels and 1870 structures would be impacted. Lands for the buffer zone are included in this number. The acreage to be acquired for the levee is unknown. It is known that the 24 pump stations will require approximately 0.23 of an acre each for a total of 5.52 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 1870 relocations.

Based on the footprint of the Option F, 30.0 foot elevation, it was determined that 3076 parcels and 1926 structures would be impacted. Lands for the buffer zone are included in this number. The acreage to be acquired for the levee is unknown. It is known that the 24 pump stations will require approximately 0.23 of an acre each for a total of 5.52 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 1926 relocations.

Based on the footprint of the Option G 20.0 foot elevation, it was determined that 3138 parcels and 1939 structures would be impacted. Lands for the buffer zone are included in this number. The acreage to be acquired for the levee is unknown. It is known that the 23 pump stations will require approximately 0.23 of an acre each for a total of 5.29 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 1939 relocations.

Based on the footprint of the Option H, 30.0 foot elevation, it was determined that 3253 parcels and 1994 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 23 pump stations will require approximately 0.23 of an acre each for a total of 5.29 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 1994 relocations. Table 3.3.11.10-1 below summarizes the real estate requirements for the various alternatives.

Table 3.3.11.10-1.
Real Estate Requirements - LOD3 Pascagoula/Moss Point Alternatives

Option	Impacted Parcels	Impacted Structures	# Pump Stations/AC	Relocations
Option A	1,075	536	28 6.44 AC	536
Option B	1,203	602	28 6.44 AC	602
Option C	1,175	550	27 6.21 AC	550
Option D	1,321	623	27 6.21 AC	623
Option E	2,964	1,870	24 5.52 AC	1870
Option F	3,076	1,926	24 5.52 AC	1926
Option G	3,138	1,939	23 5.29 AC	1939
Option H	3,253	1,994	23 5.29 AC	1994

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

In some areas the levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. To allow continued free boat access to areas behind the levee these water courses will be fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay St. Louis. A small boat access structure is shown at the mouth of one basin in the project footprint. Rising sector gates will be provided at this gate allowing shallow draft traffic most of the time. The gate will be closed prior to hurricane storm surge. No additional real estate interest is identified for boat access points as they fall within the footprint of the project and impacted parcels are included in the total that is projected. For those lands required for construction that lay below the mean high water mark, navigation servitude will apply.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.11.11 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.11.12 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.11.13 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.11.14 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.11.15 Government Owned Property

One (1) Government owned parcel is within the footprint of the project. In viewing the footprint, it appears that approximately 30% of the parcel will be impacted by construction of the levee. Land value is listed as $131,090 and improvement value is listed as $427,020. Ownership is listed in public records as US Govt (Pasc Fishery Lab). Specific impacts to this particular parcel and/or structure will be determined during PED.

3.3.11.16 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.11.17 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.11.18 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.11.19 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

Table 3.3.11.19-1 shows the number of expected relocations for each Option. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

Table 3.3.11.19-1.
PL 91-646 - Relocation Assistance

Option	Number of Relocations
Option A	536
Option B	602
Option C	550
Option D	623
Option E	1870
Option F	1926
Option G	1939
Option H	1994

3.3.11.20 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles

that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.11.21 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.11.22 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and for drainage ditches constructed outside the footprint of the levee, fee or the Drainage Ditch Easement will be used as appropriate. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.11.23 Real Estate Estimate

A summary of cost for each option is at Table 3.3.11.23-1. The real estate estimates at Tables 3.3.11.23-2 through 3.3.11.23-9 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.11.23-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	1,075	536	$237,004,000
Option B - 30.0	1,203	602	$256,517,000
Option C - 20.0	1,175	550	$278,147,000
Option D - 30.0	1,321	623	$297,899,000
Option E - 20.0	2,964	1,870	$520,145,000
Option F - 30.0	3,076	1,926	$533,059,000
Option G - 20.0	3,138	1,939	$574,040,000
Option H - 30.0	3,253	1,994	$584,742,000

Table 3.3.11.23-2.
LOD3 Jackson County Ring Levee, Pascagoula/Moss Point - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
954 Ownerships for Levee, 474 Improvements					137,828,453
93 Ownerships for Ditches, 62 Improvements					7,463,013
28 Pump Stations					1,085,233
1,075 Ownerships				Subtotal	146,376,699
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 536 relocations					15,019,200
e. Administrative Cost					28,207,500
		Relocation	Acquisition	Total	
	Federal	804,000	2,687,500	3,491,500	
	Non-Federal	3,216,000	21,500,000	24,716,000	
		4,020,000	24,187,500	28,207,500	
Sub-Total					189,603,399
Contingencies (25%)					47,400,850
	Totals				**237,004,249**
	Rounded				**237,004,000**

Table 3.3.11.23-3.
LOD3 Jackson County Ring Levee, Pascagoula/Moss Point - Option B 30.0 Estimate

a. Lands and Improvements/Permits				
1,104 Ownerships for Levee, 557 Improvements				150,053,939
71 Ownerships for Ditches, 45 Improvements				5,641,239
28 Pump Stations				1,085,233
1,203 Ownerships			subtotal	156,780,411
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 602 relocations				16,850,400
e. Administrative Cost				31,582,500
	Relocation	Acquisition	Total	
Federal	903,000	3,007,500	3,910,500	
Non-Federal	3,612,000	24,060,000	27,672,000	
	4,515,000	27,067,500	31,582,500	
Sub-Total				205,213,311
Contingencies (25%)				51,303,328
	Totals			**256,516,639**
	Rounded			**256,517,000**

Table 3.3.11.23-4.
LOD3 Jackson County Ring Levee, Washington Avenue Alternate Alignment - Option C 20.0 Estimate

a. Lands and Improvements/Permits					
926 Ownerships for Levee, 464 Improvements					128,375,987
168 Ownerships for Buffer, 58 Improvements					43,205,925
54 Ownerships for Ditches, 28 Improvements					3,926,389
27 Pump Stations					1,046,475
1,175 Ownerships				Subtotal	176,554,776
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 550 relocations					15,400,000
e. Administrative Cost					30,562,500
	Relocation	Acquisition	Total		
Federal	825,000	2,937,500	3,762,500		
Non-Federal	3,300,000	23,500,000	26,800,000		
	4,125,000	26,437,500	30,562,500		
Sub-Total					222,517,276
Contingencies (25%)					55,629,319
	Totals				**278,146,595**
	Rounded				**278,147,000**

Table 3.3.11.23-5.
LOD3 Jackson County Ring Levee, Washington Avenue Alternate Alignment - Option D 30.0 Estimate

a. Lands and Improvements/Permits					
1,099 Ownerships for Levee, 548 Improvements					142,777,351
141 Ownerships for Buffer, 47 Improvements					38,729,810
54 Ownerships for Ditches, 28 Improvements					3,926,389
27 Pump Stations					1,046,475
1,321 Ownerships				Subtotal	186,480,025
b. Mineral Rights					0
c. Damages					0
d. P. L. 91-646 Relocation costs - 623 relocations					17,444,000
e. Administrative Cost					34,395,000
		Relocation	Acquisition	Total	
	Federal	934,500	3,302,500	4,237,000	
	Non-Federal	3,738,000	26,420,000	30,158,000	
		4,672,500	29,722,500	34,395,000	
Sub-Total					238,319,025
Contingencies (25%)					59,579,756
	Totals				**297,898,781**
	Rounded				**297,899,000**

Table 3.3.11.23-6.
LOD3 Jackson County Ring Levee, Moss Point Alternate Alignment - Option E 20.0 Estimate

a. Lands and Improvements/Permits					
850 Ownerships for Levee, 385 Improvements					110,203,673
2,001 Ownerships for Buffer, 1,444 Improvements					168,271,915
89 Ownerships for Ditches, 41 Improvements					3,634,894
24 Pump Stations					930,200
2,964 Ownerships				Subtotal	283,040,682
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 1,870 relocations					52,360,000
e. Administrative Cost					80,715,000
	Relocation	Acquisition	Total		
Federal	2,805,000	7,410,000	10,215,000		
Non-Federal	11,220,000	59,280,000	70,500,000		
	14,025,000	66,690,000	80,715,000		
Sub-Total					416,115,682
Contingencies (25%)					104,028,921
	Totals				**520,144,603**
	Rounded				**520,145,000**

Table 3.3.11.23-7.
LOD3 Jackson County Ring Levee, Moss Point Alternate Alignment - Option F 30.0 Estimate

a. Lands and Improvements/Permits					
997 Ownerships for Levee, 464 Improvements					118,287,317
1,987 Ownerships for Buffer, 1,433 Improvements					166,979,295
68 Ownerships for Ditches, 29 Improvements					2,667,427
24 Pump Stations					930,200
3,076 Ownerships				Subtotal	288,864,239
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 1,926 relocations					53,928,000
e. Administrative Cost					83,655,000
		Relocation	Acquisition	Total	
	Federal	2,889,000	7,690,000	10,579,000	
	Non-Federal	11,556,000	61,520,000	73,076,000	
		14,445,000	69,210,000	83,655,000	
Sub-Total					426,447,239
Contingencies (25%)					106,611,810
	Totals				**533,059,049**
	Rounded				**533,059,000**

Table 3.3.11.23-8.
LOD3 Jackson County Ring Levee, Combined Washington Avenue and Moss Point Alternate Alignment - Option G 20.0 Estimate

a. Lands and Improvements/Permits					
819 Ownerships for Levee, 384 Improvements					100,728,605
2,169 Ownerships for Buffer, 1,502 Improvements					211,477,840
127 Ownerships for Ditches, 53 Improvements					6,694,928
23 Pump Stations					891,442
3,138 Ownerships				Subtotal	319,792,815
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 1,939 relocations					54,292,000
e. Administrative Cost					85,147,500
	Relocation	Acquisition	Total		
Federal	2,908,500	7,845,000	10,753,500		
Non-Federal	11,634,000	62,760,000	74,394,000		
	14,542,500	70,605,000	85,147,500		
Sub-Total					459,232,315
Contingencies (25%)					114,808,079
	Totals				**574,040,394**
	Rounded				**574,040,000**

Table 3.3.11.23-9.
LOD3 Jackson County Ring Levee, Combined Washington Avenue and Moss Point Alternate Alignment - Option H 30.0 Estimate

a. Lands and Improvements/Permits				
991 Ownerships for Levee, 467 Improvements				111,202,627
2,128 Ownerships for Buffer, 1,480 Improvements				205,709,105
111 Ownerships for Ditches, 47 Improvements				6,010,699
23 Pump Stations				891,442
3,253 Ownerships			Subtotal	323,813,873
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 1,994 relocations				55,832,000
e. Administrative Cost				88,147,500
	Relocation	Acquisition	Total	
Federal	2,991,000	8,132,500	11,123,500	
Non-Federal	11,964,000	65,060,000	77,024,000	
	14,955,000	73,192,500	88,147,500	
Sub-Total				467,793,373
Contingencies (25%)				116,948,343
	Totals			**584,741,716**
	Rounded			**584,742,000**

3.3.11.24 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate

Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.11.25 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.11.25-1 through 3.3.11.25-8 shows the CWBS for real estate activities.

Table 3.3.11.25-1.
Chart of Accounts - LOD3 Jackson County Ring Levee, Pascagoula/Moss Point - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	2,687,500		2,687,500
01B20	Acquisition by NFS		21,500,000	21,500,000
01BX	Contingencies (25%)	671,875	5,375,000	6,046,875
	Subtotal	3,359,375	26,875,000	30,234,375
01F	PL 91-646 Assistance			
01F20	By NFS		3,216,000	3,216,000
01FX	Contingencies (25%)		804,000	804,000
	Subtotal		4,020,000	4,020,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		146,376,699	146,376,699
01R2B	PL91-646 Relocation Payment by NFS		15,019,200	15,019,200
01R2D	Review of NFS	804,000		804,000
01RX	Contingencies (25%)	201,000	40,348,975	40,549,975
	Subtotal	1,005,000	201,744,874	202,749,874
	Totals	**4,364,375**	**232,639,874**	**237,004,249**
	Rounded			**237,004,000**

Table 3.3.11.25-2.
Chart of Accounts - LOD3 Jackson County Ring Levee, Pascagoula/Moss Point - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	3,007,500		3,007,500
01B20	Acquisition by NFS		24,060,000	24,060,000
01BX	Contingencies (25%)	751,875	6,015,000	6,766,875
	Subtotal	3,759,375	30,075,000	33,834,375
01F	PL 91-646 Assistance			
01F20	By NFS		3,612,000	3,612,000
01FX	Contingencies (25%)		903,000	903,000
	Subtotal		4,515,000	4,515,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		156,780,411	156,780,411
01R2B	PL91-646 Relocation Payment by NFS		16,850,400	16,850,400
01R2D	Review of NFS	903,000		903,000
01RX	Contingencies (25%)	225,750	43,407,703	43,633,453
	Subtotal	1,128,750	217,038,514	218,167,264
	Totals	**4,888,125**	**251,628,514**	**256,516,639**
	Rounded			**256,517,000**

Table 3.3.11.25-3.
Chart of Accounts - LOD3 Jackson County Ring Levee, Washington Avenue Alternate Alignment - Option C

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	2,937,500		2,937,500
01B20	Acquisition by NFS		23,500,000	23,500,000
01BX	Contingencies (25%)	734,375	5,875,000	6,609,375
	Subtotal	3,671,875	29,375,000	33,046,875
01F	PL 91-646 Assistance			
01F20	By NFS		3,300,000	3,300,000
01FX	Contingencies (25%)		825,000	825,000
	Subtotal		4,125,000	4,125,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		176,554,776	176,554,776
01R2B	PL91-646 Relocation Payment by NFS		15,400,000	15,400,000
01R2D	Review of NFS	825,000		825,000
01RX	Contingencies (25%)	206,250	47,988,694	48,194,944
	Subtotal	1,031,250	239,943,470	240,974,720
	Totals	**4,703,125**	**273,443,470**	**278,146,595**
	Rounded			**278,147,000**

Table 3.3.11.25-4.
Chart of Accounts - LOD3 Jackson County Ring Levee, Washington Avenue Alternate Alignment - Option D

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	3,302,500		3,302,500
01B20	Acquisition by NFS		26,420,000	26,420,000
01BX	Contingencies (25%)	825,625	6,605,000	7,430,625
	Subtotal	4,128,125	33,025,000	37,153,125
01F	PL 91-646 Assistance			
01F20	By NFS		3,738,000	3,738,000
01FX	Contingencies (25%)		934,500	934,500
	Subtotal		4,672,500	4,672,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		186,480,025	186,480,025
01R2B	PL91-646 Relocation Payment by NFS		17,444,000	17,444,000
01R2D	Review of NFS	934,500		934,500
01RX	Contingencies (25%)	233,625	50,981,006	51,214,631
	Subtotal	1,168,125	254,905,031	256,073,156
	Totals	**5,296,250**	**292,602,531**	**297,898,781**
	Rounded			**297,899,000**

Table 3.3.11.25-5.
Chart of Accounts - LOD3 Jackson County Ring Levee, Moss Point Alternate Alignment - Option E

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	7,410,000		7,410,000
01B20	Acquisition by NFS		59,280,000	59,280,000
01BX	Contingencies (25%)	1,852,500	14,820,000	16,672,500
	Subtotal	9,262,500	74,100,000	83,362,500
01F	PL 91-646 Assistance			
01F20	By NFS		11,220,000	11,220,000
01FX	Contingencies (25%)		2,805,000	2,805,000
	Subtotal		14,025,000	14,025,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		283,040,682	283,040,682
01R2B	PL91-646 Relocation Payment by NFS		52,360,000	52,360,000
01R2D	Review of NFS	2,805,000		2,805,000
01RX	Contingencies (25%)	701,250	83,850,171	84,551,421
	Subtotal	3,506,250	419,250,853	422,757,103
	Totals	**12,768,750**	**507,375,853**	**520,144,603**
	Rounded			**520,145,000**

Table 3.3.11.25-6.
Chart of Accounts - LOD3 Jackson County Ring Levee, Moss Point Alternate Alignment - Option F

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	7,690,000		7,690,000
01B20	Acquisition by NFS		61,520,000	61,520,000
01BX	Contingencies (25%)	1,922,500	15,380,000	17,302,500
	Subtotal	9,612,500	76,900,000	86,512,500
01F	PL 91-646 Assistance			
01F20	By NFS		11,556,000	11,556,000
01FX	Contingencies (25%)		2,889,000	2,889,000
	Subtotal		14,445,000	14,445,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		288,864,239	288,864,239
01R2B	PL91-646 Relocation Payment by NFS		53,928,000	53,928,000
01R2D	Review of NFS	2,889,000		2,889,000
01RX	Contingencies (25%)	722,250	85,698,060	86,420,310
	Subtotal	3,611,250	428,490,299	432,101,549
	Totals	**13,223,750**	**519,835,299**	**533,059,049**
	Rounded			**533,059,000**

Table 3.3.11.25-7.
Chart of Accounts - LOD3 Jackson County Ring Levee, Combined Washington Avenue and Moss Point Alternate Alignment - Option G

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	7,845,000		7,845,000
01B20	Acquisition by NFS		62,760,000	62,760,000
01BX	Contingencies (25%)	1,961,250	15,690,000	17,651,250
	Subtotal	9,806,250	78,450,000	88,256,250
01F	PL 91-646 Assistance			
01F20	By NFS		11,634,000	11,634,000
01FX	Contingencies (25%)		2,908,500	2,908,500
	Subtotal		14,542,500	14,542,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		319,792,815	319,792,815
01R2B	PL91-646 Relocation Payment by NFS		54,292,000	54,292,000
01R2D	Review of NFS	2,908,500		2,908,500
01RX	Contingencies (25%)	727,125	93,521,204	94,248,329
	Subtotal	3,635,625	467,606,019	471,241,644
	Totals	**13,441,875**	**560,598,519**	**574,040,394**
	Rounded			**574,040,394**

Table 3.3.11.25-8.
Chart of Accounts - LOD3 Jackson County Ring Levee, Combined Washington Avenue and Moss Point Alternate Alignment - Option H

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	8,132,500		8,132,500
01B20	Acquisition by NFS		65,060,000	65,060,000
01BX	Contingencies (25%)	2,033,125	16,265,000	18,298,125
	Subtotal	10,165,625	81,325,000	91,490,625
01F	PL 91-646 Assistance			
01F20	By NFS		11,964,000	11,964,000
01FX	Contingencies (25%)		2,991,000	2,991,000
	Subtotal		14,955,000	14,955,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		323,813,873	323,813,873
01R2B	PL91-646 Relocation Payment by NFS		55,832,000	55,832,000
01R2D	Review of NFS	2,991,000		2,991,000
01RX	Contingencies (25%)	747,750	94,911,468	95,659,218
	Subtotal	3,738,750	474,557,341	478,296,091
	Totals	**13,904,375**	**570,837,341**	**584,741,716**
	Rounded			**584,742,000**

3.4 Line of Defense 4 - Inland Barrier and Surge Gates

To preserve the shoreline environment as much as possible, a 4th line of defense for very large storms is envisioned that would be inland from the coast. This line of defense would be the highest line and could contain a larger storm surge up to that associated with a "Maximum Possible Intensity" (MPI) hurricane. Storms that will be modeled against this line will vary from a Camille type storm up to the MPI. This alignment would follow the same path as the railway that crosses the state near the coast but not cross either the Pearl River in Hancock County to the west or the Pascagoula River in Jackson County to the east. In Harrison County, this pathway is through heavily populated and commercial zones. The first major watershed divide west of the Pascagoula River was selected to turn the barrier north and extend it to a location beyond the extent of the storm surge associated with a MPI event. Similarly to the west in Hancock County, LOD-4 follows the railway to a watershed divide that is located east of the Pearl River where it follows the divide north to the MPI line. Both of these northward extensions will cross the path of Interstate 10 and may dictate some modifications to the highway depending on the selected top elevation of the line.

In order to protect much of the developed areas around Biloxi and St. Louis Bays, LOD-4 would have to include a structural surge barrier that would also cross the mouth of these bays. These surge barriers, when closed, would prevent storm surge from moving in through the inlets of the bays. The structural barriers across the bays could be similar to designs used in Europe for storm surge protection.

LOD-4 could also be designed to have roadways, even major highways on top if desired. This line would be the highest defense, but would not protect structures seaward from the larger storms that might overtop Line 3. All facilities seaward of Line 4 would be prone to flooding in a large storm, so flood-proofing would be necessary in this zone. As described prior, this barrier would extend from high ground east of the Pearl River to high ground west of the Pascagoula River for a distance of approximately 57 miles. It would not cross either of these river systems.

3.4.1 Hancock County Inland Barrier

Several high density residential and business areas are located in Hancock County. These are subject to damage from storm surges associated with hurricanes. Earthen levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88 and 40 ft NAVD88. The top width was assumed 15 ft with side-slopes of 1 vertical to 3 horizontal. These alternatives are Identified as Option A, Option B and Option C. Storm surge gates across St Louis Bay are also included to prevent flooding from hurricanes.

Hancock County is located on the west side of the Mississippi coast of Mississippi Sound as shown in Figure 3.4.1-1. The main residential and business areas are at Bay St Louis and Waveland. Ground elevations over the areas behind the levee vary between elevations 10-20 ft NAVD88 at low areas to as low as 5 ft NAVD88 in the Shoreline Park area. The area drains to the south along the coast to Mississippi Sound, to the north and east to St Louis Bay, and on the far west to Pearl River. The location of the levee in Hancock County is parallel to the CSX Railroad and the coast and turns northward across I-10 to tie into the corresponding elevation.



Figure 3.4.1-1. Vicinity Map Hancock County, MS

3.4.1.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike across the high ground of the county along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal. The levee is located mostly along high ground so ponding at the levee would be minimal. However, some ditching for drainage would be required on the outside of the levee.

3.4.1.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.1.3 Option C - Elevation 40.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 40.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.1.4 Project Description

Figures 3.4.1.4-1 through 3.4.1.4-3 show the location of the proposed project alternatives. As described above, the inland barrier will be an earthen levee constructed either at elevation 20.0 feet, 30.0 or 40.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figures 3.4.1.4-4 through 3.4.1.4-6 show the proposed locations of the pump/culvert sites. During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

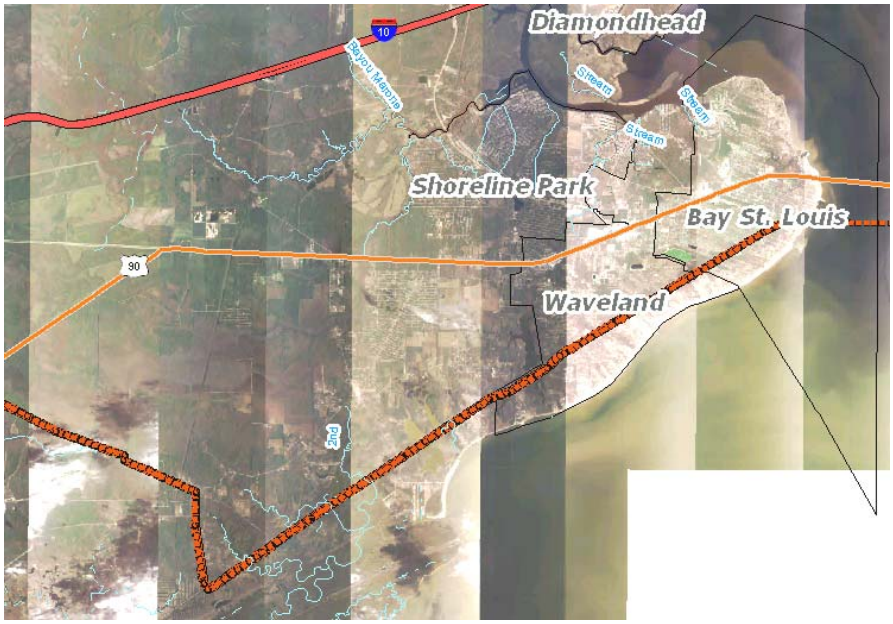


Figure 3.4.1.4-1. Hancock County Inland Barrier

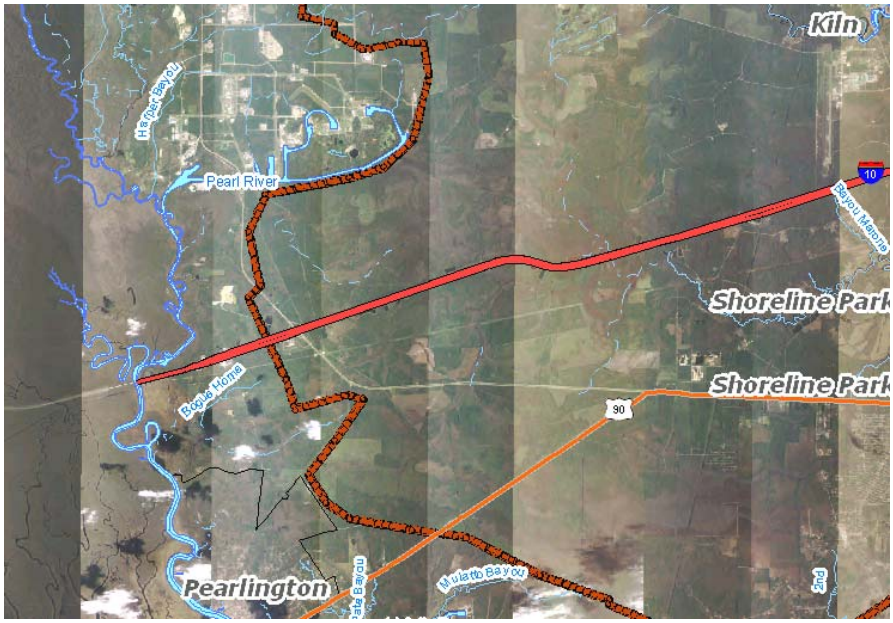


Figure 3.4.1.4-2. Hancock County Inland Barrier

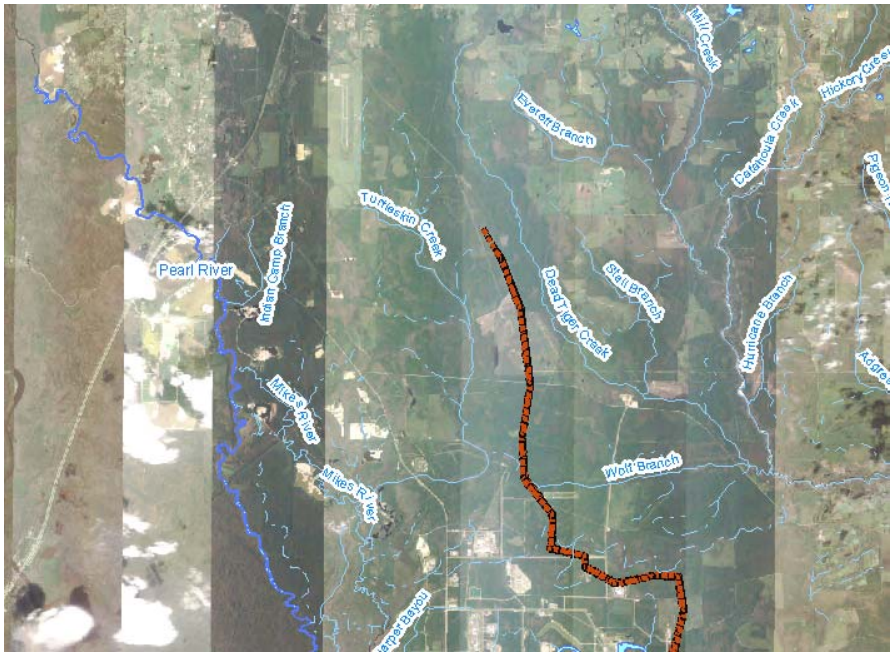


Figure 3.4.1.4-3. Hancock County Inland Barrier



Figure 3.4.1.4-4. Pump/Culvert/Sub-basins/Boat Access Site Locations

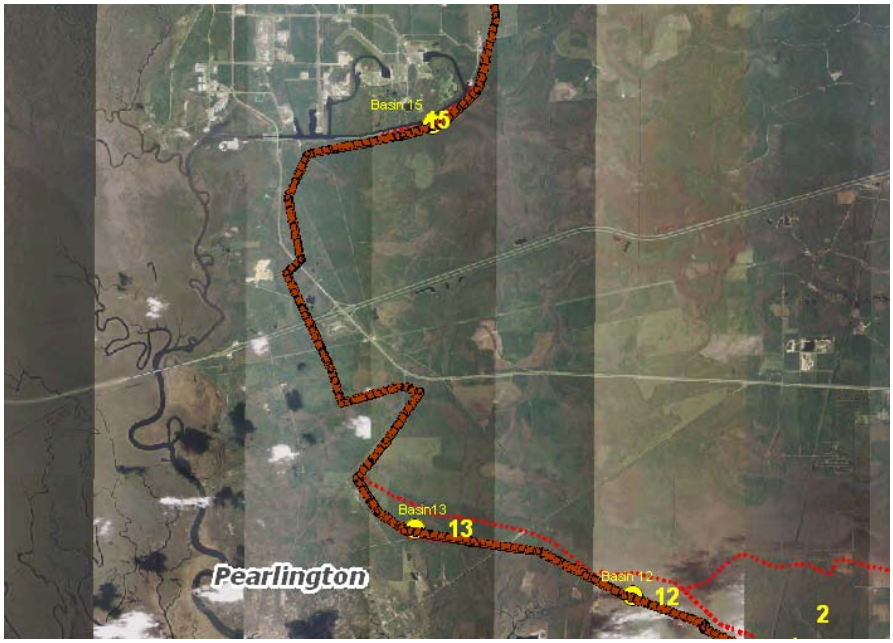


Figure 3.4.1.4-5. Pump/Culvert/Sub-basin Site Locations

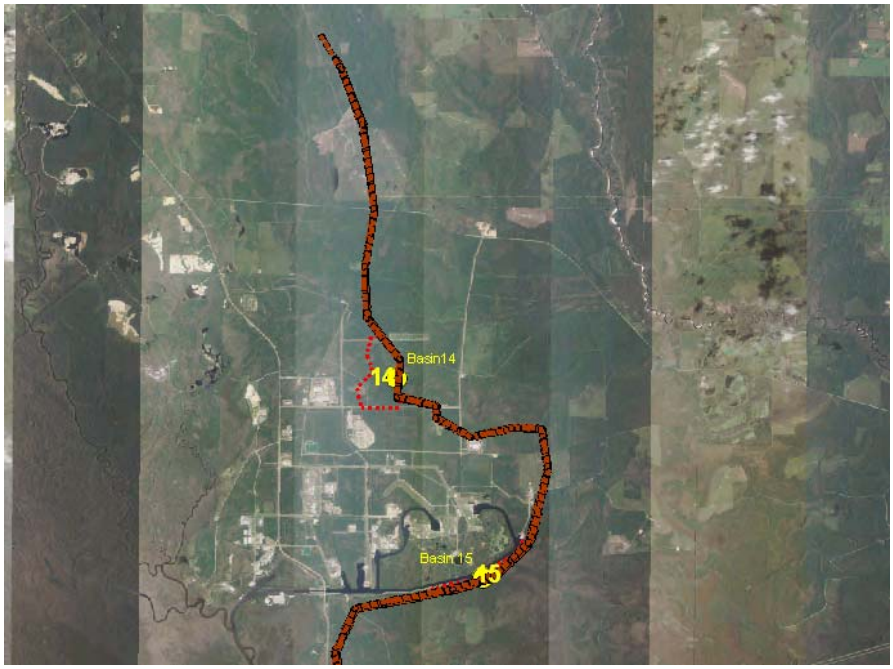


Figure 3.4.1.4-6. Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For Options A, B, and C, drainage features would be required at 16 locations ranging from 20-inch diameter reinforced concrete pipe to reinforced concrete box culverts having 11 water passages, each measuring 12' wide by 4' high. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee. With the installation of a ring levee at Option A, elevation 20.0, 14 roadway/railroad intersections would have to be accommodated. For this study it was estimated that 4 roller gate structures and 6 swing gate structures would be required. In addition, 4 railroad gate structures would be required. At Option B, elevation 30.0, 31 roadway/railroad intersections would have to be accommodated, and it was estimated that 9 roller gate structures and 18 swing gate structures would be required. In addition, 4 railroad gate structures would be required. At Option C, elevation 40.0, 40 roadway/railroad intersections would have to be accommodated, and it was estimated that all 36 of the highway crossings would require swing gates. In addition, 4 railroad gate structures would be required.

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the

embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.1.5 Real Estate Requirements

Real Estate requirements for Line of Defense 4, Hancock County Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and 3 pump station facilities.

Based on the footprint of the Option A, 20.0 foot elevation, it was determined that approximately 426 parcels and 160 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 3 pump stations will require approximately 0.23 of an acre each for a total of 0.69 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 160 relocations.

Based on the footprint of the Option B, 30.0 foot elevation, it was determined that 484 parcels and 186 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 3 pump stations will require approximately 0.23 of an acre each for a total of 0.69 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 186 relocations.

Based on the footprint of the Option C, 40.0 foot elevation, it was determined that 537 parcels and 209 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 3 pump stations will require approximately 0.23 of an acre each for a total of 0.69 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 209 relocations.

Any modifications to the roadways and utilities will most probably need to be accomplished thorough a relocation contract. This will be further investigated and confirmed during PED.

Footprints for drainage ditches are not available at time of this report. However, from the figures it appears that acquisition of additional lands for drainage ditches outside the footprint of the levee will be minimal. Until final plans and specifications are completed, land requirements for drainage ditches are assumed to be covered by contingency. This additional requirement will be determined during PED.

In some areas the levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. To allow continued free boat access to areas behind the levee these water courses will be fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay St. Louis. A small boat access structure is shown at the mouth of multiple basins in the project footprint. Rising sector gates will be provided at these gates allowing shallow draft traffic most of the time. The gates will be closed prior to hurricane storm surge. No additional real estate interest is identified for boat access points as they fall within the footprint of the project and impacted parcels are included in the total that is projected. For those lands required for construction that lay below the mean high water mark, navigation servitude will apply.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with

the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.4.1.6 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.4.1.7 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.4.1.8 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.4.1.9 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the

non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.4.1.10 Government Owned Property

There are 18-25 Government owned parcels within the footprint of the project that will be impacted depending on the option recommended for construction. In viewing the footprint, it is noted that the levee will run through the middle of many of these parcels. However, others may have only minimal impact. These lands are in the vicinity of the John C. Stennis Space Center, or within lands shown as NASA Restricted Area on a state map. Land and structure values are not listed in the public records. Ownership is listed in public records as USA or United States of America. Specific impacts to Government owned lands will be determined during PED.

3.4.1.11 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.4.1.12 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.4.1.13 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.4.1.14 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 160 relocations in Option A, approximately 186 relocations in Option B, and approximately 209 relocations in Option C. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.4.1.15 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area

to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.4.1.16 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.4.1.17 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used for construction of any drainage ditches outside the footprint of the levee as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement

hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.4.1.18 Real Estate Estimate

A summary of the cost for each option is at Table 3.4.1.18-1. The real estate estimates at Tables 3.4.1.18-2 through 3.4.1.18-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.4.1.18-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	426	160	66,177,000
Option B - 30.0	484	186	74,262,000
Option C - 40.0	537	209	81,107,000

Table 3.4.1.18-2.
LOD4 Hancock County Inland Barrier - Option A 20.0 Estimate

a. Lands and Improvements/Permits				
423 Ownerships for Levee, 160 Improvements				37,633,020
3 Pump Stations				43,699
426 Ownerships			Subtotal	37,676,719
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 160 relocations				4,480,000
e. Administrative Cost				10,785,000
	Relocation	Acquisition	Total	
Federal	240,000	1,065,000	1,305,000	
Non-Federal	960,000	8,520,000	9,480,000	
	1,200,000	9,585,000	10,785,000	
Sub-Total				52,941,719
Contingencies (25%)				13,235,430
	Totals			**66,177,149**
	Rounded			**66,177,000**

Table 3.4.1.18-3.
LOD4 Hancock County Inland Barrier - Option B 30.0 Estimate

a. Lands and Improvements/Permits					
481 Ownerships for Levee, 186 Improvements					41,884,250
3 Pump Stations					43,699
484 Ownerships				Subtotal	41,927,949
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 186 relocations					5,196,800
e. Administrative Cost					12,285,000
	Relocation	Acquisition	Total		
Federal	279,000	1,210,000	1,489,000		
Non-Federal	1,116,000	9,680,000	10,796,000		
	1,395,000	10,890,000	12,285,000		
Sub-Total					59,409,749
Contingencies (25%)					14,852,437
	Totals				**74,262,186**
	Rounded				**74,262,000**

Table 3.4.1.18-4.
LOD4 Hancock County Inland Barrier - Option C 40.0 Estimate

a. Lands and Improvements/Permits				
534 Ownerships for Levee, 209 Improvements				45,345,335
3 Pump Stations				43,699
537 Ownerships			Subtotal	45,389,034
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 209 relocations				5,846,400
e. Administrative Cost				13,650,000
	Relocation	Acquisition	Total	
Federal	313,500	1,342,500	1,656,000	
Non-Federal	1,254,000	10,740,000	11,994,000	
	1,567,500	12,082,500	13,650,000	
Sub-Total				64,885,434
Contingencies (25%)				16,221,359
	Totals			**81,106,793**
	Rounded			**81,107,000**

3.4.1.19 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L 91-646. There are a number of factors pertaining to relocations that can impact the project both

in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

Costs for easements for drainage ditches are not included in this report as the requirement was identified late in the study, and a footprint for the drainage ditches is not provided At this time it is believed that the cost will be minor and that it will have minimal impacts to the overall project costs. A determination of additional land requirements for drainage ditches will be made during PED.

3.4.1.20 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.4.1.20-1 through 3.4.1.20-3 shows the CWBS for real estate activities.

Table 3.4.1.20-1.
Chart of Accounts - LOD4 Hancock County Inland Barrier - Option A 20.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,065,000		1,065,000
01B20	Acquisition by NFS		8,520,000	8,520,000
01BX	Contingencies (25%)	266,250	2,130,000	2,396,250
	Subtotal	1,331,250	10,650,000	11,981,250
01F	PL 91-646 Assistance			
01F20	By NFS		960,000	960,000
01FX	Contingencies (25%)		240,000	240,000
	Subtotal		1,200,000	1,200,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		37,676,719	37,676,719
01R2B	PL91-646 Relocation Payment by NFS		4,480,000	4,480,000
01R2D	Review of NFS	240,000		240,000
01RX	Contingencies (25%)	60,000	10,539,180	10,599,180
	Subtotal	300,000	52,695,899	52,995,899
	Totals	**1,631,250**	**64,545,899**	**66,177,149**
	Rounded			**66,177,000**

Table 3.4.1.20-2.
Chart of Accounts - LOD4 Hancock County Inland Barrier - Option B 30.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,210,000		1,210,000
01B20	Acquisition by NFS		9,680,000	9,680,000
01BX	Contingencies (25%)	302,500	2,420,000	2,722,500
	Subtotal	1,512,500	12,100,000	13,612,500
01F	PL 91-646 Assistance			
01F20	By NFS		1,116,000	1,116,000
01FX	Contingencies (25%)		279,000	279,000
	Subtotal		1,395,000	1,395,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		41,927,949	41,927,949
01R2B	PL91-646 Relocation Payment by NFS		5,196,800	5,196,800
01R2D	Review of NFS	279,000		279,000
01RX	Contingencies (25%)	69,750	11,781,187	11,850,937
	Subtotal	348,750	58,905,936	59,254,686
	Totals	**1,861,250**	**72,400,936**	**74,262,186**
	Rounded			**74,262,000**

Table 3.4.1.20-3.
Chart of Accounts - LOD4 Hancock County Inland Barrier - Option C 40.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,342,500		1,342,500
01B20	Acquisition by NFS		10,740,000	10,740,000
01BX	Contingencies (25%)	335,625	2,685,000	3,020,625
	Subtotal	1,678,125	13,425,000	15,103,125
01F	PL 91-646 Assistance			
01F20	By NFS		1,254,000	1,254,000
01FX	Contingencies (25%)		313,500	313,500
	Subtotal		1,567,500	1,567,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		45,389,034	45,389,034
01R2B	PL91-646 Relocation Payment by NFS		5,846,400	5,846,400
01R2D	Review of NFS	313,500		313,500
01RX	Contingencies (25%)	78,375	12,808,859	12,887,234
	Subtotal	391,875	64,044,293	64,436,168
	Totals	**2,070,000**	**79,036,793**	**81,106,793**
	Rounded			**81,107,000**

3.4.2 St. Louis Bay Surge Barrier

In order to protect the properties surrounding Saint Louis Bay and along the lower portions of the various rivers and streams flowing into the bay, a barrier would be required at some point to block storm waters during major storm events. A search of other similar facilities constructed world wide revealed that the structure model best satisfying both the engineering and socio-ecological necessities of this site was that used for the Thames River Barrier in London, UK. The structure tentatively investigated for incorporation into this work was patterned after the Thames River Barrier with certain minor modifications to adapt to the site and environment specific conditions.

A photograph of the Thames River Gates is at Figure 3.4.2-1. The St. Louis Bay watershed covers approximately 654 square miles and is comprised of six sub-basins that stretch across the Mississippi counties of Harrison, Hancock, Stone and Pearl River.



Figure 3.4.2-1. Thames River Gates, London, UK

In the event of an imminent hurricane, the gates St Louis Bay would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates. The tentative location of the barrier chosen for this study is shown below in Figure 3.4.2-2. The alternatives for this proposed measure are identified as Option A, Option B and Option C.

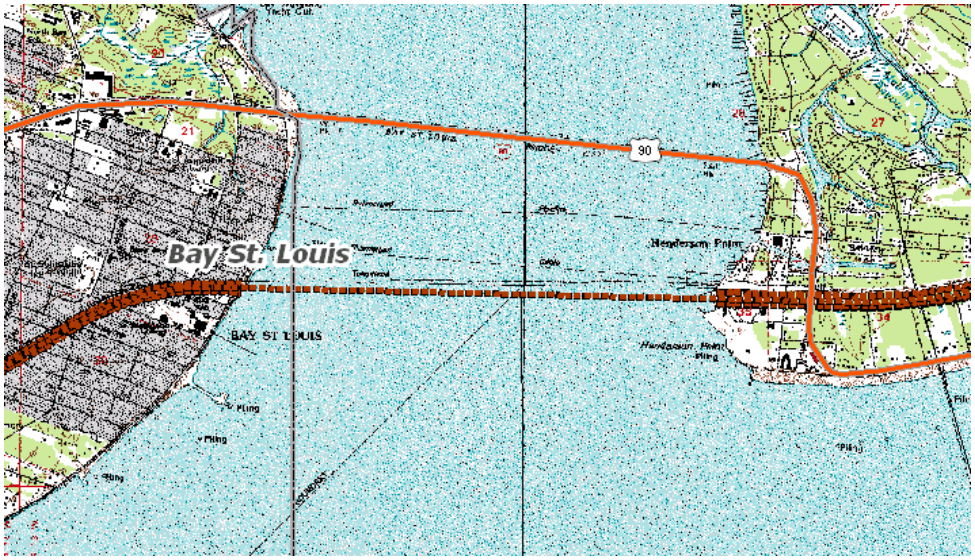


Figure 3.4.2-2. St Louis Bay Surge Barrier Location

3.4.2.1 Option A - Elevation 20.0 ft NAVD88

Option A is the design and construction of a rising sector gate in the St. Louis Bay creating a barrier to elevation 20.0.

3.4.2.2 Option B - Elevation 30.0 ft NAVD88

Option B is the design and construction of a rising sector gate in the St. Louis Bay creating a barrier to elevation 30.0.

3.4.2.3 Option C - Elevation 40.0 ft NAVD88

Option C is the design and construction of a rising sector gate in the St. Louis Bay creating a barrier to elevation 40.0.

3.4.2.4 Project Description

The alignment for the barrier structure would run parallel with and south of the Railroad Bridge crossing Saint Louis Bay. This would approximate the shortest route across the inlet leading form the Mississippi Sound into the bay. As the layout of the barrier was developed it became apparent that, because of the excavation required, a significant amount of separation would be required between the railroad bridge and the ultimate location of the structures included in the barrier. For this study the centerline of the barrier was positioned approximately 260 feet from the center of the railroad bridge. This was left unaltered for all protection levels. The entire barrier would be approximately 10,320 feet in length from water's edge to water's edge, and would consist of rock fill levees extending from the overland levee at each bank for some distance into the bay and enveloping the mass concrete non-overflow wall sections leading to each end of the gated structure.

The points at which the barrier would come ashore in Harrison County on the east and Hancock County on the west, are in urban areas with extensive residential and commercial development. Several structures would need to be relocated and it is uncertain the extent to which existing utilities might have to be relocated to clear the way for this facility.

Structurally, the Barrier as configured for this study would consist of a series of 38 large stainless steel clad, structural steel framed gates called rising sector gates. Each of these would be supported on reinforced concrete piers resting on large continuous concrete sills with pile foundations. The tentative layout used to estimate the scope of the structure was configured having gates 132 feet long mounted on 28-foot wide piers. The number of gates was determined by the extent of water having depth sufficient to support their operation. To facilitate as nearly as possible the normal ebb and flow of tide waters through the barrier, the concrete connector wall and rock fill portions of the barrier either side of the gated structure would be fitted with a series of closely spaced low level gated culverts. The gate and pier heights were varied to accommodate the "level of protection" under consideration. The three elevations selected for this study were 20, 30, and 40 NAVD88. In each instance the gate heights were set to match the protection level elevations with pier heights set approximately 3 feet higher to provide minor wave clearance for protection of operating equipment. Atop each pier an operating machinery block would be mounted to house the operating equipment. Operating and utility access would be provided through two continuous tunnels passing through the sill section and the rock fill, to operating facilities located on each bank.

In order to assure proper functioning of the facilities once they are placed in service a program of Operations and Maintenance would be developed by the U.S. Army Corps of Engineers, in conjunction and cooperation with the affected state and local entities. This O & M Plan would address specific responsibilities as to daily operation of the facilities, the periodic testing and

maintenance of the operating machinery, maintenance of specified stocks of replacement parts, security of the facilities, and maintenance of any buildings and grounds associated with the operation and maintenance of the facilities. As presently envisioned, this O & M responsibility would remain under control of the U.S. Army Corps of Engineers and would be administered under its Operations mission.

3.4.2.5 Real Estate Requirements

Real Estate requirements for Line of Defense 4, St. Louis Bay Surge Barrier include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct, rock levees and an elevated gate barrier in St. Louis Bay with operating facilities located on each landward bank of the barrier. The rock levees on either side of the gates will tie into the LOD4 inland barrier. There will be 2 operating facilities, one located in Hancock County and the other in Harrison County. Each site will be comprised of approximately 5 acres and these will be acquired in fee. The real estate cost estimate will be the same for each option as they all have the same requirements.

For those lands required for construction that lay below the mean high water mark, navigation servitude will apply. Navigation servitude is the dominant right of the Government under the Commerce Clause of the U.S. Constitution (U.S. CONST. Art.I,§8,cl.3) to use, control and regulate the navigable waters of the United States and the submerged lands hereunder for various commerce-related purposes including navigation and flood control. In tidal areas, the servitude extends to all lands below the, mean high water mark. In non-tidal areas, the servitude extends to all lands within the bed and banks of a navigable stream that lie below the ordinary high water mark. The determination of the availability of the navigation servitude should be made on a case by case basis and consists of a two -step process. First the government must determine whether the project serves a purpose that has a nexus to navigation. Purposes recognized by the courts to have the nexus include navigation, flood control and hydroelectric power. If determined that such a nexus exists, then the second step is to determine whether the land at issue is located below the mean or ordinary high water mark of a navigable watercourse. As a general rule, the Government does not acquire interests in real property that it already possesses or over which its use or control is or can be legally exercised. Therefore, if the navigation servitude is found to be available as a result of application of the process described in subparagraph b of this paragraph, then the Government will generally exercise its rights hereunder and, to the extent of such rights, will not acquire a real property interest in the land to which the navigation servitude applies. Generally, it is the policy of the U.S. Army Corps of Engineers (USACE) to utilize the navigation servitude in all situations where available, for cost shared and full Federal projects. The determination of availability will be made during PED.

3.4.2.6 Utility/Facility Relocation

It is probable that there will be some utility/facility relocations for this plan. Specific requirements are unknown at this time but will be defined during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.4.2.7 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.4.2.8 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.4.2.9 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.4.2.10 Government Owned Property

There are no known Government owned lands within the proposed project.

3.4.2.11 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.4.2.12 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.4.2.13 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.4.2.14 Public Law 91-646, Relocation Assistance Benefits

No relocations are expected with this alternative.

3.4.2.15 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.4.2.16 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.4.2.17 Estates for Proposed Project

All lands required for the operating facilities will either be acquired in Fee Simple or are available under navigation servitude.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.4.2.18 Real Estate Estimate

The real estate estimate at Table 3.4.2.18-1 includes the land cost for acquisition of land, permits, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a temporary work area. The requirement, if any, for a temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.4.2.18-1.
LOD4 St. Louis Bay Surge Barrier - Option A, B or C Estimate

a. Lands and Improvements/Permits				
4 Ownerships, 0 Improvements			Hancock	316,663
4 Ownerships, 0 Improvements			Harrison	391,310
			Subtotal	707,973
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 0 relocations				0
e. Administrative Cost				180,000
	Relocation	Acquisition	Total	
Federal	0	20,000	20,000	
Non-federal	0	160,000	160,000	
	0	180,000	180,000	
Sub-Total				887,973
Contingencies (25%)				221,993
	Totals			**1,109,966**
	Rounded			**1,110,000**

3.4.2.19 Summary of Potential Real Estate Issues

It is expected that navigation servitude will be exercised to construct the surge barrier in St. Louis Bay. This determination will be made during PED

It is probable that there will be some utility/facility relocations for this plan. Specific requirements are unknown at this time but will be defined during PED.

The requirement for temporary work areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements.

Should temporary work areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with temporary work areas and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

3.4.2.20 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.4.2.20-1 shows the CWBS for real estate activities.

Table 3.4.2.20-1.
Chart of Accounts - LOD4 St. Louis Bay Surge Barrier - Option A, B or C

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	20,000		20,000
01B20	Acquisition by NFS		160,000	160,000
01BX	Contingencies (25%)	5,000	40,000	45,000
	Subtotal	25,000	200,000	225,000
01F	PL 91-646 Assistance			
01F20	By NFS		0	0
01FX	Contingencies (25%)		0	0
	Subtotal		0	0
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		707,973	707,973
01R2B	PL91-646 Relocation Payment by NFS		0	0
01R2D	Review of NFS	0		0
01RX	Contingencies (25%)	0	176,993	176,993
	Subtotal	0	884,966	884,966
	Totals	**25,000**	**1,084,966**	**1,109,966**
	Rounded			**1,110,000**

3.4.3 Harrison County Inland Barrier

Harrison County is located along the coast of Mississippi Sound with Hancock County to the west and Jackson County to the east. In Harrison County, ground elevations over most of the residential and business areas vary between elevation 8-12 ft NAVD88 on the coast and rising within 1000 ft to elevation 30-36 along a ridge parallel to the coast line, then decreasing to the north.

Residential and business areas along the coast in Harrison County are susceptible to damage from storm surges associated with hurricanes. Earthen levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88 and 40 ft NAVD88. The top width was assumed 15 ft with side-slopes of 1 vertical to 3 horizontal. The location of the proposed inland barrier in Harrison County is shown in Figure 3.4.3-1 extending from Biloxi Bay to Pass Christian approximately 1000 - 3000 feet north of, and parallel to, the shoreline. This alignment is evaluated in Options A through E. For Options F through J, an alternate alignment is evaluated.

This alternate alignment extends from Biloxi Bay to Menge Avenue, thence northward along Menge Avenue to high ground.

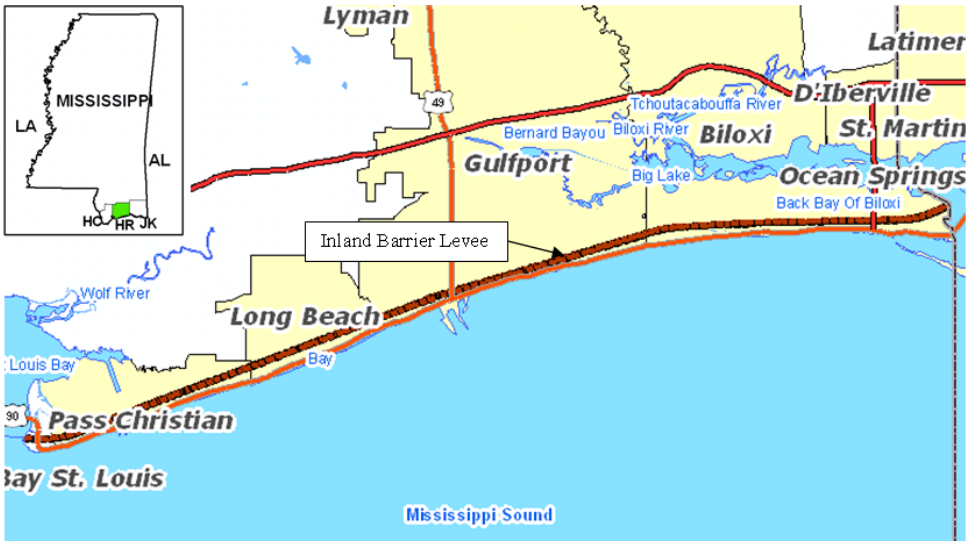


Figure 3.4.3-1. Vicinity Map Harrison County, MS

3.4.3.1 Option A - Elevation 20.0 ft NAVD88

This option consists of constructing a levee to elevation 20 ft NAVD88 along the coast of Harrison County along with the internal sub-basins and levee culvert/pump locations. These sites will be ditched along the levee to drain to St. Louis Bay and Biloxi Bay.

3.4.3.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.3.3 Option C - Elevation 40.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 40.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.3.4 Option D - Levee for Roadway, Elevation 20.0 ft NAVD88

The alignment of the levee is the same as Option A, above. The difference between this option and Option A is that the width of the top of the levee in Harrison County is 75 ft for Option D and 15 ft for Option A. This added width will allow Highway 90 to be relocated along the top of the levee.

3.4.3.5 Option E - Levee for Roadway, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as option A, above. The difference between this option and Option A is that the width of the top of the levee in Harrison County is 75 ft for Option A. In addition, the height of the levee is at 30 ft NAVD88 for Option E and 20 ft NAVD88 for Option A. This added width will allow Highway 90 to be relocated along the top of the levee.

3.4.3.6 Option F - Menge Avenue Alternate Route, Elevation 20.0 ft NAVD88

The alignment of the levee is the same as Option A on the east side of Harrison County but extends to the north along Menge Avenue instead of continuing westward.

3.4.3.7 Option G - Menge Avenue Alternate Route, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option F. The primary difference between this option and Option F is the height of the levee. Option F levee height is elevation 20 ft NAVD88 and Option G levee height is elevation 30 ft NAVD88.

3.4.3.8 Option H - Menge Avenue Alternate Route, Elevation 40.0 ft NAVD88

The alignment of the levee is the same as Option F. The primary difference between this option and Option F is the height of the levee. Option F levee height is elevation 20ft NAVD88 and Option H levee height is elevation 40 ft NAVD88.

3.4.3.9 Option I - Levee for Roadway with Menge Avenue Alternate, Route Elevation 20.0 ft NAVD88

The alignment of the levee is the same as Option F. The primary difference between this option and Option F is the top width of the east-west leg of the levee (Biloxi Bay to Menge Avenue). The east-west leg of Option F barrier top width is 15 ft and the east-west leg of Option I barrier top width is 75 ft. This will allow Highway 90 to be relocated along the top of the levee.

3.4.3.10 Option J - Levee for Roadway with Menge Avenue Alternate, Route Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option F. The primary difference between this option and Option F is the top width of the east-west leg of the levee (Biloxi Bay to Menge Avenue). The east-west leg of Option F barrier top width is 15ft and the east-west leg of Option J barrier top width is 75 ft. This will allow Highway 90 to be relocated along the top of the levee. In addition, the height of this Option J is at elevation 30 ft NAVD88.

3.4.3.11 Project Description

The location of the proposed project is shown above in Figure 3.4.3-1. As described, the levee will be an earthen levee constructed either at elevation 20.0 feet, 30.0 or 40.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figures 3.4.3.11-1 through 3.4.3.11-3 show the

proposed locations of the pump/culvert sites for Options A through E. Figures 3.4.3.11-4 through 3.4.3.11-6 show the Menge Avenue alternate route. During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas. In order to prevent hurricane surges from circumventing the levee, surge barrier gates would be constructed across both Biloxi Bay and St. Louis Bay. In the event of an imminent hurricane, the gates across the Back Bay of Biloxi and St. Louis Bay would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates.

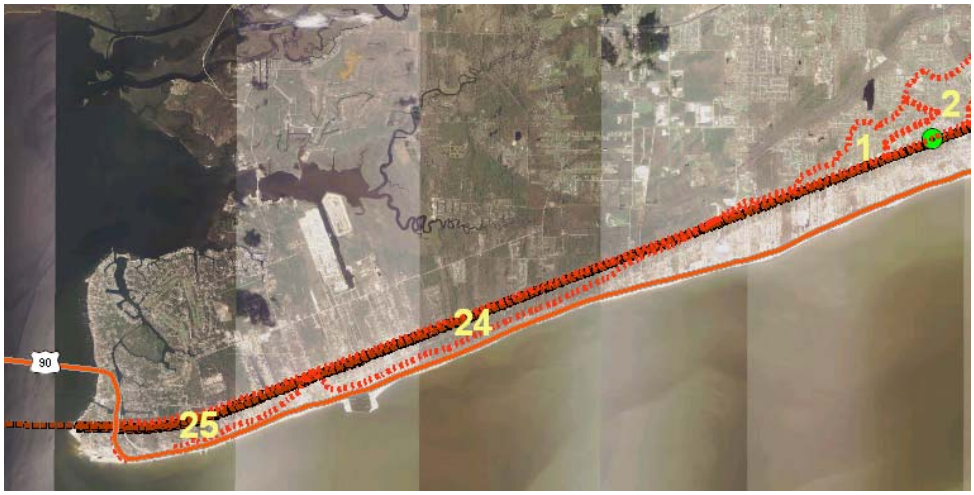


Figure 3.4.3.11-1. Pump/Culvert/Sub-basin Site Locations, Options A-E



Figure 3.4.3.11-2. Pump/Culvert/Sub-basin Site Locations, Options A-E

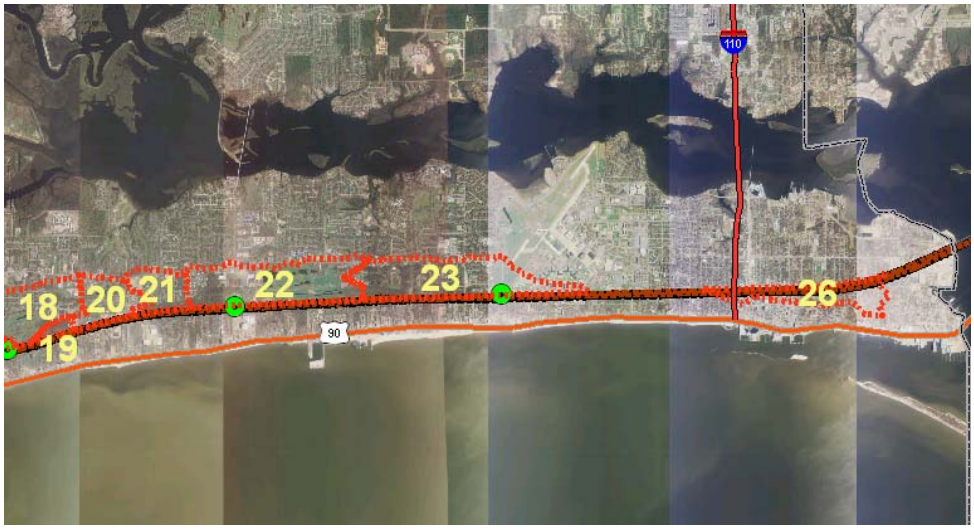


Figure 3.4.3.11-3. Pump/Culvert/Sub-basin Site Locations, Options A-E

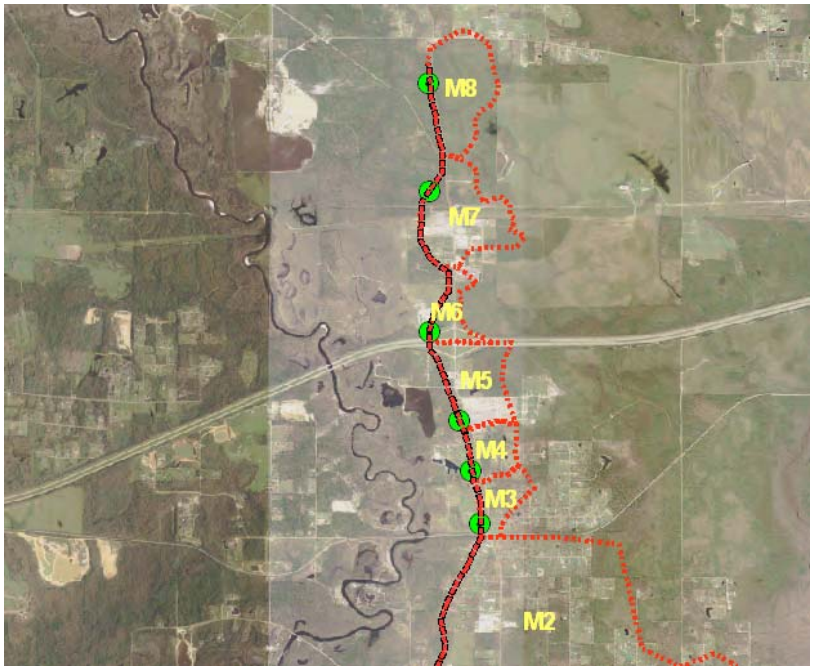


Figure 3.4.3.11-4. Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations, Options F-J

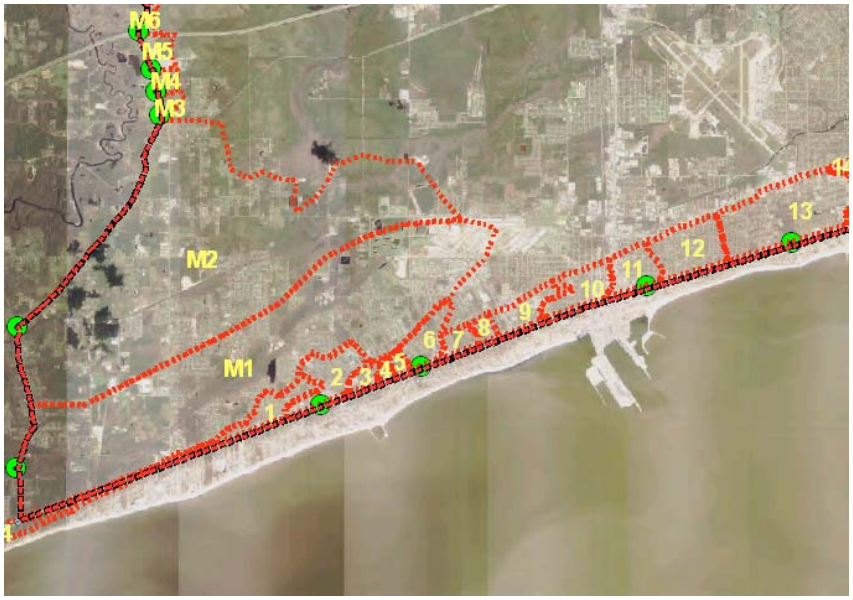


Figure 3.4.3.11-5. Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations, Options F-J

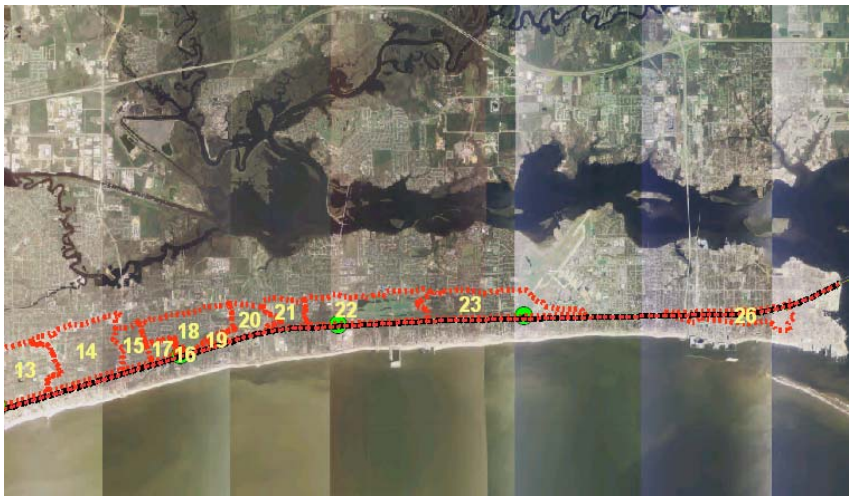


Figure 3.4.3.11-6. Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations, Options F-J

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be

armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. Pump facilities would be required at 7 - 14 locations varying with the option.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

Table 3.4.3.11-1 summarizes the number of roadway/railway intersections impacted by the various options. The number of roller gate, swing gate and railroad gate structures are listed for each option.

Table 3.4.3.11-1.
Levee and Roadway/Railway Intersections

Option	Roadway/Railway Intersections	Roller Gates	Swing Gates	Railroad Gates
Option A	45	18	27	
Option B	30	158	78	2
Option C	161	1	158	2
Option D	42	18	48	
Option E	140	82	112	2
Option F	21	17	4	
Option G	125	86	37	2
Option H	157	3	152	2
Option I	20	16	4	
Option J	123	86	35	2

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.3.12 Real Estate Requirements

Real Estate requirements for Line of Defense 4, Harrison County Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches, and culvert/pump station facilities.

Based on the footprint of the Option A, 20.0 foot elevation, it was determined that approximately 1512 parcels and 756 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 756 relocations.

Based on the footprint of the Option B, 30.0 foot elevation, it was determined that 1688 parcels and 835 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 835 relocations.

Based on the footprint of the Option C, 40.0 foot elevation, it was determined that 1927 parcels and 938 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.161 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 938 relocations.

Based on the footprint of the Option D, 20.0 foot elevation, it was determined that 568 parcels and 174 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 174 relocations.

Based on the footprint of the Option E, 30.0 foot elevation, it was determined that 1916 parcels and 1172 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 1172 relocations.

Based on the footprint of the Option F, 20.0 foot elevation, it was determined that 76 parcels and 38 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction of the levee will be acquired in fee simple interest. Footprints of the drainage ditches for this option appear to be within the footprint of the lands being acquired for the levee. Based on the number of structures being impacted, the assumption is that there will be 38 relocations.

Based on the footprint of the Option G 30.0 foot elevation, it was determined that 189 parcels and 104 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction of the levee will be acquired in fee simple interest. Footprints of the drainage ditches for this option appear to be within the footprint of the lands being acquired for the levee. Based on the number of structures being impacted, the assumption is that there will be 38 relocations.

Based on the footprint of the Option H 40.0 foot elevation, it was determined that 209 parcels and 101 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 14 pump stations will require approximately 0.23 of an acre each for a total of 3.22 acres. Lands required for construction of the levee will be acquired in fee simple interest. Footprints of the drainage ditches for this option appear to be within the footprint of the lands being acquired for the levee. Based on the number of structures being impacted, the assumption is that there will be 101 relocations.

Based on the footprint of the Option I 20.0 foot elevation, it was determined that 225 parcels and 122 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction of the levee will be acquired in fee simple interest. Footprints of the drainage ditches for this option appear to be within the footprint of the lands being acquired for the levee. Based on the number of structures being impacted, the assumption is that there will be 122 relocations.

Based on the footprint of the Option J 30.0 foot elevation, it was determined that 171 parcels and 92 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction of the levee will be acquired in fee simple interest. Footprints of the drainage ditches for this option appear to be within the footprint of the lands being acquired for the levee. Based on the number of structures being impacted, the assumption is that there will be 92 relocations.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands

will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

Table 3.4.3.12-1 below summarizes the real estate requirements for the various alternatives.

Table 3.4.3.12-1.
Real Estate Requirements - LOD4 Harrison County

Option	Impacted Parcels	Impacted Structures	# Pump Stations/AC	Relocations
Option A	1,512	756	7 1.16 AC	756
Option B	1,688	835	7 1.16 AC	835
Option C	1,927	938	7 1.16 AC	938
Option D	568	174	7 1.16 AC	174
Option E	1,916	1,172	7 1.16 AC	1,172
Option F	76	38	9 2.07 AC	38
Option G	189	104	9 2.07 AC	104
Option H	209	101	14 3.22 AC	101
Option I	225	122	14 3.22 AC	122
Option J	171	92	9 2.07 AC	92

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.4.3.13 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities and Highway 90. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.4.3.14 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.4.3.15 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.4.3.16 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.4.3.17 Government Owned Property

There are 1-5 Government owned parcels within the footprint of the project that will be impacted depending on the option recommended for construction. In viewing the footprint, it is noted that the parcels will be impacted where they abut Highway 90. The parcels may be impacted by approximately 20-30%. Land and structure values are not listed in the public records. Ownership is listed in public records as US Govt, US Veterans Hospital and United States of America. Specific impacts to Government owned lands will be determined during PED.

3.4.3.18 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.4.3.19 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.4.3.20 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.4.3.21 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

Table 3.4.3.21-1 shows the number of expected relocations for each Option. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

Table 3.4.3.21-1.
PL 91-646 - Relocation Assistance

Option	Number of Relocations
Option A	756
Option B	835
Option C	938
Option D	174
Option E	1,172
Option F	38
Option G	104
Option H	101
Option I	122
Option J	92

3.4.3.22 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many

of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.4.3.23 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.4.3.24 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and for drainage ditches constructed outside the footprint of the levee, fee or the Drainage Ditch Easement will be used as appropriate. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.4.3.25 Real Estate Estimate

A summary of the cost for each option is at Table 3.4.3.25-1. The real estate cost estimates at Tables 3.4.3.25-2 through 3.4.3.25-11 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.4.3.25-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	1,512	756	253,268,000
Option B - 30.0	1,688	835	271,797,000
Option C - 40.0	1,927	938	300,446,000
Option D - 20.0	568	174	58,266,000
Option E - 30.0	1,916	1172	298,748,000
Option F - 20.0	76	38	8,917,000
Option G - 30.0	189	104	20,801,000
Option H - 40.0	209	101	28,271,000
Option I - 20.0	225	122	23,938,000
Option J - 30.0	171	92	25,351,000

Table 3.4.3.25-2.
LOD4 Harrison County Inland Barrier - Option A 20.0 Estimate

a. Lands and Improvements/Permits				
1,350 Ownerships for Levee, 722 Improvements				131,791,462
155 Ownerships for Ditches, 34 Improvements				9,827,564
7 Pump Stations				126,002
1,512 Ownerships			Subtotal	141,745,028
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 756 relocations				21,179,200
e. Administrative Cost				39,690,000
	Relocation	Acquisition	Total	
Federal	1,134,000	3,780,000	4,914,000	
Non- Federal	4,536,000	30,240,000	34,776,000	
	5,670,000	34,020,000	39,690,000	
Sub-Total				202,614,228
Contingencies (25%)				50,653,557
	Totals			**253,267,785**
	Rounded			**253,268,000**

Table 3.4.3.25-3.
LOD4 Harrison County Inland Barrier - Option B 30.0 Estimate

a. Lands and Improvements/Permits				
1,526 Ownerships for Levee, 801 Improvements				139,799,904
155 Ownerships for Ditches, 34 Improvements				9,827,564
7 Pump Stations				126,002
1,688 Ownerships			Subtotal	149,753,470
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 835 relocations				23,441,600
e. Administrative Cost				44,242,500
	Relocation	Acquisition	Total	
Federal	1,252,500	4,220,000	5,472,500	
Non- Federal	5,010,000	33,760,000	38,770,000	
	6,262,500	37,980,000	44,242,500	
Sub-Total				217,437,570
Contingencies (25%)				54,359,393
	Totals			**271,796,963**
	Rounded			**271,797,000**

Table 3.4.3.25-4.
LOD4 Harrison County Inland Barrier - Option C 40.0 Estimate

a. Lands and Improvements/Permits				
1,765 Ownerships for Levee, 904 Improvements				153,724,698
155 Ownerships for Ditches, 34 Improvements				9,827,564
7 Pump Stations				126,002
1,927 Ownerships			subtotal	163,678,264
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 938 relocations				26,286,400
e. Administrative Cost				50,392,500
	Relocation	Acquisition	Total	
Federal	1,407,000	4,817,500	6,224,500	
Non- Federal	5,628,000	38,540,000	44,168,000	
	7,035,000	43,357,500	50,392,500	
Sub-Total				240,357,164
Contingencies (25%)				60,089,291
	Totals			**300,446,455**
	Rounded			**300,446,000**

Table 3.4.3.25-5.
Option D - Levee for Roadway - Elevation 20.0 Estimate

a. Lands and Improvements/Permits					
406 Ownerships for Levee, 140 Improvements					18,486,170
155 Ownerships for Ditches, 34 Improvements					9,827,564
7 Pump Stations					126,002
568 Ownerships				Subtotal	28,439,736
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 174 relocations					4,088,000
e. Administrative Cost					14,085,000
	Relocation	Acquisition	Total		
Federal	261,000	1,420,000	1,681,000		
Non- Federal	1,044,000	11,360,000	12,404,000		
	1,305,000	12,780,000	14,085,000		
Sub-Total					46,612,736
Contingencies (25%)					11,653,184
	Totals				**58,265,920**
	Rounded				**58,266,000**

Table 3.4.3.25-6.
Option E - Levee for Roadway - Elevation 30.0 Estimate

a. Lands and Improvements/Permits				
1,754 Ownerships for Levee, 1,138 Improvements				150,701,678
155 Ownerships for Ditches, 34 Improvements				9,827,564
7 Pump Stations				126,002
1,916 Ownerships			Subtotal	160,655,244
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 1,172 relocations				26,443,200
e. Administrative Cost				51,900,000
	Relocation	Acquisition	Total	
Federal	1,758,000	4,790,000	6,548,000	
Non- Federal	7,032,000	38,320,000	45,352,000	
	8,790,000	43,110,000	51,900,000	
Sub-Total				238,998,444
Contingencies (25%)				59,749,611
	Totals			**298,748,055**
	Rounded			**298,748,000**

Table 3.4.3.25-7.
Option F - Menge Avenue Alternate Route - Elevation 20.0 Estimate

a. Lands and Improvements/Permits				
67 Ownerships for Levee, 38 Improvements				4,125,356
9 Pump Stations				162,002
76 Ownerships			Subtotal	4,287,358
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 38 relocations				851,200
e. Administrative Cost				1,995,000
	Relocation	Acquisition	Total	
Federal	57,000	190,000	247,000	
Non- Federal	228,000	1,520,000	1,748,000	
	285,000	1,710,000	1,995,000	
Sub-Total				7,133,558
Contingencies (25%)				1,783,390
	Totals			**8,916,948**
	Rounded			**8,917,000**

Table 3.4.3.25-8.
Option G - Menge Avenue Alternate Route - Elevation 30.0 Estimate

a. Lands and Improvements/Permits				
180 Ownerships for Levee, 104 Improvements				9,116,968
9 Pump Stations				162,002
189 Ownerships			Subtotal	9,278,970
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 104 relocations				2,329,600
e. Administrative Cost				5,032,500
	Relocation	Acquisition	Total	
Federal	156,000	472,500	628,500	
Non- Federal	624,000	3,780,000	4,404,000	
	780,000	4,252,500	5,032,500	
Sub-Total				16,641,070
Contingencies (25%)				4,160,268
	Totals			**20,801,338**
	Rounded			**20,801,000**

Table 3.4.3.25-9.
Option H - Menge Avenue Alternate Route - Elevation 40.0 Estimate

a. Lands and Improvements/Permits				
195 Ownerships for Levee, 101 Improvements				14,642,288
14 Pump Stations				252,004
209 Ownerships			Subtotal	14,894,292
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 101 relocations				2,262,400
e. Administrative Cost				5,460,000
	Relocation	Acquisition	Total	
Federal	151,500	522,500	674,000	
Non- Federal	606,000	4,180,000	4,786,000	
	757,500	4,702,500	5,460,000	
Sub-Total				22,616,692
Contingencies (25%)				5,654,173
	Totals			**28,270,865**
	Rounded			**28,271,000**

Table 3.4.3.25-10.
Option I - Levee for Roadway with Menge Avenue Alternate - Route Elevation 20.0 Estimate

a. Lands and Improvements/Permits				
216 Ownerships for Levee, 122 Improvements				10,277,860
9 Pump Stations				162,002
225 Ownerships			Subtotal	10,439,862
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 122 relocations				2,732,800
e. Administrative Cost				5,977,500
	Relocation	Acquisition	Total	
Federal	183,000	562,500	745,500	
Non- Federal	732,000	4,500,000	5,232,000	
	915,000	5,062,500	5,977,500	
Sub-Total				19,150,162
Contingencies (25%)				4,787,541
	Totals			**23,937,703**
	Rounded			**23,938,000**

Table 3.4.3.25-11.
Option J - Levee for Roadway with Menge Avenue Alternate - Route Elevation 30.0 Estimate

a. Lands and Improvements/Permits				
162 Ownerships for Levee, 92 Improvements				13,520,366
9 Pump Stations				162,002
171 Ownerships			Subtotal	13,682,368
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 92 relocations				2,060,800
e. Administrative Cost				4,537,500
	Relocation	Acquisition	Total	
Federal	138,000	427,500	565,500	
Non- Federal	552,000	3,420,000	3,972,000	
	690,000	3,847,500	4,537,500	
Sub-Total				20,280,668
Contingencies (25%)				5,070,167
	Totals			**25,350,835**
	Rounded			**25,351,000**

3.4.3.26 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both

in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.4.3.27 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.4.3.27-1 through 3.4.3.27-10 shows the CWBS for real estate activities.

Table 3.4.3.27-1.
Chart of Accounts - LOD4 Harrison County Inland Barrier - Option A 20.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	3,780,000		3,780,000
01B20	Acquisition by NFS		30,240,000	30,240,000
01BX	Contingencies (25%)	945,000	7,560,000	8,505,000
	Subtotal	4,725,000	37,800,000	42,525,000
01F	PL 91-646 Assistance			
01F20	By NFS		4,536,000	4,536,000
01FX	Contingencies (25%)		1,134,000	1,134,000
	Subtotal		5,670,000	5,670,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		141,745,028	141,745,028
01R2B	PL91-646 Relocation Payment by NFS		21,179,200	21,179,200
01R2D	Review of NFS	1,134,000		1,134,000
01RX	Contingencies (25%)	283,500	40,731,057	41,014,557
	Subtotal	1,417,500	203,655,285	205,072,785
	Totals	**6,142,500**	**247,125,285**	**253,267,785**
	Rounded			**253,268,000**

Table 3.4.3.27-2.
Chart of Accounts - LOD4 Harrison County Inland Barrier - Option B 30.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	4,220,000		4,220,000
01B20	Acquisition by NFS		33,760,000	33,760,000
01BX	Contingencies (25%)	1,055,000	8,440,000	9,495,000
	Subtotal	5,275,000	42,200,000	47,475,000
01F	PL 91-646 Assistance			
01F20	By NFS		5,010,000	5,010,000
01FX	Contingencies (25%)		1,252,500	1,252,500
	Subtotal		6,262,500	6,262,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		149,753,470	149,753,470
01R2B	PL91-646 Relocation Payment by NFS		23,441,600	23,441,600
01R2D	Review of NFS	1,252,500		1,252,500
01RX	Contingencies (25%)	313,125	43,298,768	43,611,893
	Subtotal	1,565,625	216,493,838	218,059,463
	Totals	**6,840,625**	**264,956,338**	**271,796,963**
	Rounded			**271,797,000**

Table 3.4.3.27-3.
Chart of Accounts - LOD4 Harrison County Inland Barrier - Option C 40.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	4,817,500		4,817,500
01B20	Acquisition by NFS		38,540,000	38,540,000
01BX	Contingencies (25%)	1,204,375	9,635,000	10,839,375
	Subtotal	6,021,875	48,175,000	54,196,875
01F	PL 91-646 Assistance			
01F20	By NFS		5,628,000	5,628,000
01FX	Contingencies (25%)		1,407,000	1,407,000
	Subtotal		7,035,000	7,035,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		163,678,264	163,678,264
01R2B	PL91-646 Relocation Payment by NFS		26,286,400	26,286,400
01R2D	Review of NFS	1,407,000		1,407,000
01RX	Contingencies (25%)	351,750	47,491,166	47,842,916
	Subtotal	1,758,750	237,455,830	239,214,580
	Totals	**7,780,625**	**292,665,830**	**300,446,455**
	Rounded			**300,446,000**

Table 3.4.3.27-4.
Chart of Accounts - LOD 4 Harrison County Inland Barrier Option D 20.0 - Levee for Roadway

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	1,420,000		1,420,000
01B20	Acquisition by NFS		11,360,000	11,360,000
01BX	Contingencies (25%)	355,000	2,840,000	3,195,000
	Subtotal	1,775,000	14,200,000	15,975,000
01F	PL 91-646 Assistance			
01F20	By NFS		1,044,000	1,044,000
01FX	Contingencies (25%)		261,000	261,000
	Subtotal		1,305,000	1,305,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		28,439,736	28,439,736
01R2B	PL91-646 Relocation Payment by NFS		4,088,000	4,088,000
01R2D	Review of NFS	261,000		261,000
01RX	Contingencies (25%)	65,250	8,131,934	8,197,184
	Subtotal	326,250	40,659,670	40,985,920
	Totals	**2,101,250**	**56,164,670**	**58,265,920**
	Rounded			**58,266,000**

Table 3.4.3.27-5.
Chart of Accounts - LOD 4 Harrison County Inland Barrier Option E 30.0 - Levee for Roadway

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	4,790,000		4,790,000
01B20	Acquisition by NFS		38,320,000	38,320,000
01BX	Contingencies (25%)	1,197,500	9,580,000	10,777,500
	Subtotal	5,987,500	47,900,000	53,887,500
01F	PL 91-646 Assistance			
01F20	By NFS		7,032,000	7,032,000
01FX	Contingencies (25%)		1,758,000	1,758,000
	Subtotal		8,790,000	8,790,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		160,655,244	160,655,244
01R2B	PL91-646 Relocation Payment by NFS		26,443,200	26,443,200
01R2D	Review of NFS	1,758,000		1,758,000
01RX	Contingencies (25%)	439,500	46,774,611	47,214,111
	Subtotal	2,197,500	233,873,055	236,070,555
	Totals	**8,185,000**	**290,563,055**	**298,748,055**
	Rounded			**298,748,000**

Table 3.4.3.27-6.
Chart of Accounts - LOD4 Harrison County Inland Barrier Option F 20.0 - Menge Avenue Alternate Route

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	190,000		190,000
01B20	Acquisition by NFS		1,520,000	1,520,000
01BX	Contingencies (25%)	47,500	380,000	427,500
	Subtotal	237,500	1,900,000	2,137,500
01F	PL 91-646 Assistance			
01F20	By NFS		228,000	228,000
01FX	Contingencies (25%)		57,000	57,000
	Subtotal		285,000	285,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		4,287,358	4,287,358
01R2B	PL91-646 Relocation Payment by NFS		851,200	851,200
01R2D	Review of NFS	57,000		57,000
01RX	Contingencies (25%)	14,250	1,284,640	1,298,890
	Subtotal	71,250	6,423,198	6,494,448
	Totals	**308,750**	**8,608,198**	**8,916,948**
	Rounded			**8,917,000**

Table 3.4.3.27-7.
Chart of Accounts - LOD4 Harrison County Inland Barrier Option G 30.0 - Menge Avenue Alternate Route

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	472,500		472,500
01B20	Acquisition by NFS		3,780,000	3,780,000
01BX	Contingencies (25%)	118,125	945,000	1,063,125
	Subtotal	590,625	4,725,000	5,315,625
01F	PL 91-646 Assistance			
01F20	By NFS		624,000	624,000
01FX	Contingencies (25%)		156,000	156,000
	Subtotal		780,000	780,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		9,278,970	9,278,970
01R2B	PL91-646 Relocation Payment by NFS		2,329,600	2,329,600
01R2D	Review of NFS	156,000		156,000
01RX	Contingencies (25%)	39,000	2,902,143	2,941,143
	Subtotal	195,000	14,510,713	14,705,713
	Totals	**785,625**	**20,015,713**	**20,801,338**
	Rounded			**20,801,000**

Table 3.4.3.27-8.
Chart of Accounts - LOD4 Harrison County Inland Barrier Option H 40.0 - Menge Avenue Alternate Route

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	522,500		522,500
01B20	Acquisition by NFS		4,180,000	4,180,000
01BX	Contingencies (25%)	130,625	1,045,000	1,175,625
	Subtotal	653,125	5,225,000	5,878,125
01F	PL 91-646 Assistance			
01F20	By NFS		606,000	606,000
01FX	Contingencies (25%)		151,500	151,500
	Subtotal		757,500	757,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		14,894,292	14,894,292
01R2B	PL91-646 Relocation Payment by NFS		2,262,400	2,262,400
01R2D	Review of NFS	151,500		151,500
01RX	Contingencies (25%)	37,875	4,289,173	4,327,048
	Subtotal	189,375	21,445,865	21,635,240
	Totals	**842,500**	**27,428,365**	**28,270,865**
	Rounded			**28,271,000**

Table 3.4.3.27-9.
Chart of Accounts - LOD4 Harrison County Inland Barrier Option I 20.0 - Levee for Roadway with Menge Avenue Alternate Route

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	562,500		562,500
01B20	Acquisition by NFS		4,500,000	4,500,000
01BX	Contingencies (25%)	140,625	1,125,000	1,265,625
	Subtotal	703,125	5,625,000	6,328,125
01F	PL 91-646 Assistance			
01F20	By NFS		732,000	732,000
01FX	Contingencies (25%)		183,000	183,000
	Subtotal		915,000	915,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		10,439,862	10,439,862
01R2B	PL91-646 Relocation Payment by NFS		2,732,800	2,732,800
01R2D	Review of NFS	183,000		183,000
01RX	Contingencies (25%)	45,750	3,293,166	3,338,916
	Subtotal	228,750	16,465,828	16,694,578
	Totals	**931,875**	**23,005,828**	**23,937,703**
	Rounded			**23,938,000**

Table 3.4.3.27-10.
Chart of Accounts - LOD4 Harrison County Inland Barrier Option J 30.0 - Levee for Roadway with Menge Avenue Alternate Route

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	427,500		427,500
01B20	Acquisition by NFS		3,420,000	3,420,000
01BX	Contingencies (25%)	106,875	855,000	961,875
	Subtotal	534,375	4,275,000	4,809,375
01F	PL 91-646 Assistance			
01F20	By NFS		552,000	552,000
01FX	Contingencies (25%)		138,000	138,000
	Subtotal		690,000	690,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		13,682,368	13,682,368
01R2B	PL91-646 Relocation Payment by NFS		2,060,800	2,060,800
01R2D	Review of NFS	138,000		138,000
01RX	Contingencies (25%)	34,500	3,935,792	3,970,292
	Subtotal	172,500	19,678,960	19,851,460
	Totals	**706,875**	**24,643,960**	**25,350,835**
	Rounded			**25,351,000**

3.4.4 Back Bay of Biloxi Surge Barrier

In order to protect the properties surrounding Biloxi Bay and along the lower portions of the various rivers and streams flowing into the bay, a barrier would be required at some point to block storm waters during major storm events. A search of other similar facilities constructed world wide revealed that the structure model best satisfying both the engineering and socio-ecological necessities of this site was that used for the Thames River Barrier in London, UK. The structure tentatively investigated for incorporation into this work was patterned after the Thames River Barrier with certain minor modifications to adapt to the site and environment specific conditions. A photograph of the Thames River Gates is at Figure 3.4.4-1. The Biloxi Bay watershed covers approximately 640 square miles and is comprised of six sub-basins that stretch across Harrison, Hancock, Stone and Jackson County, MS.

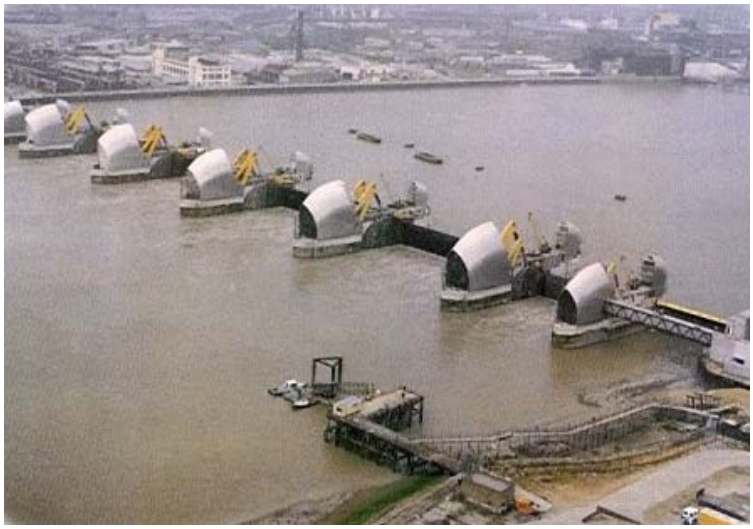


Figure 3.4.4-1. Thames River Gates, London, UK

In the event of an imminent hurricane, the gates across the Back Bay of Biloxi would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates. The tentative location of the barrier chosen for this study is shown below in Figure 3.4.4-2. The alternatives for this proposed measure are identified as Option A, Option B and Option C.

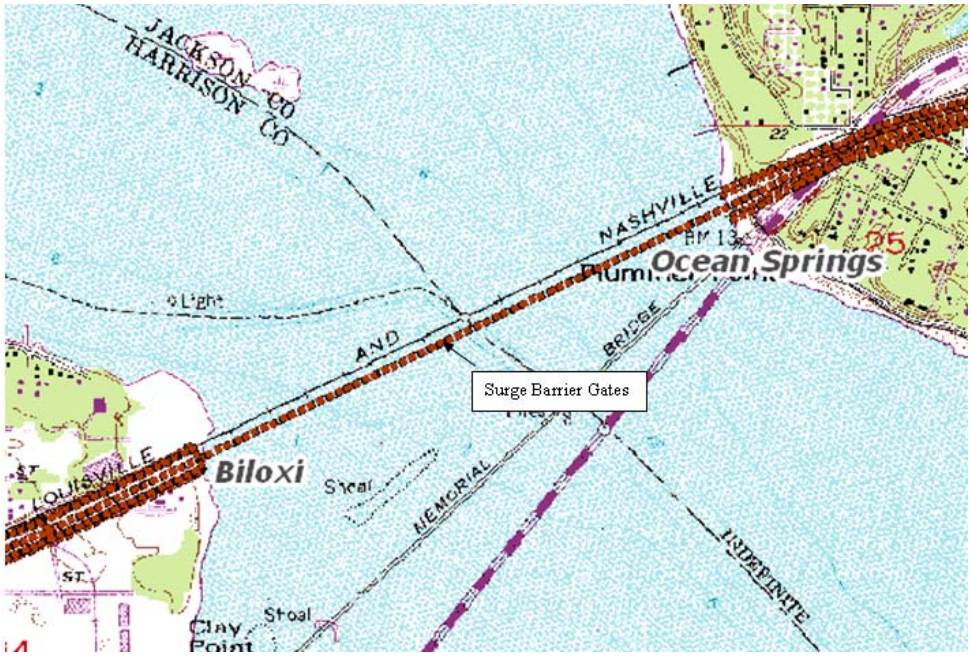


Figure 3.4.4-2. Back Bay of Biloxi Surge Barrier Location

3.4.4.1 Option A - Elevation 20.0 ft NAVD88

Option A is the design and construction of a rising sector gate in the Back Bay of Biloxi creating a barrier to elevation 20.0.

3.4.4.2 Option B - Elevation 30.0 ft NAVD88

Option B is the design and construction of a rising sector gate in the Back Bay of Biloxi creating a barrier to elevation 30.0.

3.4.4.3 Option C - Elevation 40.0 ft NAVD88

Option C is the design and construction of a rising sector gate in the Back Bay of Biloxi creating a barrier to elevation 40.0.

3.4.4.4 Project Description

The alignment suggested herein for the barrier structure would run parallel with and south of the Railroad Bridge crossing Biloxi Bay. This would approximate the shortest route across the inlet leading from the Mississippi Sound into the bay. As the preliminary layout of the barrier was developed it became apparent that, because of the excavation required, a significant amount of separation would be required between the railroad bridge and the ultimate location of the structures included in the barrier. For this study the centerline of the barrier was positioned approximately 260 feet from the center of the railroad bridge. This was left unaltered for all protection levels. The entire barrier would be approximately 6,100 feet in length from water's edge to water's edge, and would consist of rock fill levees extending from the overland levee at each bank for some distance into the bay and enveloping the mass concrete non-overflow wall sections leading to each end of the gated structure.

The points at which the barrier would come ashore in Jackson County on the east and Harrison County on the west, are in urban areas with extensive residential and commercial development. Several structures would need to be relocated and it is uncertain the extent to which existing utilities might have to be relocated to clear the way for this facility.

Structurally, the Barrier as configured for this study would consist of a series of 25 large stainless steel clad, structural steel framed gates called rising sector gates. Each of these would be supported on reinforced concrete piers resting on large continuous concrete sills with pile foundations. The tentative layout used to estimate the scope of the structure was configured having gates 132 feet long mounted on 28-foot wide piers. The number of gates was determined by the extent of water having depth sufficient to support their operation. To facilitate as nearly as possible the normal ebb and flow of tide waters through the barrier, the concrete connector wall and rock fill portions of the barrier either side of the gated structure would be fitted with a series of closely spaced low level gated culverts. The gate and pier heights were varied to accommodate the "level of protection" under consideration. The three elevations selected for this study were 20, 30, and 40 NAVD88. In each instance the gate heights were set to match the protection level elevations with pier heights set approximately 3 feet higher to provide minor wave clearance for protection of operating equipment. Atop each pier an operating machinery block would be mounted to house the operating equipment. Operating and utility access would be provided through two continuous tunnels passing through the sill section and the rock fill, to operating facilities located on each bank.

In order to assure proper functioning of the facilities once they are placed in service a program of Operations and Maintenance would be developed by the U.S. Army Corps of Engineers, in conjunction and cooperation with the affected state and local entities. This O & M Plan would

address specific responsibilities as to daily operation of the facilities, the periodic testing and maintenance of the operating machinery, maintenance of specified stocks of replacement parts, security of the facilities, and maintenance of any buildings and grounds associated with the operation and maintenance of the facilities. As presently envisioned, this O & M responsibility would remain under control of the U.S. Army Corps of Engineers and would be administered under its Operations mission.

3.4.4.5 Real Estate Requirements

Real Estate requirements for Line of Defense 4, Back Bay of Biloxi Surge Barrier include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct, rock levees and an elevated gate barrier in the Back Bay of Biloxi with operating facilities located on each landward bank of the barrier. The rock levees on either side of the gates will tie into the LOD4 inland barrier. There will be 2 operating facilities, one located in Jackson County and the other in Harrison County. Each site will be comprised of approximately 5 acres and these will be acquired in fee. The real estate cost estimate will be the same for each option as they all have the same requirements.

For those lands required for construction that lay below the mean high water mark, navigation servitude will apply. Navigation servitude is the dominant right of the Government under the Commerce Clause of the U.S. Constitution (U.S. CONST. Art.I,§8,cl.3) to use, control and regulate the navigable waters of the United States and the submerged lands hereunder for various commerce-related purposes including navigation and flood control. In tidal areas, the servitude extends to all lands below the, mean high water mark. In non-tidal areas, the servitude extends to all lands within the bed and banks of a navigable stream that lie below the ordinary high water mark. The determination of the availability of the navigation servitude should be made on a case by case basis and consists of a two -step process. First the government must determine whether the project serves a purpose that has a nexus to navigation. Purposes recognized by the courts to have the nexus include navigation, flood control and hydroelectric power. If determined that such a nexus exists, then the second step is to determine whether the land at issue is located below the mean or ordinary high water mark of a navigable watercourse. As a general rule, the Government does not acquire interests in real property that it already possesses or over which its use or control is or can be legally exercised. Therefore, if the navigation servitude is found to be available as a result of application of the process described in subparagraph b of this paragraph, then the Government will generally exercise its rights hereunder and, to the extent of such rights, will not acquire a real property interest in the land to which the navigation servitude applies. Generally, it is the policy of the U.S. Army Corps of Engineers (USACE) to utilize the navigation servitude in all situations where available, for cost shared and full Federal projects. The determination of availability will be made during PED.

3.4.4.6 Utility/Facility Relocation

It is probable that there will be some utility/facility relocations for this plan. Specific requirements are unknown at this time but will be defined during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.4.4.7 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.4.4.8 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.4.4.9 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.4.4.10 Government Owned Property

There are no known Government owned lands within the proposed project.

3.4.4.11 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.4.4.12 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.4.4.13 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.4.4.14 Public Law 91-646, Relocation Assistance Benefits

No relocations are expected with this alternative.

3.4.4.15 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.4.4.16 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.4.4.17 Estates for Proposed Project

All lands required for the operating facilities will be acquired in Fee Simple.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.4.4.18 Real Estate Estimate

The real estate cost estimate at Table 3.4.4.18-1 includes the land cost for acquisition of land, permits, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a temporary work area. The requirement, if any, for a temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.4.4.18-1.
LOD4 Back Bay of Biloxi Surge Barrier - Option A, B or C Estimate

a. Lands and Improvements/Permits				
4 Ownerships, 0 Improvements			Hancock	842,573
4 Ownerships, 0 Improvements			Harrison	391,310
			Subtotal	1,233,883
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 0 relocations				0
e. Administrative Cost				180,000
	Relocation	Acquisition	Total	
Federal	0	20,000	20,000	
Non-Federal	0	160,000	160,000	
	0	180,000	180,000	
Sub-Total				1,413,883
Contingencies (25%)				353,471
	Totals			**1,767,354**
	Rounded			**1,767,000**

3.4.4.19 Summary of Potential Real Estate Issues

It is expected that navigation servitude will be exercised to construct the surge barrier in the Back Bay of Biloxi. This determination will be made during PED.

It is probable that there will be some utility/facility relocations for this plan. Specific requirements are unknown at this time but will be defined during PED.

The requirement for temporary work areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements.

Should temporary work areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with temporary work areas and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

3.4.4.20 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.4.4.20-1 shows the CWBS for real estate activities.

Table 3.4.4.20-1.
Chart of Accounts - LOD4 Back Bay of Biloxi Surge Barrier - Option A, B or C

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	20,000		20,000
01B20	Acquisition by NFS		160,000	160,000
01BX	Contingencies (25%)	5,000	40,000	45,000
	Subtotal	25,000	200,000	225,000
01F	PL 91-646 Assistance			
01F20	By NFS		0	0
01FX	Contingencies (25%)		0	0
	Subtotal		0	0
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		1,233,883	1,233,883
01R2B	PL91-646 Relocation Payment by NFS		0	0
01R2D	Review of NFS	0		0
01RX	Contingencies (25%)	0	308,471	308,471
	Subtotal	0	1,542,354	1,542,354
	Totals	**25,000**	**1,742,354**	**1,767,354**
	Rounded			**1,767,000**

3.4.5 Jackson County Inland Barrier

Residential and business areas along the coast in Jackson County are susceptible to damage from storm surges associated with hurricanes. Earthen levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88 and 40 ft NAVD88. The top width was assumed 15 ft with side-slopes of 1 vertical to 3 horizontal. These alternatives are Identified as Option A, Option B and Option C. The location of the proposed project in Jackson County is shown in Figures 3.4.5-1. The levee will be constructed parallel to the CSX Railroad, Highway 57 and Highway 90.

Jackson County is located on the east side of the Mississippi at the Mississippi Sound coast. The main residential and business area is at Ocean Springs, which is mostly south of the proposed levee. Ground elevations over the areas behind the proposed levee vary between elevations 10-20 ft NAVD88 at low areas to as high as 50 ft NAVD88. The area is drained by Old Fort Bayou.



Figure 3.4.5-1. Vicinity Map Jackson County, MS

3.4.5.1 Option A - Elevation 20.0 ft NAVD88

This option consists of constructing a levee to elevation 20 ft NAVD88 parallel to Highway 90 along with the internal sub-basins and levee culvert/pump locations. The levee will be located mostly along high ground so ponding at the levee would be minimal. Ponding will occur on the outside of the levee which would require ditching to other drainage basins.

3.4.5.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.5.3 Option C - Elevation 40.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 40.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.5.4 Project Description

The location of the proposed levee project is shown in Figures 3.4.5.4-1 through 3.4.5.4-3. As described, the levee will be an earthen berm constructed either at elevation 20.0 feet, 30.0 or 40.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.4.5.4-4 shows the proposed locations of the pump/culvert sites. During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas. In order to prevent hurricane surges from circumventing the levee, surge barrier gates would be constructed across both Biloxi Bay and St. Louis Bay. In the event of an imminent hurricane, barrier gates across the Back Bay of Biloxi would be closed, and flow from the Biloxi and Tchoutacabouffa Rivers, as well as local runoff would pond behind the gates.

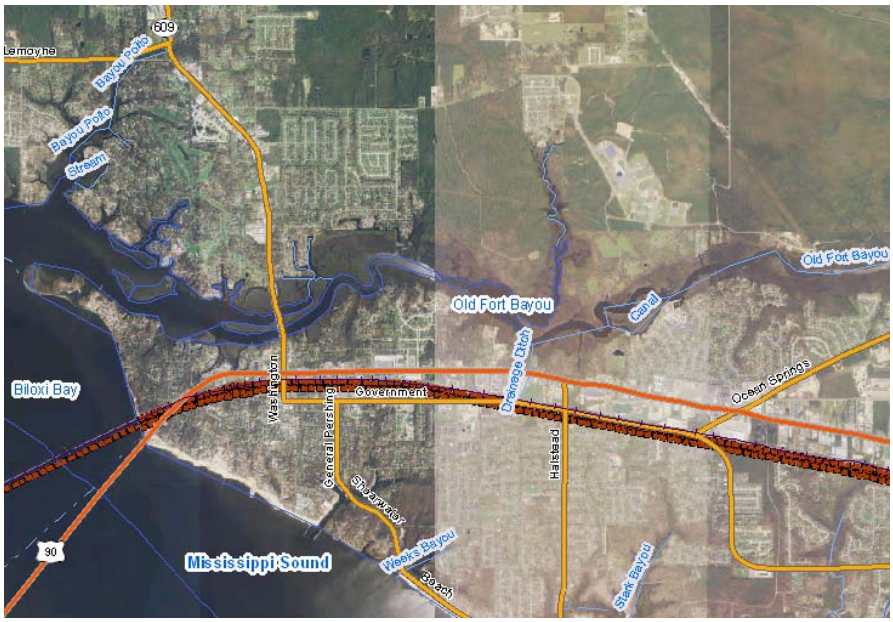


Figure 3.4.5.4-1. Jackson County Inland Barrier

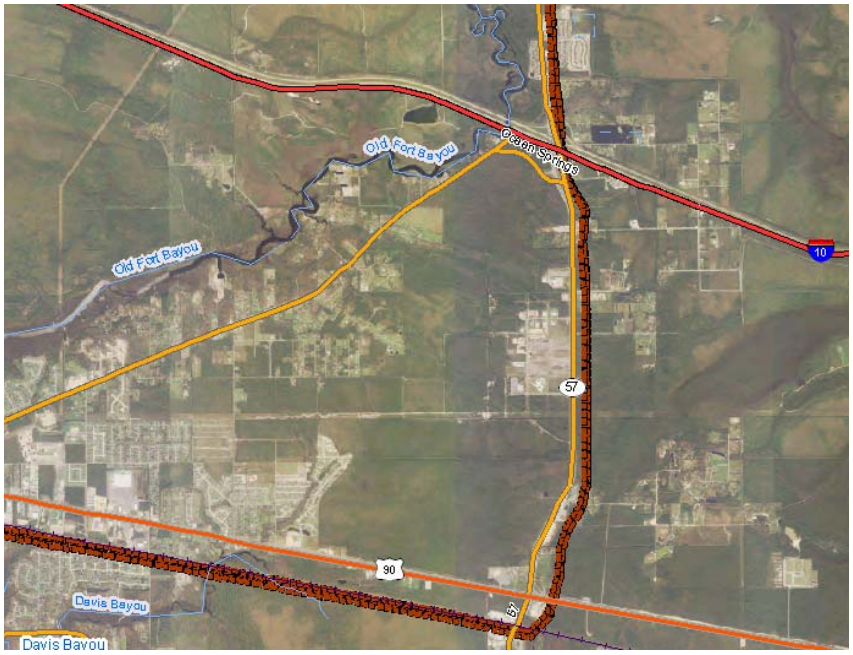


Figure 3.4.5.4-2. Jackson County Inland Barrier



Figure 3.4.5.4-3. Jackson County Inland Barrier

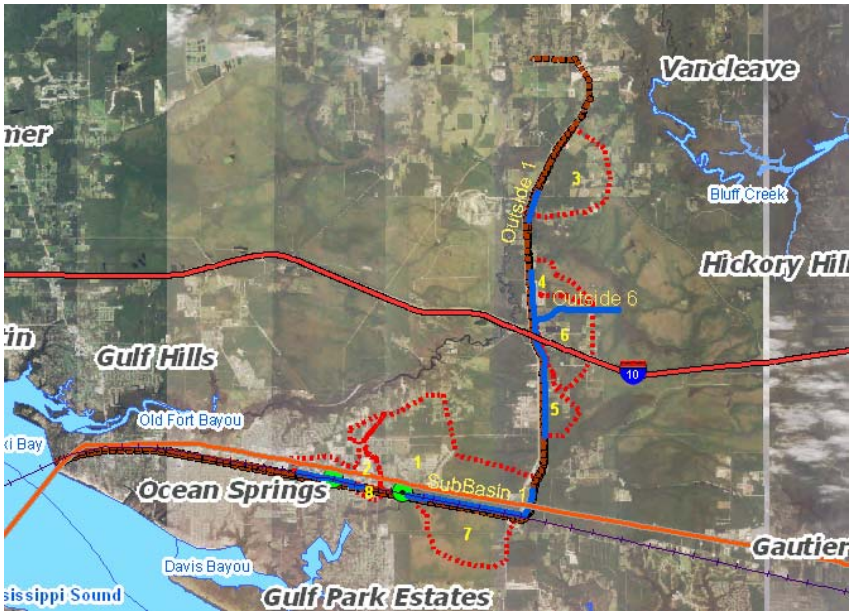


Figure 3.4.5.4-4. Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For Options A, B, and C, drainage features would be required at 2 locations with the culvert requirement ranging from seven 7' wide by 3' high, to eleven 10' wide by 4; high water passages. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used

including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee. Roadway and railway intersections are not applicable to Option A, 20.0 and Option B, 30.0. At Option C, elevation 40.0, 3 roadway intersections would have to be accommodated. It was determined that roller gate structures would suffice for all thee of these locations.

There are two sites in Jackson County that would require special flood protection with the flood protection level set at elevation 40, the court facilities located immediately south of the protection line in downtown Biloxi and similar governmental facilities in downtown Moss Point. The Biloxi facilities would require a three sided Tee Wall structure approximately 1410 feet long originating and terminating in the levee at its northwest and northeast ends. It would be fitted with four face sealing roller gates to close off the required street and driveway access points in time of flood. The Moss Point Tee Wall would be similarly configured and would extend approximately 1552 feet. It would require two roadway closure gates.

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.5.5 Real Estate Requirements

Real Estate requirements for Line of Defense 4, Jackson County Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and 2 pump station facilities.

Based on the footprint of the Option A, 20.0 foot elevation, it was determined that approximately 323 parcels and 171 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 2 pump stations will require approximately 0.23 of an acre each for a total of 0.46 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 171 relocations.

Based on the footprint of the Option B, 30.0 foot elevation, it was determined that 361 parcels and 191 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 2 pump stations will require approximately 0.23 of an acre each for a total of 0.46 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 191 relocations.

Based on the footprint of the Option C, 40.0 foot elevation, it was determined that 404 parcels and 217 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 2 pump stations will require approximately 0.23 of an acre each for a total of 0.46 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 217 relocations.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

Footprints for drainage ditches are not available at time of this report. However, from the figures it appears that acquisition of additional lands for drainage ditches outside the footprint of the levee will be minimal. Until final plans and specifications are completed, land requirements for drainage ditches are assumed to be covered by contingency. This additional requirement will be determined during PED.

During the formulation of the nonstructural (NS) measures and alternative plans, the NS PDT became aware of local efforts by the leadership of Moss Point, MS to relocate several public buildings out of the hurricane surge zone to a higher elevation within the municipal area. A series of meetings with the Mayor of Moss Point and other city officials followed to work toward development of a plan to relocate these facilities that are critical to the safety and continued operations of the local government. As a result of the meetings the NS PDT developed a Pilot Relocations Project for Moss Point, MS. The public buildings included in the pilot project are the city hall, police station, fire station and community recreation center. As these structures are owned and operated by the City of Moss Point and are considered essential to the operation of the city, they would therefore be eligible for facility relocation. The description of the relocations measure, eligible facilities and costs are included in the Nonstructural Appendix at Section 4.3.9.6 Pilot Moss Point Public Buildings Relocations Project. Any substitute facilities relocations will be performed under a Real Estate Relocation Contract. The cost for these relocations is captured in the Nonstructural Appendix but final crediting would be considered as part of the LERRD credit.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.4.5.6 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. As discussed above any municipal buildings designated as essential to the operation of the city could be relocated as substitute facilities relocations See Chapter 2 Section 2.10 for more detailed discussion, and the Nonstructural Appendix at Section 4.3.9.6.

3.4.5.7 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.4.5.8 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix for a full discussion on environmental effects.

3.4.5.9 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.4.5.10 Government Owned Property

There are 7-8 Government owned parcels within the footprint of the project that will be impacted depending on the option recommended for construction. In viewing the footprint, it is noted that the parcels will be impacted where they abut Highway 90 and Highway 57. The parcels may be impacted by approximately 10-30%. Land values are listed in the public records, but no improvement values are listed. Ownership is listed in public records as United States of America and USA Dept of the Navy. Specific impacts to Government owned lands will be determined during PED.

3.4.5.11 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.4.5.12 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.4.5.13 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.4.5.14 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 171 relocations in Option A, approximately 191 relocations in Option B, and approximately 217 relocations in Option C. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.4.5.15 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.4.5.16 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.4.5.17 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used for construction of any drainage ditches outside the footprint of the levee as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.4.5.18 Real Estate Estimate

A summary of the cost for each option is at Table 3.4.5.18-1. The real estate estimates at Tables 3.4.5.18-2 through 3.4.5.18-4 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of

lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.4.5.18-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	323	171	58,506,000
Option B - 30.0	361	191	66,571,000
Option C - 40.0	404	217	76,231,000

Table 3.4.5.18-2.
LOD4 Jackson County Inland Barrier - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
321 Ownerships for Levee, 171 Improvements					33,383,509
2 Pump Stations					77,517
323 Ownerships				Subtotal	33,461,026
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 171 relocations					4,793,600
e. Administrative Cost					8,550,000
		Relocation	Acquisition	Total	
	Federal	256,500	807,500	1,064,000	
	Non-Federal	1,026,000	6,460,000	7,486,000	
		1,282,500	7,267,500	8,550,000	
Subtotal					46,804,626
Contingencies (25%)					11,701,157
		Totals			**58,505,783**
		Rounded			**58,506,000**

Table 3.4.5.18-3.
LOD4 Jackson County Inland Barrier - Option B 30.0 Estimate

a. Lands and Improvements/Permits					
359 Ownerships for Levee, 191 Improvements					38,270,710
2 Pump Stations					77,517
361 ownerships				Subtotal	38,348,227
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 191 relocations					5,353,600
e. Administrative Cost					9,555,000
		Relocation	Acquisition	Total	
	Federal	286,500	902,500	1,189,000	
	Non-Federal	1,146,000	7,220,000	8,366,000	
		1,432,500	8,122,500	9,555,000	
Subtotal					53,256,827
Contingencies (25%)					13,314,207
		Totals			**66,571,034**
		Rounded			**66,571,000**

Table 3.4.5.18-4.
LOD4 Jackson County Inland Barrier - Option C 40.0 Estimate

a. Lands and Improvements/Permits					
402 Ownerships for Levee, 217 Improvements					44,096,883
2 Pump Stations					77,517
404 Ownerships				Subtotal	44,174,400
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 217 relocations					6,092,800
e. Administrative Cost					10,717,500
		Relocation	Acquisition	Total	
	Federal	325,500	1,010,000	1,335,500	
	Non-Federal	1,302,000	8,080,000	9,382,000	
		1,627,500	9,090,000	10,717,500	
Subtotal					60,984,700
Contingencies (25%)					15,246,175
		Totals			**76,230,875**
		Rounded			**76,231,000**

3.4.5.19 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both

in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.4.5.20 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.4.5.20-1 through 3.4.5.20-3 shows the CWBS for real estate activities.

Table 3.4.5.20-1.
Chart of Accounts LOD4 Jackson County Inland Barrier - Option A 20.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	807,500		807,500
01B20	Acquisition by NFS		6,460,000	6,460,000
01BX	Contingencies (25%)	201,875	1,615,000	1,816,875
	Subtotal	1,009,375	8,075,000	9,084,375
01F	PL 91-646 Assistance			
01F20	By NFS		1,026,000	1,026,000
01FX	Contingencies (25%)		256,500	256,500
	Subtotal		1,282,500	1,282,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		33,461,026	33,461,026
01R2B	PL91-646 Relocation Payment by NFS		4,793,600	4,793,600
01R2D	Review of NFS	256,500		256,500
01RX	Contingencies (25%)	64,125	9,563,657	9,627,782
	Subtotal	320,625	47,818,283	48,138,908
	Totals	**1,330,000**	**57,175,783**	**58,505,783**
	Rounded			**58,506,000**

Table 3.4.5.20-2.
Chart of Accounts LOD4 Jackson County Inland Barrier - Option B 30.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	902,500		902,500
01B20	Acquisition by NFS		7,220,000	7,220,000
01BX	Contingencies (25%)	225,625	1,805,000	2,030,625
	Subtotal	1,128,125	9,025,000	10,153,125
01F	PL 91-646 Assistance			
01F20	By NFS		1,146,000	1,146,000
01FX	Contingencies (25%)		286,500	286,500
	Subtotal		1,432,500	1,432,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		38,348,227	38,348,227
01R2B	PL91-646 Relocation Payment by NFS		5,353,600	5,353,600
01R2D	Review of NFS	286,500		286,500
01RX	Contingencies (25%)	71,625	10,925,457	10,997,082
	Subtotal	358,125	54,627,284	54,985,409
	Totals	**1,486,250**	**65,084,784**	**66,571,034**
	Rounded			**66,571,000**

Table 3.4.5.20-3.
Chart of Accounts LOD4 Jackson County Inland Barrier - Option C 40.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,010,000		1,010,000
01B20	Acquisition by NFS		8,080,000	8,080,000
01BX	Contingencies (25%)	252,500	2,020,000	2,272,500
	Subtotal	1,262,500	10,100,000	11,362,500
01F	PL 91-646 Assistance			
01F20	By NFS		1,302,000	1,302,000
01FX	Contingencies (25%)		325,500	325,500
	Subtotal		1,627,500	1,627,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		44,174,400	44,174,400
01R2B	PL91-646 Relocation Payment by NFS		6,092,800	6,092,800
01R2D	Review of NFS	325,500		325,500
01RX	Contingencies (25%)	81,375	12,566,800	12,648,175
	Subtotal	406,875	62,834,000	63,240,875
	Totals	**1,669,375**	**74,561,500**	**76,230,875**
	Rounded			**76,231,000**

3.5 Line of Defense 5 - Retreat and/or Relocation of Critical Facilities

Hurricanes are a naturally occurring phenomena that wreak havoc on natural and man-made environments through three different but related mechanisms: torrential rainfall, high winds, and storm surge. While each of these can produce costly outcomes in their own right, storm surge is typically the most damaging and particularly deadly. It is also the most difficult and costly to provide enduring and confident protection against. However, if one cannot be reached by storm surge by virtue of being on ground at elevation higher than any storm surge might reach, one cannot be directly damaged by it. The limit of storm surge represents the first line of avoidance to hurricane related damages. It therefore makes sense to identify the potential inland limit of storm surge so that prudent choices might be made by any and all regarding their exposure to damage by storm surge.

The primary measures identified for the project area include permanent acquisitions, flood proofing by elevation and other means, relocations of public buildings, flood preparedness and evacuation planning, public education, changes in the current municipal and county NFIP and building codes, implementation of either a transfer of development rights or purchase of development rights program, potential changes in zoning ordinances, development impact fees, and redirection of new development. These measures have been combined into several plans that can be implemented by either agencies of the Federal government or collaboratively by those agencies and state, county and local governmental units. In several cases, only local jurisdictions can implement some of the measures identified.

Computer simulations have predicted how far inland storm surge will extend if the worse-case hurricane or maximum possible intensity (MPI) event hits the Mississippi coast.

This line of defense is shown in Figure 3.5-1. This line represents a line of safety where homes, facilities or transportation routes north of this line should not be directly damaged by storm surge. This would be an area where hospitals, schools, emergency response and management facilities, power stations, water supply facilities, or other critical infrastructure might be located. It would also represent an area whereby future development (commercial, industrial, or residential) might be redirected. The maximum water level along the Mississippi coastline was determined to be approximately 30 ft along the entire western half of the state and east of Pascagoula. The landward extent of the inundation indicates the storm surge reaches Interstate 10 for much of the western portion of the state. Lower peaks near Biloxi and Mobile Bay (24-27 ft) may be attributed to the protection afforded by the barrier islands. The line of defense accordingly approximates the 24 to 30 ft. (NAVD '88 datum) contours.

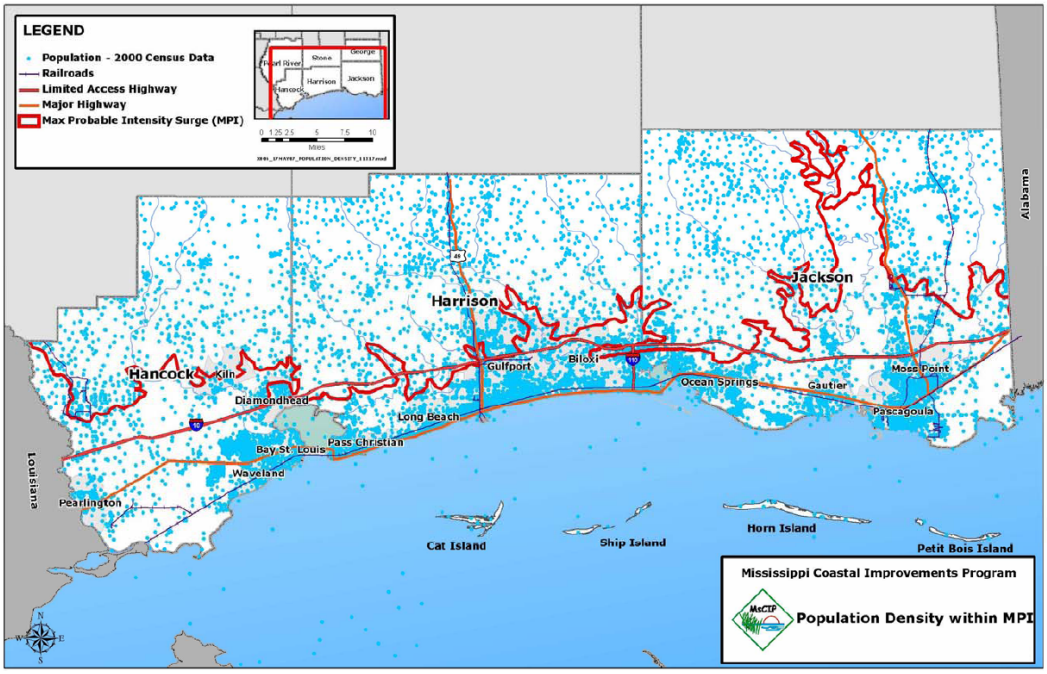


Figure 3.5-1. Maximum Probable Intensity Storm Surge Limits

The area seaward of the line of defense is occupied by natural, rural, suburban, and urban environments and residential, commercial, and industrial development. Approximately 1/3 (visually estimated) of the coastal county areas fall within the estimated surge limits. With the exceptions of seawalls fronting Harrison County, Bay St. Louis, and the city of Pascagoula, there are no hurricane storm damage reduction structures in place. These structures provide little inundation protection over what the natural ground elevation would provide for and do not provide hurricane protection for surge events approaching or exceeding the 1 in 100 annual chance event.

There are no alternative alignments to this line of defense. The line of defense alignment could be changed or modified due to any of the following: (a) revised hydrodynamic modeling results; (b) the

construction of storm damage reduction measures, such as levees and/or storm surge barriers; (c) sea level rise; (d) construction of other infrastructure (e.g. roadway embankments) that might materially obstruct or alter surge flow pathways.

A thorough discussion of non-structural alternative measures is provided in the Non-Structural Measures Plan Formulation Appendix.

No real estate plan has been prepared for this line of defense as specific sites for relocation of facilities have not been identified. A plan will be prepared during PED should this plan be approve for implementation.

CHAPTER 4. NONSTRUCTURAL

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Flood damage reduction measures are divided into two distinct components: structural and nonstructural. Application of nonstructural measures or those measures directly associated with modifying the location, construction or operation of property, structures, and facilities located in hazard areas is one method of reducing storm/hurricane-related damages and saving lives that are at-risk. There are numerous nonstructural methods, but the Real Estate Appendix focuses on permanent evacuation of the hazard areas.

Permanent acquisition of coastal properties is an effective way to reduce flood damages and loss of life due to hurricane surge drowning. Existing properties with or without structures can be purchased under the provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646). Permanent acquisition furthers the objectives of migrating the population northward and away from the coast. This nonstructural measure would be applied to a quilt-like, land use pattern of residential, commercial, and institutional uses as well as both occupied and vacant parcels. The purpose of purchasing vacant parcels is to prevent future building on those parcels. Post-acquisition use of the land could include wetland habitat restoration, recreation or open space uses that would not result in re-establishment of damageable property,

4.1 Hancock County Acquisition

4.1.1 Project Description

High Hazard Zones: The nonstructural project delivery team (PDT) identified several zones within the project area, where due to extreme forces generated by storms and hurricanes, other measures such as elevation of an existing or rebuilt structure would not be prudent and may endanger the future occupants. Within these zones, successful emergency evacuation during a storm event would be highly improbable and dangerous for the responders, elevated structures may be prone to foundation failures due to waves and surge, elevation by placed fill material is prohibited or infeasible, and non-elevated structures would likely suffer total or significant losses. Each of these zones was graphically identified using GIS mapping and FEMA database information. There are three identified zones where permanent acquisition and evacuation of the property is the preferred nonstructural treatment. Those zones are:

The FEMA-identified V/VE Zone displayed on the National Flood Insurance Rate Maps (FIRM) within the project area. This “Velocity” water zone features high-energy wave action that was responsible for much of the building damages during the Katrina event and makes elevating structures or otherwise flood-proofing structures in-place very dangerous.

The FEMA-identified “catastrophic damages zone” which was identified in a “post-Katrina” damage assessment of FEMA insured structures within the project area. This zone included a preponderance of insured structures that had received damages in excess of 50% of the structure’s value. Field observations by the nonstructural PDT confirmed that most of those structures in the zone had been totally destroyed or severely damaged (major structural damages). This area includes the V/VE zone within its boundaries.

A flood damage zone was delineated extending 800 feet back from the beachfront within portions of Jackson County. The aforementioned “catastrophic damage zone” established by FEMA was based upon the Katrina event only and therefore did not account for the area of damages that could be expected along Jackson County should a Katrina-like storm strike at that location. The 800 feet zone approximated the spatial extent of observed total structure loss and severe structural damages

observed within Hancock and Harrison counties located closer to the Katrina landfall. Modifications of this zone's extent from the waterline could be made to account for intervening topography that would limit the impacts of surge and waves.

The preferred nonstructural measure in these three high-hazard zones would be permanent acquisition of the property under the general provisions of the Uniform Act. Relocations assistance would be provided to residential landowners and/or tenants of the property to locate and secure suitable replacement housing. Remaining structures, pavements, foundations and utilities on the acquired parcel would be demolished and removed to approved landfills. The acquired property could be reused for ecosystem restoration (wetlands), recreation or other purposes that would be in keeping with the identified flood hazards, the National Flood Insurance Program (NFIP) and the provisions of the Project Cooperation Agreement (PCA). The acquired property would be transferred to a local project sponsor for future Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R).

A High Hazard Area Risk Reduction Plan (HARP) is currently being considered as a component of the comprehensive plan to address hurricane and storm damage reduction for certain areas within the Advisory Base Flood Elevation (ABFE) zones along the coast defined as high hazard areas. This plan which is supported by the State of Mississippi contemplates acquisitions in identified areas within Hancock, Harrison and Jackson Counties that should be considered for acquisition beginning in FY 2008 to facilitate relocation of homeowners outside the ABFE prior to their rebuilding. The plan under consideration is not specifically reflected in the nonstructural portion of the Real Estate Appendix. However, the HARP is incorporated in the report at Exhibit "C" to the Real Estate Appendix. Should the plan be authorized, significant adjustments will have to be made to the real estate costs for the buy out areas initially identified in the MsCIP report.

Non-Flood-proofing Zones: The nonstructural PDT also identified one additional zone within the project area where the preferred method of flood damage reduction would be permanent acquisition and evacuation of the property. This zone is located where water depths at the individual structure location occurring during the specified inundation event would exceed the maximum height of elevation prescribed by FEMA's 550 Guidelines for structure elevation. Those guidelines indicate that elevating structures more than 15 feet from the ground surface in hurricane areas would place the elevated structure in high-velocity hurricane force winds resulting in significant damages to the building. Any structure that would be required to be elevated more that 15 feet to place the first habitable or sales floor above the specified inundation level would be acquired. Using GIS software, a zone of inundation deeper than 13 feet (plus 2 feet of freeboard equals 15 feet) was identified within the project area where permanent acquisition would be the preferred method of nonstructural protection. The area for which permanent acquisition is recommended in Hancock County is shown in Figure 4.1.1-1. The acquisition area is shaded in dark green.

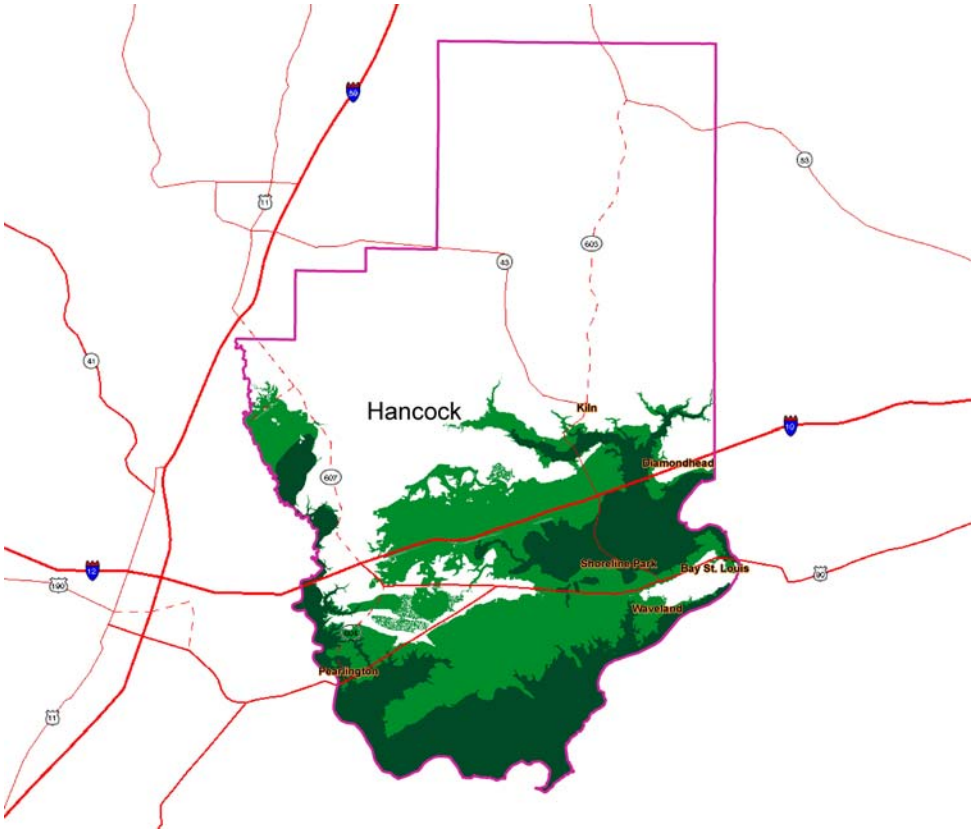


Figure 4.1.1-1. Location of Acquisition Areas in Hancock County (dark green)

4.1.2 Real Estate Requirements

Real Estate requirements for the Nonstructural Acquisition in Hancock County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire in fee simple approximately 17,845 impacted parcels and 10,192 structures. The project is divided into 9 reaches. The reaches are identified below in Table 4.1.2-1. Based on the number of structures being impacted, the assumption is that there will be 10,192 relocations to include residences and businesses. The plan calls to use an “approved landfill” for disposal of the demolished structures. An assumption is made that the excavated material will be disposed of in commercial or county landfills. In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Table 4.1.2-1.
Hancock County Acquisition Reaches

Reach	Impacted Parcels	Impacted Structures
1	997	268
2	9,911	7,133
3	2,202	1,326
4	922	373
5	2,714	447
6	567	540
7	450	79
36	32	2
38	50	24
Total	**17,845**	**10,192**

4.1.3 Utility/Facility Relocation

Specific information about relocation of utilities/facilities is unknown at this time. An assumption is made that if required, this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

4.1.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

4.1.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

4.1.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

4.1.7 Government Owned Property

There are approximately 35 Government owned parcels within the footprint of the project proposed for acquisition in Hancock County. These lands are in the vicinity of the John C. Stennis Space Center, or within lands shown as NASA Restricted Area on a state map. Land and structure values are not listed in the public records. Ownership is listed in public records as USA. Specific impacts to Government owned lands and/or structures will be determined during PED.

4.1.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

4.1.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

4.1.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

4.1.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 10,192 relocations in Hancock County. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. The availability of decent safe and sanitary housing is a potential problem. Large scale construction of new residences will most likely be required. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

4.1.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

4.1.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

4.1.14 Estates for Proposed Project

All lands acquired in the buy-out area will be acquired in Fee Simple. The Temporary Work Area Easement will be used for a disposal site if required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

4.1.15 Real Estate Estimate

The real estate cost estimate at Table 4.1.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a disposal site. The requirement, if any, for a disposal site will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 4.1.15-1.
Hancock County Acquisitions Estimate

a. Lands and Improvements/Permits					
17,845 Ownerships & 10,192 Improvements					2,630,117,775
					0
				Subtotal	2,630,117,775
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 10,192 relocations					285,376,000
e. Administrative Cost					477,952,500
		Relocation	Acquisition	Total	
	Federal	15,288,000	44,612,500	59,900,500	
	Non-Federal	61,152,000	356,900,000	418,052,000	
		76,440,000	401,512,500	477,952,500	
Subtotal					3,393,446,275
Contingencies (25%)					848,361,569
		Totals			**4,241,807,844**
		Rounded			**4,241,808,000**

4.1.16 Summary of Potential Real Estate Issues

In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

If the nonstructural acquisition measure is approved, additional time would need to be allowed for staffing up to handle the increased workload for the large number of acquisitions.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

The availability of decent safe and sanitary housing is a potential problem. Large scale construction of new residences will most likely be required.

4.1.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 4.1.17-1 shows the CWBS for real estate activities.

Table 4.1.17-1.
Chart of Accounts - Hancock County Acquisitions

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	44,612,500		44,612,500
01B20	Acquisition by NFS		356,900,000	356,900,000
01BX	Contingencies (25%)	11,153,125	89,225,000	100,378,125
	Subtotal	55,765,625	446,125,000	501,890,625
01F	PL 91-646 Assistance			
01F20	By NFS		61,152,000	61,152,000
01FX	Contingencies (25%)		15,288,000	15,288,000
	Subtotal		76,440,000	76,440,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		2,630,117,775	2,630,117,775
01R2B	PL91-646 Relocation Payment by NFS		285,376,000	285,376,000
01R2D	Review of NFS	15,288,000		15,288,000
01RX	Contingencies (25%)	3,822,000	728,873,444	732,695,444
	Subtotal	19,110,000	3,644,367,219	3,663,477,219
	Totals	**74,875,625**	**4,166,932,219**	**4,241,807,844**
	Rounded			**4,241,808,000**

4.2 Harrison County Acquisition

4.2.1 Project Description

High Hazard Zones: The nonstructural project delivery team (PDT) identified several zones within the project area, where due to extreme forces generated by storms and hurricanes, other measures such as elevation of an existing or rebuilt structure would not be prudent and may endanger the future occupants. Within these zones, successful emergency evacuation during a storm event would be highly improbable and dangerous for the responders, elevated structures may be prone to foundation failures due to waves and surge, elevation by placed fill material is prohibited or infeasible, and non-elevated structures would likely suffer total or significant losses. Each of these zones was graphically identified using GIS mapping and FEMA database information. There are three identified zones where permanent acquisition and evacuation of the property is the preferred nonstructural treatment. Those zones are:

The FEMA-identified V/VE Zone displayed on the National Flood Insurance Rate Maps (FIRM) within the project area. This “Velocity” water zone features high-energy wave action that was responsible for much of the building damages during the Katrina event and makes elevating structures or otherwise flood-proofing structures in-place very dangerous.

The FEMA-identified “catastrophic damages zone” which was identified in a “post-Katrina” damage assessment of FEMA insured structures within the project area. This zone included a preponderance of insured structures that had received damages in excess of 50% of the structure’s value. Field observations by the nonstructural PDT confirmed that most of those structures in the zone had been

totally destroyed or severely damaged (major structural damages). This area includes the V/VE zone within its boundaries.

A flood damage zone was delineated extending 800 feet back from the beachfront within portions of Jackson County. The aforementioned “catastrophic damage zone” established by FEMA was based upon the Katrina event only and therefore did not account for the area of damages that could be expected along Jackson County were a Katrina-like storm to strike at that location. The 800 feet zone approximated the spatial extent of observed total structure loss and severe structural damages observed within Hancock and Harrison counties located closer to the Katrina landfall. Modifications of this zone’s extent from the waterline could be made to account for intervening topography that would limit the impacts of surge and waves.

The preferred nonstructural measure in these three high-hazard zones would be permanent acquisition of the property under the general provisions of the Uniform Act. Relocations assistance would be provided to residential landowners and/or tenants of the property to locate and secure suitable replacement housing. Remaining structures, pavements, foundations and utilities on the acquired parcel would be demolished and removed to approved landfills. The acquired property could be reused for ecosystem restoration (wetlands), recreation or other purposes that would be in keeping with the identified flood hazards, the NFIP and the provisions of the PCA. The acquired property would be transferred to a local project sponsor for future OMRR&R.

A High Hazard Area Risk Reduction Plan (HARP) is currently being considered as a component of the comprehensive plan to address hurricane and storm damage reduction for certain areas within the Advisory Base Flood Elevation (ABFE) zones along the coast defined as high hazard areas. This plan which is supported by the State of Mississippi contemplates acquisitions in identified areas within Hancock, Harrison and Jackson Counties that should be considered for acquisition beginning in FY 2008 to facilitate relocation of homeowners outside the ABFE prior to their rebuilding. The plan under consideration is not specifically reflected in the nonstructural portion of the Real Estate Appendix. However, the HARP is incorporated in the report at Exhibit "C" to the Real Estate Appendix. Should the plan be authorized, significant adjustments will have to be made to the real estate costs for the buy out areas initially identified in the MsCIP report.

Non-Flood-proofing Zones: The nonstructural PDT also identified one additional zone within the project area where the preferred method of flood damage reduction would be permanent acquisition and evacuation of the property. This zone is located where water depths at the individual structure location occurring during the specified inundation event would exceed the maximum height of elevation prescribed by FEMA’s 550 Guidelines for structure elevation. Those guidelines indicate that elevating structures more than 15 feet from the ground surface in hurricane areas would place the elevated structure in high-velocity hurricane force winds resulting in significant damages to the building. Any structure that would be required to be elevated more that 15 feet to place the first habitable or sales floor above the specified inundation level would be acquired. Using GIS software, a zone of inundation deeper than 13 feet (plus 2 feet of freeboard equals 15 feet) was identified within the project area where permanent acquisition would be the preferred method of nonstructural protection. The area for which permanent acquisition is recommended in Harrison County is shown in Figure 4.2.1-1. The acquisition area is shaded in dark green.



Figure 4.2.1-1. Location of Acquisition Area in Harrison County (dark green)

4.2.2 Real Estate Requirements

Real Estate requirements for the Nonstructural Buy Out in Harrison County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire in fee simple approximately 10,912 impacted parcels and 5,911 structures. The project is divided into 11 reaches. The reaches are identified below in Table 4.2.2-1. Based on the number of structures being impacted, the assumption is that there will be 5,911 relocations to include residences and businesses. The plan calls to use an "approved landfill" for disposal of the demolished structures. An assumption is made that the excavated material will be disposed of in commercial or county landfills. In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Table 4.2.2-1.
Harrison County Acquisition Reaches

Reach	Impacted Parcels	Impacted Structures
8	3,623	1,819
9	44	9
10	1,945	1,157
12	1,047	469
13	650	412
15	85	47
16	78	19
18	1,502	984
19	46	4
20	1,397	851
50	495	140
Total	**10,912**	**5,911**

4.2.3 Utility/Facility Relocation

Specific information about relocation of utilities/facilities is unknown at this time. An assumption is made that if required, this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

4.2.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

4.2.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

4.2.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the

Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

4.2.7 Government Owned Property

There are approximately 11 Government owned parcels within the footprint of the project proposed for acquisition in Harrison County. Some of these lands are associated with Keesler AFB and the US Coast Guard. Land and structure values are not listed in the public records. Ownership is listed in public records as US Govt, US Govt-Keesler AFB, US of America, US of America (USCG) and US Veterans Hospital. Specific impacts to Government owned lands and/or structures will be determined during PED.

4.2.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

4.2.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

4.2.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

4.2.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 5,911 relocations in Harrison County. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. The availability of decent safe and sanitary housing is a potential problem.

Large scale construction of new residences will most likely be required. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

4.2.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

4.2.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

4.2.14 Estates for Proposed Project

All lands acquired in the buy-out area will be acquired in Fee Simple. The Temporary Work Area Easement will be used for a disposal site if required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

4.2.15 Real Estate Estimate

The real estate cost estimate at Table 4.2.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a disposal site. The requirement, if any, for a disposal site will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 4.2.15-1.
Harrison County Acquisitions Estimate

a. Lands and Improvements/Permits					
10,912 Ownerships & 5,911 Improvements					1,722,841,076
					0
				Subtotal	1,722,841,076
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 5,911 relocations					165,508,000
e. Administrative Cost					289,852,500
		Relocation	Acquisition	Total	
	Federal	8,866,500	27,280,000	36,146,500	
	Non-Federal	35,466,000	218,240,000	253,706,000	
		44,332,500	245,520,000	289,852,500	
Subtotal					2,178,201,576
Contingencies (25%)					544,550,394
		Totals			**2,722,751,970**
		Rounded			**2,722,752,000**

4.2.16 Summary of Potential Real Estate Issues

In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

If the nonstructural acquisition measure is approved, additional time would need to be allowed for staffing up to handle the increased workload for the large number of acquisitions.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

The availability of decent safe and sanitary housing is a potential problem. Large scale construction of new residences will most likely be required.

4.2.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 4.2.17-1 shows the CWBS for real estate activities.

Table 4.2.17-1.
Chart of Accounts - Harrison County Acquisitions

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	27,280,000		27,280,000
01B20	Acquisition by NFS		218,240,000	218,240,000
01BX	Contingencies (25%)	6,820,000	54,560,000	61,380,000
	Subtotal	34,100,000	272,800,000	306,900,000
01F	PL 91-646 Assistance			
01F20	By NFS		35,466,000	35,466,000
01FX	Contingencies (25%)		8,866,500	8,866,500
	Subtotal		44,332,500	44,332,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		1,722,841,076	1,722,841,076
01R2B	PL91-646 Relocation Payment by NFS		165,508,000	165,508,000
01R2D	Review of NFS	8,866,500		8,866,500
01RX	Contingencies (25%)	2,216,625	472,087,269	474,303,894
	Subtotal	11,083,125	2,360,436,345	2,371,519,470
	Totals	**45,183,125**	**2,677,568,845**	**2,722,751,970**
	Rounded			**2,722,752,000**

4.3 Jackson County Acquisition

4.3.1 Project Description

High Hazard Zones: The nonstructural project delivery team (PDT) identified several zones within the project area, where due to extreme forces generated by storms and hurricanes, other measures such as elevation of an existing or rebuilt structure would not be prudent and may endanger the future occupants. Within these zones, successful emergency evacuation during a storm event would be highly improbable and dangerous for the responders, elevated structures may be prone to foundation failures due to waves and surge, elevation by placed fill material is prohibited or infeasible, and non-elevated structures would likely suffer total or significant losses. Each of these zones was graphically identified using GIS mapping and FEMA database information. There are three identified zones where permanent acquisition and evacuation of the property is the preferred nonstructural treatment. Those zones are:

The FEMA-identified V/VE Zone displayed on the National Flood Insurance Rate Maps (FIRM) within the project area. This “Velocity” water zone features high-energy wave action that was responsible for much of the building damages during the Katrina event and makes elevating structures or otherwise flood-proofing structures in-place very dangerous.

The FEMA-identified “catastrophic damages zone” which was identified in a “post-Katrina” damage assessment of FEMA insured structures within the project area. This zone included a preponderance of insured structures that had received damages in excess of 50% of the structure’s value. Field

observations by the nonstructural PDT confirmed that most of those structures in the zone had been totally destroyed or severely damaged (major structural damages). This area includes the V/VE zone within its boundaries.

A flood damage zone was delineated extending 800 feet back from the beachfront within portions of Jackson County. The aforementioned “catastrophic damage zone” established by FEMA was based upon the Katrina event only and therefore did not account for the area of damages that could be expected along Jackson County were a Katrina-like storm to strike at that location. The 800 feet zone approximated the spatial extent of observed total structure loss and severe structural damages observed within Hancock and Harrison counties located closer to the Katrina landfall. Modifications of this zone’s extent from the waterline could be made to account for intervening topography that would limit the impacts of surge and waves.

The preferred nonstructural measure in these three high-hazard zones would be permanent acquisition of the property under the general provisions of the Uniform Act. Relocations assistance would be provided to residential landowners and/or tenants of the property to locate and secure suitable replacement housing. Remaining structures, pavements, foundations and utilities on the acquired parcel would be demolished and removed to approved landfills. The vacated property could be reused for ecosystem restoration (wetlands), recreation or other purposes that would be in keeping with the identified flood hazards, the National Flood Insurance Program (NFIP) and the provisions of the Project Cooperation Agreement (PCA). The vacated property would be transferred to a local project sponsor for future OMRR&R.

A High Hazard Area Risk Reduction Plan is currently being considered as a component of the comprehensive plan to address hurricane and storm damage reduction for certain areas within the Advisory Base Flood Elevation (ABFE) zones along the coast defined as high hazard areas. This plan which is supported by the State of Mississippi contemplates acquisitions in identified areas within Hancock, Harrison and Jackson Counties that should be considered for acquisition beginning in FY 2008 to facilitate relocation of homeowners outside the ABFE prior to their rebuilding. The plan under consideration is not specifically reflected in the nonstructural portion of the Real Estate Appendix. However, the HARP is incorporated in the report at Exhibit “C” to the Real Estate Appendix. Should the plan be authorized, significant adjustments will have to be made to the real estate costs for the buy out areas initially identified in the MsCIP report.

Non-Flood-proofing Zones: The nonstructural PDT also identified one additional zone within the project area where the preferred method of flood damage reduction would be permanent acquisition and evacuation of the property. This zone is located where water depths at the individual structure location occurring during the specified inundation event would exceed the maximum height of elevation prescribed by FEMA’s 550 Guidelines for structure elevation. Those guidelines indicate that elevating structures more than 15 feet from the ground surface in hurricane areas would place the elevated structure in high-velocity hurricane force winds resulting in significant damages to the building. Any structure that would be required to be elevated more that 15 feet to place the first habitable or sales floor above the specified inundation level would be acquired. Using GIS software, a zone of inundation deeper than 13 feet (plus 2 feet of freeboard equals 15 feet) was identified within the project area where permanent acquisition would be the preferred method of nonstructural protection. The area for which permanent acquisition is recommended for Jackson County is shown in Figure 4.3.1-1. The acquisition area is shaded in dark green.



Figure 4.3.1-1. Location of Acquisition Areas in Jackson County (dark green)

4.3.2 Real Estate Requirements

Real Estate requirements for the Nonstructural Acquisition in Jackson County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire in fee simple approximately 4,434 impacted parcels and 1,047 structures. The project is divided into 14 reaches. The reaches are identified below in Table 4.3.2-1. Based on the number of structures being impacted, the assumption is that there will be 1,047 relocations to include residences and businesses. The plan calls to use an “approved landfill” for disposal of the demolished structures. An assumption is made that the excavated material will be disposed of in commercial or county landfills. In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Table 4.3.2-1.
Jackson County Acquisition Reaches

Reach	Impacted Parcels	Impacted Structures
21	2,108	378
22	61	50
24	220	45
26	37	35
27	53	32
28	961	57
29	147	46
30	90	66
31	51	19
32	1	0
35	12	2
52	285	146
53	399	169
54	9	2
Total	**4,434**	**1,047**

4.3.3 Utility/Facility Relocation

Specific information about relocation of utilities/facilities is unknown at this time. An assumption is made that if required, this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

4.3.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

4.3.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

4.3.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by

Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

4.3.7 Government Owned Property

There are approximately 34 Government owned parcels within the footprint of the project proposed for acquisition in Jackson County. Most of these lands are within wildlife preserves. Three parcels appear to have improvements. Ownership is listed in public records as United States of America. Specific impacts to Government owned lands and/or structures will be determined during PED.

4.3.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

4.3.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

4.3.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

4.3.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 1,047 relocations in Jackson County. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential

relocations is unknown. The availability of decent safe and sanitary housing is a potential problem. Large scale construction of new residences will most likely be required. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

4.3.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

4.3.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

4.3.14 Estates for Proposed Project

All lands acquired in the buy-out area will be acquired in Fee Simple. The Temporary Work Area Easement will be used for a disposal site if required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

4.3.15 Real Estate Estimate

The real estate cost estimate at Table 4.3.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a disposal site. The requirement, if any, for a disposal site will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 4.3.15-1.
Jackson County Acquisitions Estimate

a. Lands and Improvements/Permits					
4,434 Ownerships & 1,047 Improvements					483,342,423
					0
				Subtotal	483,342,423
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 1,047 relocations					29,316,000
e. Administrative Cost					107,617,500
		Relocation	Acquisition	Total	
	Federal	1,570,500	11,085,000	12,655,500	
	Non-Federal	6,282,000	88,680,000	94,962,000	
		7,852,500	99,765,000	107,617,500	
Subtotal					620,275,923
Contingencies (25%)					155,068,981
		Totals			**775,344,904**
		Rounded			**775,345,000**

4.3.16 Summary of Potential Real Estate Issues

In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

If the nonstructural acquisition measure is approved, additional time would need to be allowed for staffing up to handle the increased workload for the large number of acquisitions.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

The availability of decent safe and sanitary housing is a potential problem. Large scale construction of new residences will most likely be required.

4.3.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 4.3.17-1 shows the CWBS for real estate activities.

Table 4.3.17-1.
Chart of Accounts - Jackson County Acquisitions

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	11,085,000		11,085,000
01B20	Acquisition by NFS		88,680,000	88,680,000
01BX	Contingencies (25%)	2,771,250	22,170,000	24,941,250
	Subtotal	13,856,250	110,850,000	124,706,250
01F	PL 91-646 Assistance			
01F20	By NFS		6,282,000	6,282,000
01FX	Contingencies (25%)		1,570,500	1,570,500
	Subtotal		7,852,500	7,852,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		483,342,423	483,342,423
01R2B	PL91-646 Relocation Payment by NFS		29,316,000	29,316,000
01R2D	Review of NFS	1,570,500		1,570,500
01RX	Contingencies (25%)	392,625	128,164,606	128,557,231
	Subtotal	1,963,125	640,823,029	642,786,154
	Totals	**15,819,375**	**759,525,529**	**775,344,904**
	Rounded			**775,345,000**

CHAPTER 5. ECOSYSTEM RESTORATION

The Environmental Recommended Plan proposes the construction of two (2) pilot projects at Turkey Creek in Harrison County, and Bayou Cumbest in Jackson County. The restoration will consist of restoring emergent tidal marsh habitat and wet pine savannah habitat. These two pilot projects give a basis for future environmental restoration sites identified to be developed. The Comprehensive Plan envisions the construction of environmental restoration projects that would ensure preservation of fish and wildlife, prevent saltwater intrusion, and provide stabilization of the State of Mississippi's shorelines, in order, to reduce or eliminate coastal erosion and restore lost fish and wildlife habitat by identifying degraded critical components of the vital coastal system. It is important to note that ecosystem restoration sites were chosen in areas where environmental restoration can be performed and at the same time reduce risk of future damages to property by acquisition.

5.1 Harrison County Turkey Creek

Figure 5.1-1 identifies areas recommended for environmental restoration in Harrison County. Should all proposed areas be restored, approximately 1,259 parcels with 251 structures would be impacted at a projected acquisition cost of $223,357,000. This REP however, focuses on the pilot project at Turkey Creek.



Figure 5.1-1. Location of Restoration Sites in Harrison County

5.1.1 Project Description

The project site is located north of Gulfport, Mississippi, adjacent to U.S. highway 49, a major north-west thoroughfare, and within the Turkey Creek watershed. The area is becoming increasingly urbanized and development pressures are resulting in increased wetland degradation and loss by the direct filling. The project site as shown in Figure 5.1.1-1 is comprised of 689 acres south (pink border) of the existing railway located on top of an elevated berm. Approximately 190 acres are located north (yellow border) of the railway and functions separately. The combined areas are referred to as Option A, the south area is referred to as Option B, and the north area is referred to as Option C. The site is primarily comprised of a degraded pine savannah wetland. Several miles of ditches have been excavated throughout the site. Additionally the elevated railway berm fragments the wetland habitat and substantially alters the hydrology of the wetlands located to the north. As the areas are undeveloped, no demolition of structures is required. Objectives are to restore native vegetation, restore natural hydrology, restore fish and wildlife habitat, and provide storm water storage protection. The plan calls for mandatory buy-out of lands within the area.

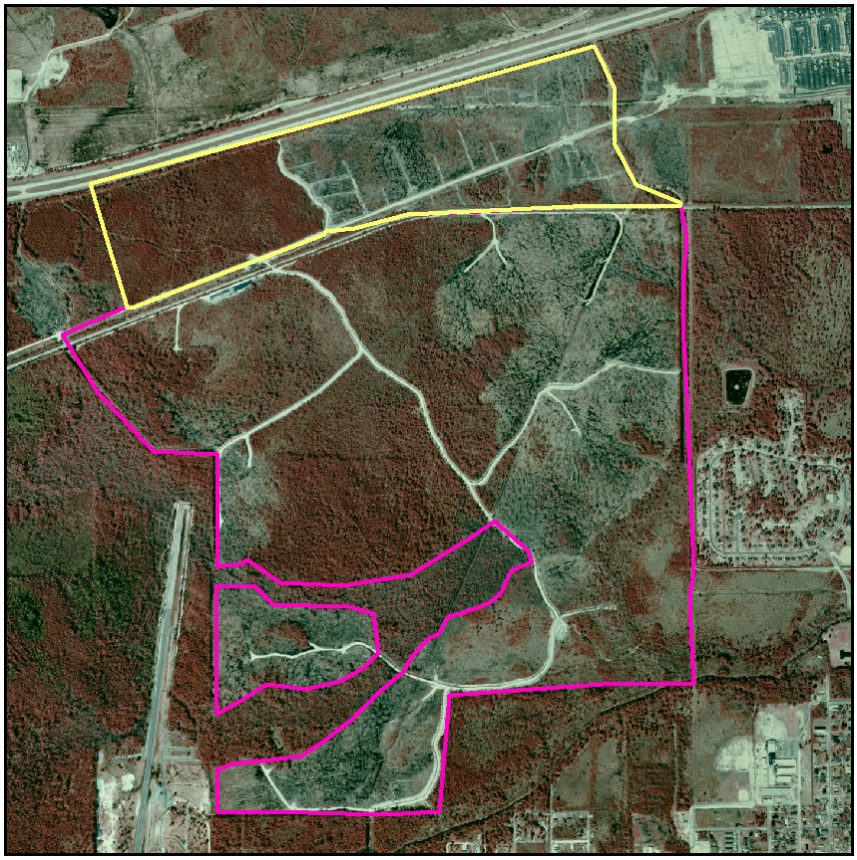


Figure 5.1.1-1. Turkey Creek, Harrison County

5.1.2 Real Estate Requirements

Real Estate requirements for the Turkey Creek Ecosystem Restoration Site in Harrison County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire in fee simple approximately 13 impacted parcels for Option A, 8 parcels for Option B or 5 parcels for Option C. There are no known structures. No other real estate requirements are known at this time.

EP 1165-2-502, paragraph 7 (m.) states that as a general rule, land value should not exceed 25 percent of total project costs for ecosystem restoration, and that proposals consisting primarily of land acquisition are not appropriate as Civil Works ecosystem restoration investments. This project proposes to reduce risk from future hurricane and storm events and to restore the environment. These are two major objectives of the comprehensive plan. The estimated land value is within 25 percent of the estimated total project cost.

5.1.3 Utility/Facility Relocation

Specific information about relocation of utilities/facilities is unknown at this time. An assumption is made that if required, this work will be accomplished under a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

5.1.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

5.1.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

5.1.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

5.1.7 Government Owned Property

There are no known Government owned lands within the proposed project.

5.1.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

5.1.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

5.1.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

5.1.11 Public Law 91-646, Relocation Assistance Benefits

Not applicable.

5.1.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

5.1.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to

advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

5.1.14 Estates for Proposed Project

All lands acquired in the buy-out area will be acquired in Fee Simple.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

5.1.15 Real Estate Estimate

The real estate cost estimates at Tables 5.1.15-1 through 5.1.15-3 include the land cost for acquisition of land and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 5.1.15-1.
Harrison County Turkey Creek Ecosystem Restoration Site Estimate Option A

a. Lands and Improvements/Permits					
13 Ownerships & 0 Improvements					588,692
					0
				Subtotal	588,692
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 0 relocations					0
e. Administrative Cost					292,500
		Relocation	Acquisition	Total	
	Federal	0	32,500	32,500	
	Non-Federal	0	260,000	260,000	
		0	292,500	292,500	
Subtotal					881,192
Contingencies (25%)					220,298
		Totals			**1,101,490**
		Rounded			**1,101,000**

Table 5.1.15-2.
Harrison County Turkey Creek Ecosystem Restoration Site Estimate Option B

a. Lands and Improvements/Permits					
8 Ownerships & 0 Improvements					421,448
					0
				Subtotal	421,448
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 0 relocations					0
e. Administrative Cost					180,000
		Relocation	Acquisition	Total	
	Federal	0	20,000	20,000	
	Non-Federal	0	160,000	160,000	
		0	180,000	180,000	
Subtotal					601,448
Contingencies (25%)					150,362
		Totals			**751,810**
		Rounded			**752,000**

Table 5.1.15-3.
Harrison County Turkey Creek Ecosystem Restoration Site Estimate Option C

a. Lands and Improvements/Permits					
5 Ownerships & 0 Improvements					167,244
					0
				Subtotal	167,244
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 0 relocations					0
e. Administrative Cost					112,500
		Relocation	Acquisition	Total	
	Federal	0	12,500	12,500	
	Non-Federal	0	100,000	100,000	
		0	112,500	112,500	
Subtotal					279,744
Contingencies (25%)					69,936
		Totals			**349,680**
		Rounded			**350,000**

5.1.16 Summary of Potential Real Estate Issues

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

5.1.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Charts of Accounts at Tables 5.1.17-1 through 5.1.17-3 show the CWBS for real estate activities.

Table 5.1.17-1.
Chart of Accounts - Harrison County Turkey Creek Ecosystem Restoration Site Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	32,500		32,500
01B20	Acquisition by NFS		260,000	260,000
01BX	Contingencies (25%)	8,125	65,000	73,125
	Subtotal	40,625	325,000	365,625
01F	PL 91-646 Assistance			
01F20	By NFS		0	0
01FX	Contingencies (25%)		0	0
	Subtotal		0	0
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		588,692	588,692
01R2B	PL91-646 Relocation Payment by NFS		0	0
01R2D	Review of NFS	0		0
01RX	Contingencies (25%)	0	147,173	147,173
	Subtotal	0	735,865	735,865
	Totals	**40,625**	**1,060,865**	**1,101,490**
	Rounded			**1,101,000**

Table 5.1.17-2.
Chart of Accounts - Harrison County Turkey Creek Ecosystem Restoration Site Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	20,000		20,000
01B20	Acquisition by NFS		160,000	160,000
01BX	Contingencies (25%)	5,000	40,000	45,000
	Subtotal	25,000	200,000	225,000
01F	PL 91-646 Assistance			
01F20	By NFS		0	0
01FX	Contingencies (25%)		0	0
	Subtotal		0	0
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		421,448	421,448
01R2B	PL91-646 Relocation Payment by NFS		0	0
01R2D	Review of NFS	0		0
01RX	Contingencies (25%)	0	105,362	105,362
	Subtotal	0	526,810	526,810
	Totals	**25,000**	**726,810**	**751,810**
	Rounded			**752,000**

Table 5.1.17-3.
Chart of Accounts - Harrison County Turkey Creek Ecosystem Restoration Site Option C

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	12,500		12,500
01B20	Acquisition by NFS		100,000	100,000
01BX	Contingencies (25%)	3,125	25,000	28,125
	Subtotal	15,625	125,000	140,625
01F	PL 91-646 Assistance			
01F20	By NFS		0	0
01FX	Contingencies (25%)		0	0
	Subtotal		0	0
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		167,244	167,244
01R2B	PL91-646 Relocation Payment by NFS		0	0
01R2D	Review of NFS	0		0
01RX	Contingencies (25%)	0	41,811	41,811
	Subtotal	0	209,055	209,055
	Totals	**15,625**	**334,055**	**349,680**
	Rounded			**350,000**

5.2 Jackson County Bayou Cumbest

Figure 5.2-1 identifies the areas recommended for environmental restoration in Jackson County. Should all proposed areas be restored, approximately 2,402 parcels with 658 structures would be impacted at a projected acquisition cost of $335,009,000. This REP however, focuses on the pilot project at Bayou Cumbest. This area is subject to an ongoing Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program (HMGP) to Mississippi Emergency Management Agency (MEMA) and Jackson County to acquire all those repetitively flooded properties in the Bayou Cumbest community. Separate discussion with MEMA indicates they will also acquire properties that do not meet the repetitively flooded criteria to avoid a "piece-meal" acquisition pattern. This activity is currently ongoing with or without the MsCIP. Coordination with MEMA indicated that environmental restoration of the area would be an allowable activity but that FEMA would not provide resources to accomplish restoration. Figure 5.2.1-1 shows those parcels in red acquired through the HMGP. It is important to note that as per Engineer Circular 1105-2-218, paragraph 9. Real Estate Crediting Considerations, dated October 1, 2000, "Where use of lands acquired with HMGP funds for a Corps project is consistent with such policies and procedures, and such lands are provided by the non-Federal sponsor for the Corps project, the non-Federal sponsor shall not receive credit toward its required contribution for the value of such lands or any interests therein.. The non-Federal sponsor also shall not receive credit for incidental costs of acquiring lands provided for the Corps project that were paid with HMGP funds. Similarly, the value of such lands, including incidental costs, shall not be included as part of total project costs for cost sharing or NED plan determination."

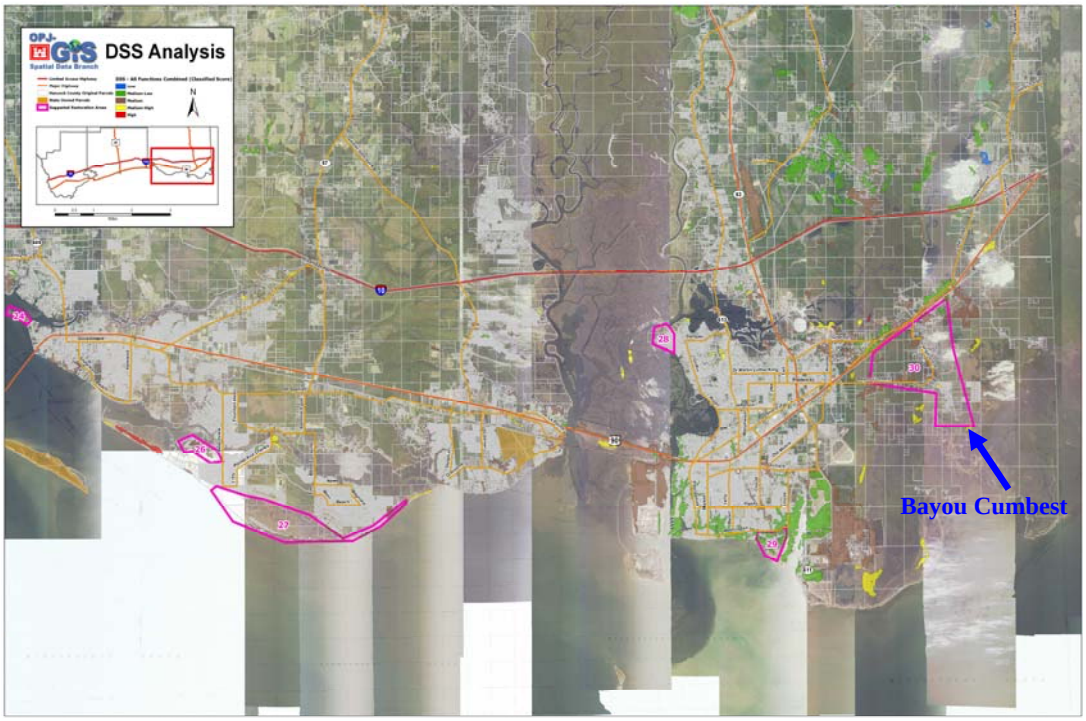


Figure 5.2-1. Location of Restoration Sites in Jackson County

5.2.1 Project Description

The Bayou Cumbest restoration area contains approximately 148 acres of which 110 acres would be restored to emergent tidal marsh and the remaining 38 acres would remain scrub/shrub wetland habitat. The area is shown in Figure 5.2.1-1. The area presently consists of previously filled areas, some tidal marsh and scrub shrub. Objectives are to restore marsh to historical (pre-development ~1950's) conditions, provide storm surge protection, restore native tidal wetland plant community, provide fish and tidal wildlife habitat, and prevent saltwater intrusion. The plan calls for mandatory buy-out of land and 100% removal of existing structures in the area.

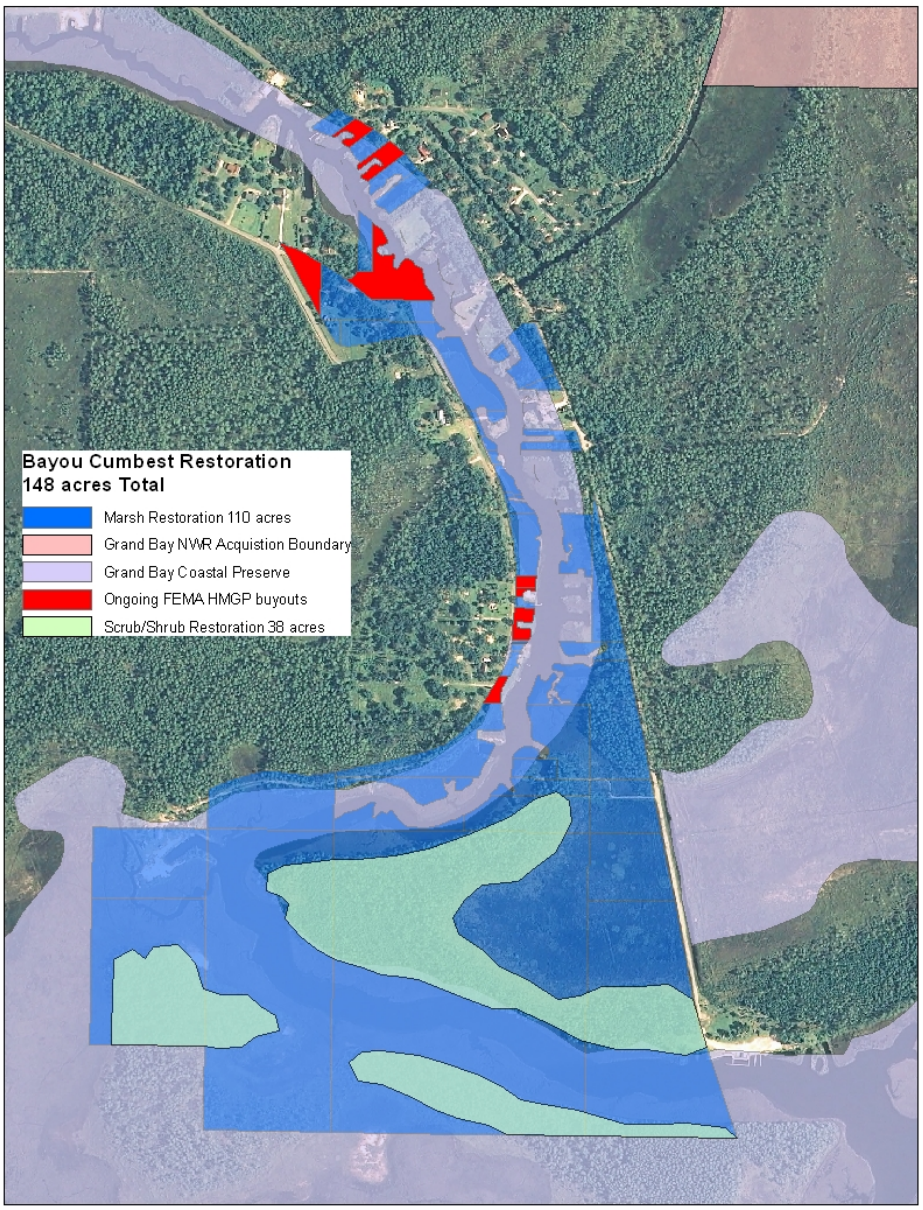


Figure 5.2.1-1. Bayou Cumbest Jackson County

5.2.2 Real Estate Requirements

Real Estate requirements for the Bayou Cumbest Ecosystem Restoration Site in Jackson County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire in fee simple approximately 61 impacted parcels and 19 structures. Based on the

number of structures being impacted, the assumption is that there will be 19 relocations to include residences and businesses. The plan calls to use “approved landfills” for disposal of the demolished structures. An assumption is made that the excavated material will be disposed of in commercial or county landfills. In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

EP 1165-2-502, paragraph 7 (m.) states that as a general rule, land value should not exceed 25 percent of total project costs for ecosystem restoration, and that proposals consisting primarily of land acquisition are not appropriate as Civil Works ecosystem restoration investments. This project proposes to reduce risk from future hurricane and storm events and to restore the environment. These are two major objectives of the comprehensive plan. The estimated land value is within 25 percent of the estimated total project cost.

5.2.3 Utility/Facility Relocation

Specific information about relocation of utilities/facilities is unknown at this time. An assumption is made that if required, this work will be accomplished under a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

5.2.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

5.2.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

5.2.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

5.2.7 Government Owned Property

There are no known Government owned lands within the proposed project.

5.2.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

5.2.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

5.2.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

5.2.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 19 relocations in Bayou Cumbest Ecosystem Restoration Site area. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. The availability of decent safe and sanitary housing may be a potential problem. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

5.2.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area

to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

5.2.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

5.2.14 Estates for Proposed Project

All lands acquired in the buy-out area will be acquired in Fee Simple. The Temporary Work Area Easement will be used for a disposal site if required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

5.2.15 Real Estate Estimate

The real estate cost estimate at Table 5.2.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a

disposal site. The requirement, if any, for a disposal site will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 5.2.15-1.
Jackson County Bayou Cumbest Ecosystem Restoration Estimate

a. Lands and Improvements/Permits				
61 Ownerships & 19 Improvements				1,798,283
			Subtotal	1,798,283
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs -19 relocations				532,000
e. Administrative Cost				1,515,000
	Relocation	Acquisition	Total	
Federal	28,500	152,500	181,000	
Non-Federal	114,000	1,220,000	1,334,000	
	142,500	1,372,500	1,515,000	
Sub-Total				3,845,283
Contingencies (25%)				961,321
	Totals			**4,806,604**
	Rounded			**4,807,000**

5.2.16 Summary of Potential Real Estate Issues

In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available

decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

The availability of decent safe and sanitary housing may be a potential problem.

5.2.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 5.2.17-1 shows the CWBS for real estate activities.

Table 5.2.17-1.
Chart of Accounts - Jackson County Bayou Cumbest Ecosystem Restoration

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	152,500		152,500
01B20	Acquisition by NFS		1,220,000	1,220,000
01BX	Contingencies (25%)	38,125	305,000	343,125
	Subtotal	190,625	1,525,000	1,715,625
01F	PL 91-646 Assistance			
01F20	By NFS		114,000	114,000
01FX	Contingencies (25%)		28,500	28,500
	Subtotal		142,500	142,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		1,798,283	5,083,421
01R2B	PL91-646 Relocation Payment by NFS		532,000	532,000
01R2D	Review of NFS	28,500		28,500
01RX	Contingencies (25%)	7,125	582,571	589,696
	Subtotal	35,625	2,912,854	2,948,479
	Totals	**672,500**	**4,580,354**	**4,806,604**
	Rounded			**4,807,000**

EXHIBITS

AUTHORIZATION FOR ENTRY FOR CONSTRUCTION

I _____, _____ for the
(Name of accountable official) (Title)

(Sponsor Name), do hereby certify that the (Sponsor Name) has acquired the real property interest required by the Department of the Army, and otherwise is vested with sufficient title and interest in lands to support construction for (Project Name, Specifically identified project features, etc.). Further, I hereby authorize the Department of the Army, its agents, employees and contractors, to enter upon _____
(identify tracts)

to construct (Project Name, Specifically identified project features, etc.) as set forth in the plans and specifications held in the U. S. Army Corps of Engineers' (district, city, state)

WITNESS my signature as _____ for the
(Title)

(Sponsor Name) this __ day of _____, 20_____.

BY: _____
(Name)

_____
(Title)

ATTORNEY'S CERTIFICATE OF AUTHORITY

I, _____ , _____ for the
(Name) (Title of legal officer)

(Sponsor Name), certify that _____ has
(Name of accountable official)

authority to grant Authorization for Entry; that said Authorization for Entry is executed by the proper duly authorized officer; and that the Authorization for Entry is in sufficient form to grant the authorization therein stated.

WITNESS my signature as _____ for the
(Title)

(Sponsor Name), this_____day of_____, 20____.

BY: _____
(Name)

_____
(Title)

Exhibit A

Assessment of Non-Federal Sponsor's

Real Estate Acquisition Capability

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? (yes/no)

b. Does the sponsor have the power to eminent domain for this project? (yes/no)

c. Does the sponsor have "quick-take" authority for this project? (yes/no)

d. Are any of the land/interests in the land required for this project located outside the sponsor's political boundary? (yes/no)

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? (yes/no)

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P. L. 91-646, as amended? (yes/no)

b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training? (yes/no)

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? (yes/no)

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? (yes/no)

e. Can the sponsor obtain contractor support, if required in a timely fashion? (yes/no)

f. Will the sponsor likely request USACE assistance in acquiring real estate? (yes/no)

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? (yes/no)

b. Has the sponsor approved the project/real estate schedule/milestones? (yes/no)

Exhibit B
1st page

IV. Overall Assessment:

a. Has the sponsor performed satisfactory on other USACE projects? (yes/no/not applicable)

b. With regard to the project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable.

V. Coordination:

a. Has this assessment been coordinated with the sponsor? (yes/no)

b. Does the sponsor concur with this assessment? (yes/no) (If "no", provide explanation)

Prepared by:

_____
Realty Specialist

Reviewed and approved by:

_____
Chief, Real Estate Division

Exhibit B
2nd page

MISSISSIPPI COASTAL IMPROVEMENT PROGRAM (MsCIP)

High Hazard Area Risk Reduction Plan
Phase I

29 January 2009

Exhibit "C"

Real Estate Summary

This report addresses a nonstructural plan for the purchase of approximately 15,000 parcels located in the high hazard zones of the three coastal counties of Mississippi. This tentatively selected plan would be implemented under two phases. Phase I referred to as the High Hazard Area Risk Reduction Plan (HARP) would include the purchase of approximately 2,000 parcels over the next five years. The second phase or Phase II of the HARP would be for purchase of an estimated 13,000 parcels and would include floodproofing of structures as part of a comprehensive long term risk reduction plan coordinated between HUD, FEMA and the Corps.

The sheer magnitude of the devastation, together with the number of residential homeowners still displaced more than three years after Hurricane Katrina, presents unprecedented challenges and opportunities. Acquisition of properties where the residential owner has not yet rebuilt and continues to be displaced, presents a unique window of opportunity to minimize cost.

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1. STUDY Authority/Background

The Mississippi Coastal Improvements Program, Hancock, Harrison, and Jackson Counties, Mississippi (MsCIP) and the MsCIP Comprehensive Plan Report was authorized for study by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005. The authorization was in response to numerous deaths, extensive damage to environmental resources, homes, businesses and industries, exacerbated saltwater intrusion problems, widespread coastal erosion, damage to public infrastructure and the regional economy caused by the Hurricanes of 2005.

During the study, based upon Corps of Engineers' data, FEMA damage estimates, State of Mississippi post-Katrina reports and on-site Corps investigations, a visually distinct zone was identified in which all residential and commercial structures were destroyed or so significantly damaged as to deny re-occupation. A majority of residential and commercial structures within the "high-hazard zone" (see Figures 1 – 4) designated by the Corps were destroyed and have not yet been rebuilt. The rebuilding rate within the inundated area and in particular the high-hazard zone has been much slower than might typically be expected following a hurricane.

The comprehensive plan developed by the study team, resource agencies and public contains a recommendation for the implementation of a significant non-structural alternative for the acquisition and/or floodproofing of properties within the area identified as having a 1 percent annual chance of inundation from hurricane and storm surges, with the goal of reconstructing the project area as a disaster-resilient community. A portion of this area, designated the high-hazard zone, is regarded as too dangerous for certain types of nonstructural measures that would place a residential structure (using normal building code construction practices), even an elevated residential structure, in the pathway of the surge and waves from a Katrina-like storm. Therefore the high-hazard zone is not considered an appropriate location for floodproofing by elevation while permanent acquisition of properties and removal of structures from that zone is considered an appropriate measure. To implement this component of the 1% annual chance plan the study team formulated an approach referred to as the High Hazard Area Risk Reduction Plan (a.k.a. the HARP).

The nonstructural component of the comprehensive plan is to acquire or floodproof all properties within the 1 percent annual chance inundation zone commonly referred to as the '100-yr' floodplain. This equates to an estimated 58,000 parcels of which an estimated 15,000 parcels are within the high hazard zone. Obviously it is not realistic to consider that this action could be undertaken within a short timeframe due to impacts on local tax base, ability to acquire etc. It is more realistic to consider that the component could be phased in over an extended multi-year period. For this reason phased implementation was developed including a floodproofing demonstration, a municipal acquisition and relocation project, a high hazard area risk reduction plan or HARP, and a comprehensive long-term risk reduction plan coordinated between HUD, FEMA and the Corps. The HARP would address approximately 2,000 parcels in the most high risk areas that are not suitable for floodproofing that could be implemented over a five year period. The long-term risk reduction plan is envisioned as a coordinated effort between HUD, FEMA, and the Corps to be applied over a much longer period and would include acquisition of additional parcels, floodproofing of existing structures and designated elevation requirements for new structures. In order to maximize benefits under the HARP, the plan would be implemented in the most high risk areas first and, initially, with owners who are still displaced and willing to sell. However, eminent domain may be used when warranted.

2. Advantages

There are significant advantages to an acquisition plan for residential and other properties within the high risk zones of coastal Mississippi. An acquisition plan utilizing the application of constructive occupancy for these parcels would:

- Reduce future property loss and potential loss of life.
- Eliminate costly structural alternatives and associated long term operation and maintenance costs.
- Provide a buffer and aid in reducing storm surge to adjoining properties.
- Provide an opportunity as lands are acquired both now and in the future to initiate alternative uses of these lands for fish and wildlife preservation, ecosystem restoration and public recreation and other compatible public uses.

There are substantial additional benefits that can be attained with an expeditious authorization of the HARP and the near-term benefits could significantly be reduced or lost should the program not be authorized until a later date.

- Prompt initiation of acquisition is more cost effective to the Government than commencing acquisition several years hence. Acquisition prior to rebuilding also avoids displacement impacts which increase significantly after residents have rebuilt.
- Near-term acquisition will reduce requirements for other Government-assisted temporary housing programs for those owners that are still displaced, and may continue to receive financial assistance from the State or Federal Government.

3. Schedule

Under Phase 1 of the HARP, it is proposed that approximately 2,000 of the estimated 15,000 parcels identified in the high hazard zones of the three coastal counties of Mississippi be acquired from those owners who are still displaced and are willing to sell.

When identifying the acquisition process and steps for a HARP based on the acquisition of an estimated 2,000 parcels, the total time required was estimated to take approximately five (5) years. The HARP acquisition process should require less administrative time and related costs as a traditional acquisition since the traditional survey of the entire project area would not be required and the time spent for negotiations would be minimal due to initially acquiring parcels from owners willing to sell. Additionally, the administrative cost associated with the legal requirements for processing condemnations should not be necessary or minimal.

Considering that many of the estimated 15,000 parcel owners may not participate in an acquisition program and that many may not be eligible for other reasons, the MsCIP Project Delivery Team estimated that approximately 2,000 of these property owners would likely sell their parcel under a HARP. An estimate of 400 parcels per year based on a five (5) year program would be a reasonable number of acquisitions to expect with an adequately staffed office.

4. Costs

Because of the uncertainties regarding the number of parcels that may remain vacant at the time of acquisition, the value of any new improvements, and the applicability of occupancy requirements under a typical relocation program, the following Tables indicate the estimated range of cost that may be incurred with implementing a Phase I HARP with and without a RHP.

Table 1
HARP Costs Without RHP

For Acquisition of Approximately 2,000 Parcels

Number Parcels	Vacant Parcel Value	Structure Value	91-646 Payment	Demolition Costs	Acq.Cost Admin	Total Acquisition Cost
2,000 vacant	100,000,000	0	0	0	$50,000,000	$150,000,000 *

* Note: Total with contingencies would be $187,500,000.

Table 2

HARP Cost With Use of RHP

For Acquisition of Approximately 2,000 parcels

Number Parcels Occupied Pre-K	Vacant Parcel Value	RHP Payment	Less Other Payments Ins/Grants	91-646 Payment (moving)	Demolition Costs	Acquisition Admin Costs	Total Acquisition Cost
2,000 Vacant	100,000,000	360,000,000	180,000,000	5,000,000	0	50,000,000	$335,000,000 *

* Note: Total with contingencies would be $397,000,000.

5. Application of the Uniform Relocation Assistance and Real Property Acquisition Policy Act of 1970, as Amended (URA)

The URA for the acquisition of real property provides various benefits to property owners when their property is acquired for an authorized Federal project. In keeping with the vision of the MsCIP for establishing a disaster-resilient coastline in regards to hurricane and storm surge, any benefit payments such as a Replacement Housing Payment (RHP) under the proposed HARP would be subject to the property owner establishing occupancy in decent, safe and sanitary (DSS) housing outside the designated high-hazard zone. Depending on the flood zone criteria for the area that the owner relocates to, the DSS designation would include the necessity to elevate the first floor of the home in accordance with the new Digital Flood Insurance Rate Map (DFIRM).

6. Replacement Housing Payment (RHP) Under the URA

Eligibility for relocation benefits under the URA is triggered generally by the occurrence of one of the following actions taken by the Federal Government or by a non-Federal sponsor for a Federally assisted project: (1) the initiation of negotiations, (2) the issuance of a notice of intent to acquire, or

(3) the actual acquisition of the property, whichever comes first. Generally, persons otherwise eligible under the URA requirements who move from their property, or move personal property, as a direct result of these displacing activities are considered displaced persons covered by the URA. One benefit under the URA available to eligible displaced persons of residential properties is payment of a RHP. Such a payment would be in addition to the payment of the fair market value for the land itself.

Because many of the residential owners of the HARP Phase 1 parcels displaced by Hurricane Katrina may not occupy the property when the acquisition phase of the project is commenced, the potential for application of a "constructive residential occupancy" theory under the URA and its implementing regulation contained in 49 CFR Part 24 is being evaluated as a means to provide a RHP for residents who otherwise meet eligibility requirements under the URA.

7. Acquisition Implementation and Management Plan

Specific guidelines for deployment of a HARP should be developed as a part of the authorization process and should be utilized to implement and manage the HARP. Preparation of an Acquisition Implementation and Management Plan (AIMP) in coordination with the Project Sponsor would ensure successful implementation and management of the HARP. The AIMP should be utilized and updated throughout the acquisition program as a working document and should include acquisition schedules, real estate costs, budgets, processes, a relocation plan, program eligibility requirements, contacts, notification letters, applicable state and federal laws, defined acquisition areas, parcels identified for acquisition, prioritizing of parcels for acquisition, appraisal and comparable housing data, closing processes and any other relevant issues. To facilitate the acquisition process, it is recommended that a Draft AIMP be initiated as soon as possible and prior to a HARP implementation.

8. Other Federal Disaster Assistance Programs in Coastal Mississippi

There are at least two other significant post-Katrina Federal programs currently operating within the communities of the project area. Both the Federal Emergency Management Agency (FEMA) and the US Housing and Urban Development Administration (HUD) have ongoing programs within the project area that are designed to reduce future damages or to compensate landowners for damages.

9. FEMA Assistance Programs

FEMA has been operating several post-Katrina programs designed to compensate landowners for storm-related damages, reconstruct and repair damaged structures and reduce future flood damages and loss of life due to hurricane surge and other storm-related threats. FEMA administers the Individual Assistance Program (IAP), Public Assistance Program (PAP), Other than Housing Needs Assistance Program, Debris Removal Program, Temporary Housing Program and the Hazard Mitigation Grant Program within the project area. Each of these programs is administered locally by The Mississippi Emergency Management Agency (MEMA). To date over 350,000 individuals and families have been helped by the assistance programs. Most of these grant programs cover losses or needs over and above any flood insurance payments that may be available to the landowner and the grants are provided tax-free.

The individual assistance program provides grant funds to individuals and families for temporary housing, and the repair, replacement or reconstruction of homes damaged by Katrina. Those repairs

must be made in conformance with NFIP requirements according to the local floodplain management ordinances and the funds do not cover losses to second or vacation homes in the project area. This disaster assistance program is implemented under the Individuals and Households Program (IHP) and provides grant assistance for re-establishment of households in the affected areas. Opportunities for applying flood damage mitigation measures to damaged homes are encouraged by FEMA administrators but for those landowners without flood insurance, but receiving disaster assistance, the mitigation measures are optional. Additional long-term recovery funding can be provided through low-interest loans from the Small Business Administration.

As of April 2008, over 200,000 individuals and families have received Housing Assistance payments and over 130,000 have received Other Needs Assistance grants. Total payments to these two components of the FEMA assistance program have reached $1.2 billion to date. In addition, more than $2.8 billion has been obligated by FEMA in their Public Assistance program helping to reconstruct public buildings and facilities, utilities, roads and bridges and recreation facilities.

The Hazards Mitigation Grant Program is also being administered in the project area through the Mississippi Emergency Management Agency (MEMA). This program provides grant funds to address flood damages for structures and property that are subject to repetitive flooding or were damaged by Katrina and had been identified for acquisition in the state All-Hazards Mitigation Plan. Projects must show savings greater than costs. Some of the activities that can be implemented under the HMGP to protect either public or private property from future flood damages are:

1) Acquisition of property or relocation of buildings to convert the property to open space use

2) Retrofitting structures to minimize damages from high winds, flood, or other hazards

3) Elevation of flood prone structures

4) Development and initial implementation of vegetative management programs

5) Minor flood control projects that do not duplicate the activities of other Federal agencies

6) Localized flood control projects, such as ring levees and floodwalls designed specifically to protect critical facilities

7) Post-disaster building code activities that support code officials during the reconstruction process

10. HUD Assistance Programs

The Homeowner Assistance Grant Program (a.k.a. HAP) is a disaster recovery program being implemented through the Mississippi Development Authority for those areas specifically damaged by Katrina hurricane surge inundation. The program is generally available to low to moderate income households (up to 120% of the median household income) with limited funding for higher-income households. The program is being implemented in two phases – Phase 1 for those structures located outside the 100-year flood zone established in the FIRM but were flooded by the Katrina surge and Phase 2 for those structures damaged by hurricane surge and located within the 100-year flood zone mapped in the FIRM.

The program has two components. The first component is a compensation grant of up to $150K (phase 1) to compensate homeowners for losses to single-family, owner-occupied duplexes or mobile homes due to flooding by surge that were not covered by insurance. The percentage of the total grant available is dependent upon the insured value of the home times the percentage of damage determined in a damage assessment. Homeowners may repair, replace or reconstruct

homes as they choose with the funds. No local permits for home repair or construction or evidence of the use of the funds for those purposes is required by HUD or MDA. Homeowners must comply with NFIP requirements for elevating the structure and may apply for the second component of the program – the elevation grant (see description in Section 11) – to defray the costs of elevating the home. In phase 2 of the HAP, the compensation grant amount is limited to $100K.

The second component of the HAP is the elevation grant and is available to homeowners who did not have flood insurance through the NFIP. Section 11 has more discussion of this elevation program through HUD.

Neither the compensation grant program nor the elevation grant program restricts any homeowner from rebuilding a destroyed or substantially damaged structure or elevating a damaged/repaired structure in the new DFIRM-designated V or VE zone. The only requirements are compliance with current NFIP guidelines as described in local floodplain management ordinances and current building codes. Any structure being elevated under either program would be raised to the new BFE established in the DFIRM flood zone mapping. This new BFE may be lower than the surge elevation that came ashore with Katrina in some areas. Residual damages during a recurrence of a Katrina-like storm as a result these elevation and compensation programs could be significant.

As of May 15, 2008, the HAP has received 19,401 applications for Phase 1 and 8,534 for Phase 2 of the program and has distributed grant funds to 20,437 of those applicants totaling more than $1.4 billion.

In addition to the Homeowners Assistance Program discussed above, the MDA is implementing, through the HUD Community Development Block Grant (CDBG) program, the Long Term Workforce Housing Program. The purpose of this program is to provide grants and loans for local jurisdictions, non-profits and for-profit organizations to provide long-term affordable housing in the three coastal counties and Pearl River County. These funds can be used to repair, rehabilitate, or reconstruct housing units for low and moderate income families and must include at least 40 dwelling units for each grant or loan request. The program projects that as many as 5,800 housing units may be created in these four counties with only local building code and NFIP restrictions.

11. Non-Corps Federal Floodproofing Programs

Following the rescue and recovery operations in the project area, both FEMA and the HUD entered the damaged Gulf areas and began to implement assistance (grant and loan) programs. Each of the two agencies has been offering floodproofing (or elevation) grants to eligible landowners so that homes, businesses and public structures could be elevated to reduce future damages.

FEMA has been providing elevation grants ($30K) to eligible landowners so that either new construction or retro-fitted homes could be elevated in accordance with the NFIP and local floodplain management ordinances. The grant would be in addition to any flood insurance payments that an insured property owner may have received. The elevation requirements specify the base flood elevation (BFE) or the Advisory Base Flood Elevation (ABFE), whichever is the best available data at that time. Regardless of the specified BFE elevation used to site the first floor of the structure, there are no restrictions in the FEMA elevation grant program to elevating homes in the newly-mapped V or VE zone. Other than any building code requirements of the municipal or county area or restrictions included in the local floodplain management ordinances, elevating structures in the mapped V or VE zone is allowed under the FEMA assistance program.

Likewise, HUD has an elevation grant program as well that provides $30K to eligible landowners to assist in raising the first floor of either a new home or a retro-fitted home to reduce future flood damages. The $30K grant helps to defray the cost of elevating the home and is payable in two

installments - $15K when the elevation permit is obtained and $15K when an occupancy permit is obtained. Neither HUD nor MDA are providing direct oversight for the elevation design or construction processes, but are relying on local NFIP and building code inspectors to assure compliance with the local ordinances. Also similar to the FEMA elevation grants, the HUD program has no restrictions on elevating homes within the V or VE zones shown on the floodplain mapping.

Both of these programs provide grant funds to landowners that assist in elevating their homes, but in many cases the grant may not provide the total amount necessary to cover the entire costs of elevating the structure according to the full requirements of the NFIP or the local building codes (IRC/IBC). When the distance between the ground surface and the BFE is minor (1-3 feet) and the structure is being constructed, the grant may cover the increased costs of the extended foundation, utility lines and additional steps that support, service and access the higher first floor. Normally, the incremental cost of elevating new construction to meet NFIP requirements is less than retro-fitting an existing structure.

Where an existing structure must be retro-fitted with a new foundation or where a new structure must be raised to a higher level (8-15 feet) above the ground surface, the assistance grant will not likely cover the homeowner's full cost. Retro-fitting normally requires much preparatory work beneath the structure (dependent upon the foundation type; slab, crawl space, basement) followed by raising the first floor of the structure to the new design flood height (BFE) and installing new piling or masonry columns beneath the structure. This total cost normally exceeds the elevation grant by a significant amount. Significantly elevating a new structure (10-15 feet) can be quite expensive considering the costs of installing deep pilings, bracing the pilings, construction of extended utilities and providing access to the higher first floor. Any special needs of the household members under the American Disabilities Act (ADA) that require wheelchair ramps or chair lifts can add significantly to these costs.

12. Integration of Corps and Non-Corps Nonstructural Programs

In their implementation, components of the three programs do not mesh well at this time. Redevelopment within the V and VE zones in both the FEMA and HUD programs directly conflicts with the proposed MsCIP plan to offer only permanent acquisition in those areas. In terms of elevation or floodproofing, both the FEMA and HUD programs have no restrictions to floodproofing within the V or VE zone while the MsCIP avoids any floodproofing actions within the V/VE zones.

In addition to the cost differentials between elevation costs (based upon Corps project cost data) and the grant amounts that may surface during implementation of the two programs, the lack of specific guidelines for elevating residential construction within the mapped V and VE zones in the FEMA and HUD programs should be considered. Generally, the base flood elevation to which all new construction or retro-fitted construction included within the FEMA and HUD assistance programs must raise the first habitable floor, may be lower than the hurricane surge that would be expected (and was experienced during Katrina) from a Category 5 hurricane. Hurricane surge depths in Katrina exceeded 25 feet in the V/VE zones of the project area. The number of totally destroyed homes in the V and VE zones that had been elevated in compliance with the pre-Katrina BFE is a testament to the potential for significant residual damages and loss of life that could occur as a result of implementing the two non-Corps elevation grant programs.

The MsCIP plan in comparison, although using the storm events of 2005 and especially Katrina as its benchmark for protection and reducing flood damages and loss of life, would substantially reduce residual damages and threats to public safety.

In terms of financial assistance, the MsCIP is founded on the premise of government-directed construction activities with associated design, regulatory and contracting controls to assure good quality, legality and accountability. Both the FEMA and HUD programs are essentially grants to landowners with minimal or no controls for design quality or accountability (esp. in the HUD compensation program). The MsCIP program costs are founded on the requirements of the Uniform Relocations Act and actual floodproofing/relocations construction costs while the FEMA and HUD programs have set grant limits regardless of the actual costs of the work required.

As stated in Section 24 below, much coordination work needs to be completed between the agencies to assure that these programs can be integrated in a safe and efficient manner so that residents are offered practical and safe options for protecting their lives and property.

13. Project Sponsor Responsibilities and Capabilities

The Non-Federal Sponsor will have the responsibility to acquire all real estate interest required for the Project and perform all relocations determined by the Government to be necessary for the project. The Government will have oversight of these activities and with compliance of PL 91-646.

14. Conclusions

The nonstructural program components discussed above can provide significant levels of risk reduction to the residents and businesses in the project area and can be the foundation for development of a disaster-resilient community along the Gulf Coast. When compared to other flood damage reduction alternatives for the project area the nonstructural components are cost effective, environmentally friendly, incremental in deployment but cumulative in benefit accrual, affordable in terms of local sponsor OMRR&R costs, supportive of local NFIP ordinances, and can be integrated into other community plans for energy conservation, new housing development, economic development, public transit strategies, and renewal of public facilities through local Capital Improvements Programs.

According to a FEMA report dated 4 Dec 08, there have been 40,195 travel trailers and mobile homes deactivated in Mississippi since Katrina of which 3,020 remain in service. Of these units, 1,783 are currently occupied within the three coastal counties. This would suggest that substantial benefits can still be realized from a near term acquisition program.

15. Outstanding Coordination Issues

Continue to petition both FEMA and HUD to obtain the non-Corps assistance application data that would form the basis of further detailed planning for the structural and nonstructural elements of the proposed protection plan. Also, formulate collaborative strategies for integrating the Corps and non-Corps projects/programs within the project area so that residents will get the most benefit from the programs without excessive duplication of Federal effort, missed opportunities for synergistic solutions or misuse of Federal funds.

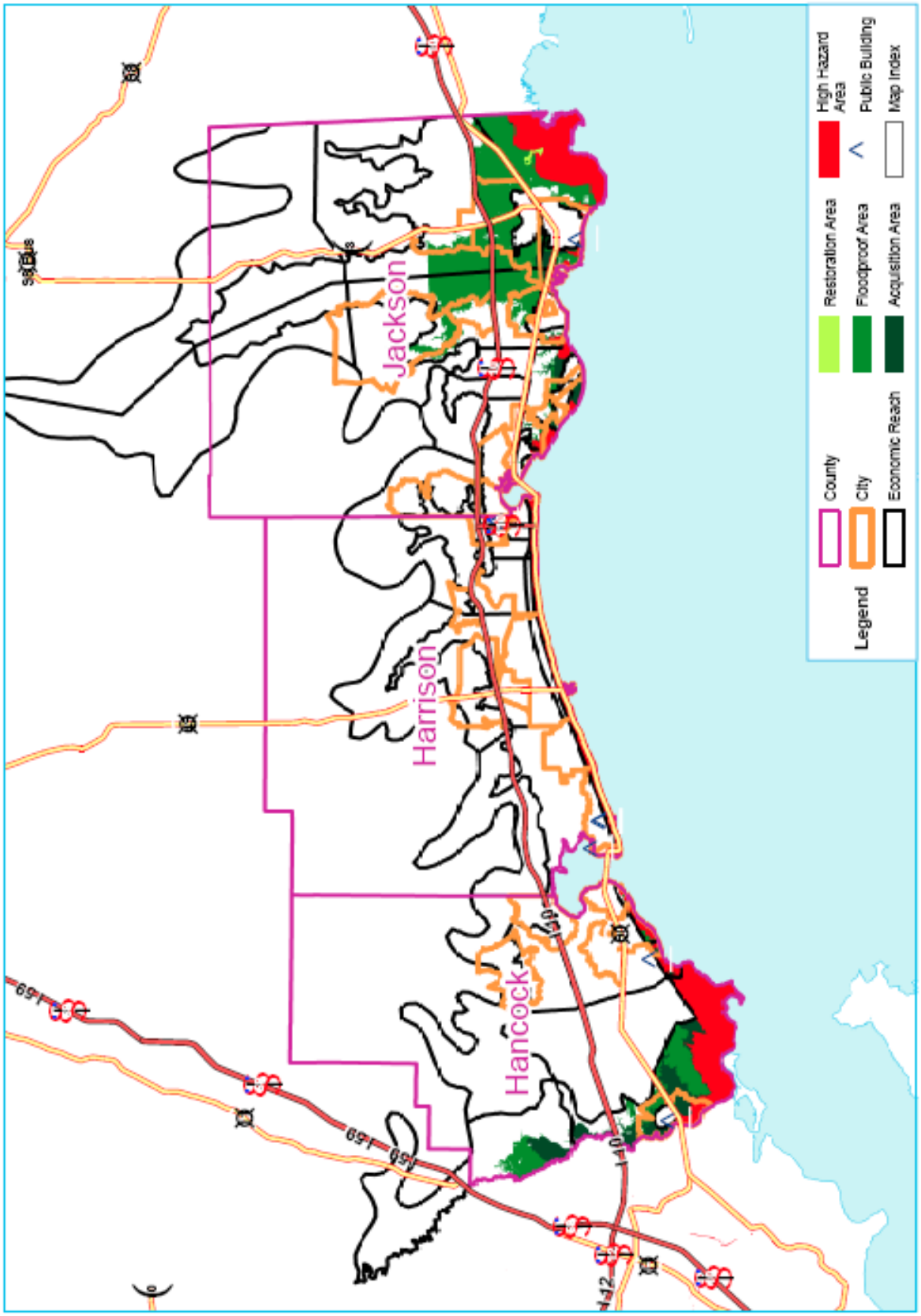


Figure 1 - High Hazard Zone Project Overview

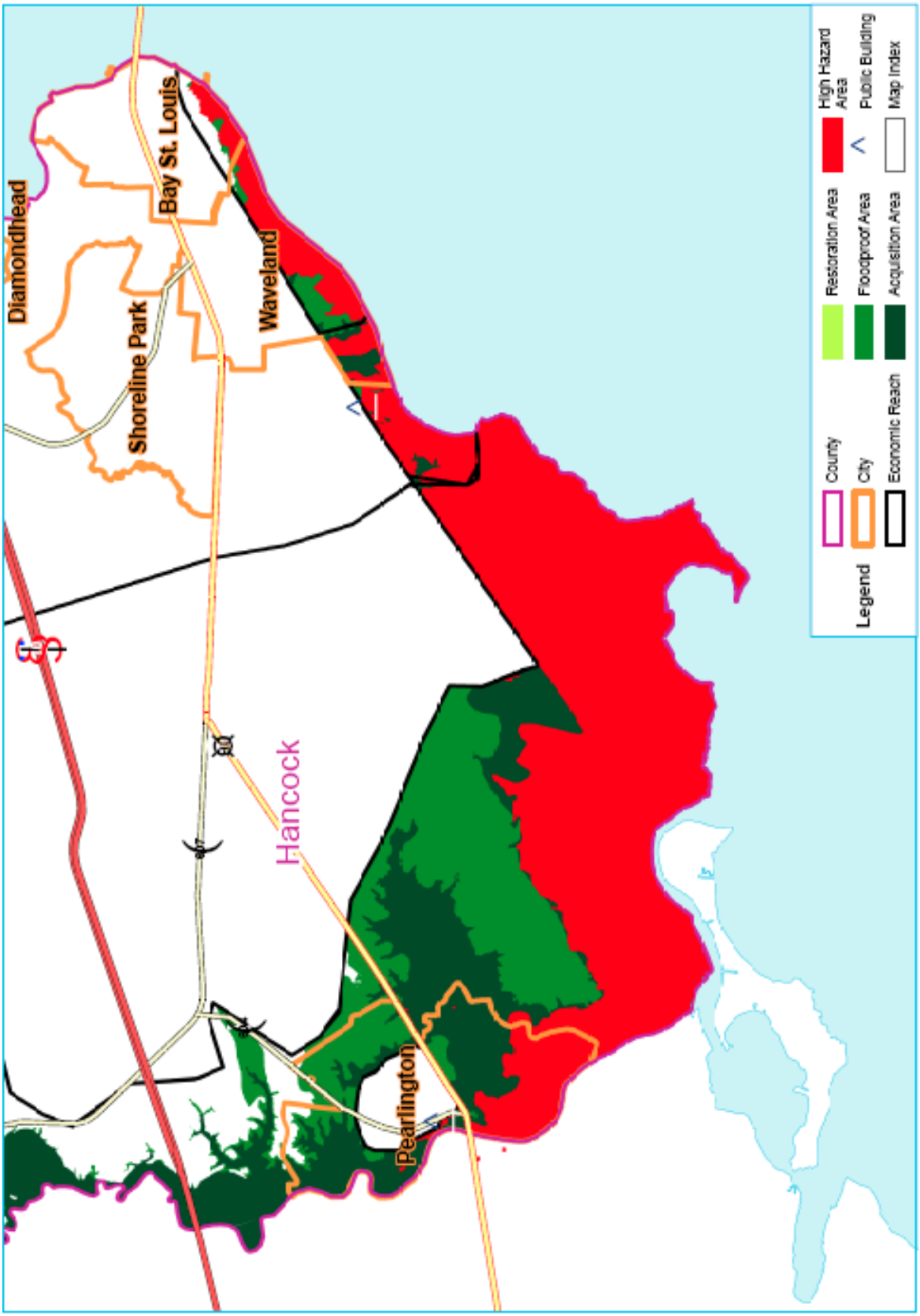


Figure 2 - High Hazard Zone in Hancock County

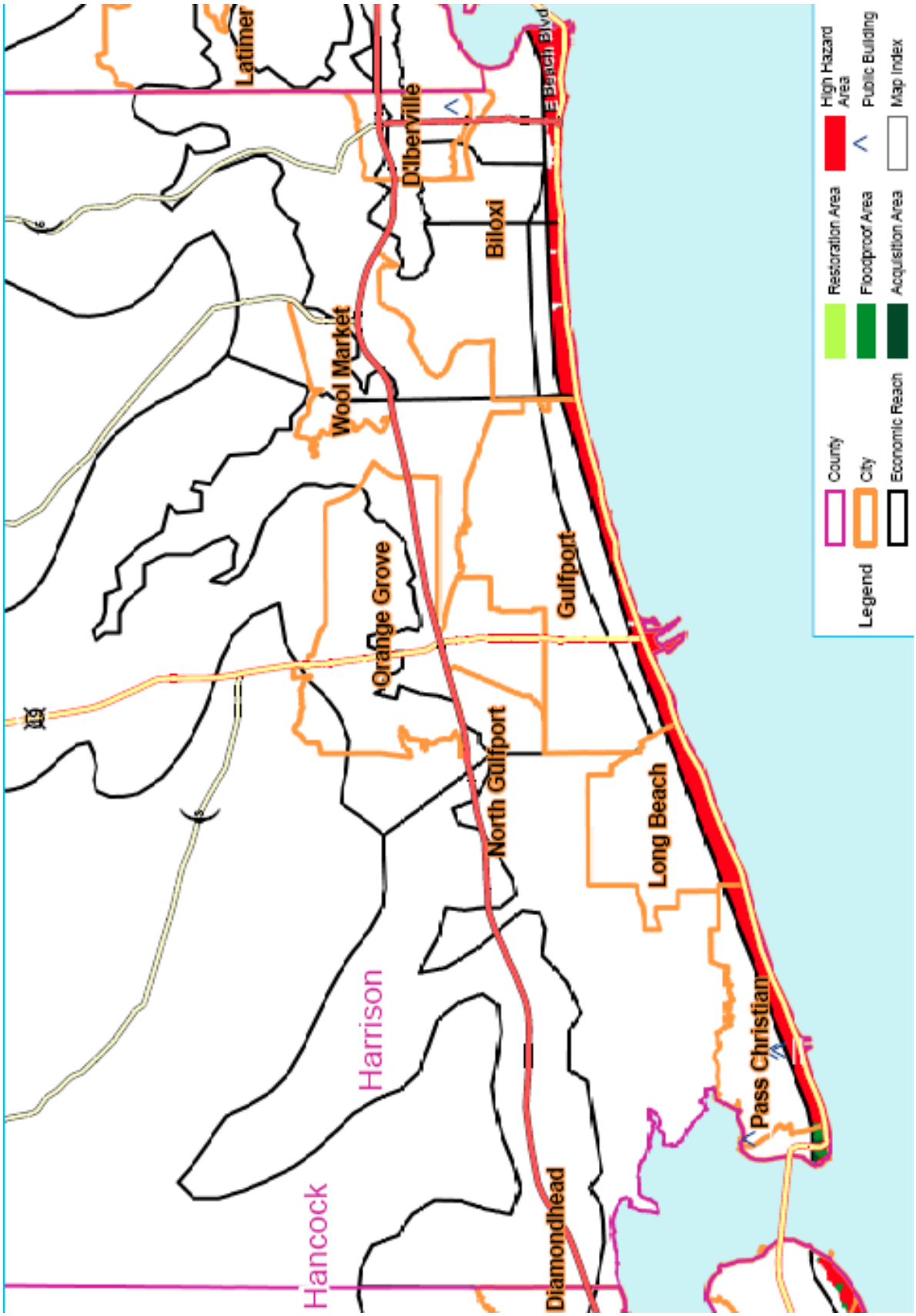


Figure 3 - High Hazard Zone in Harrison County

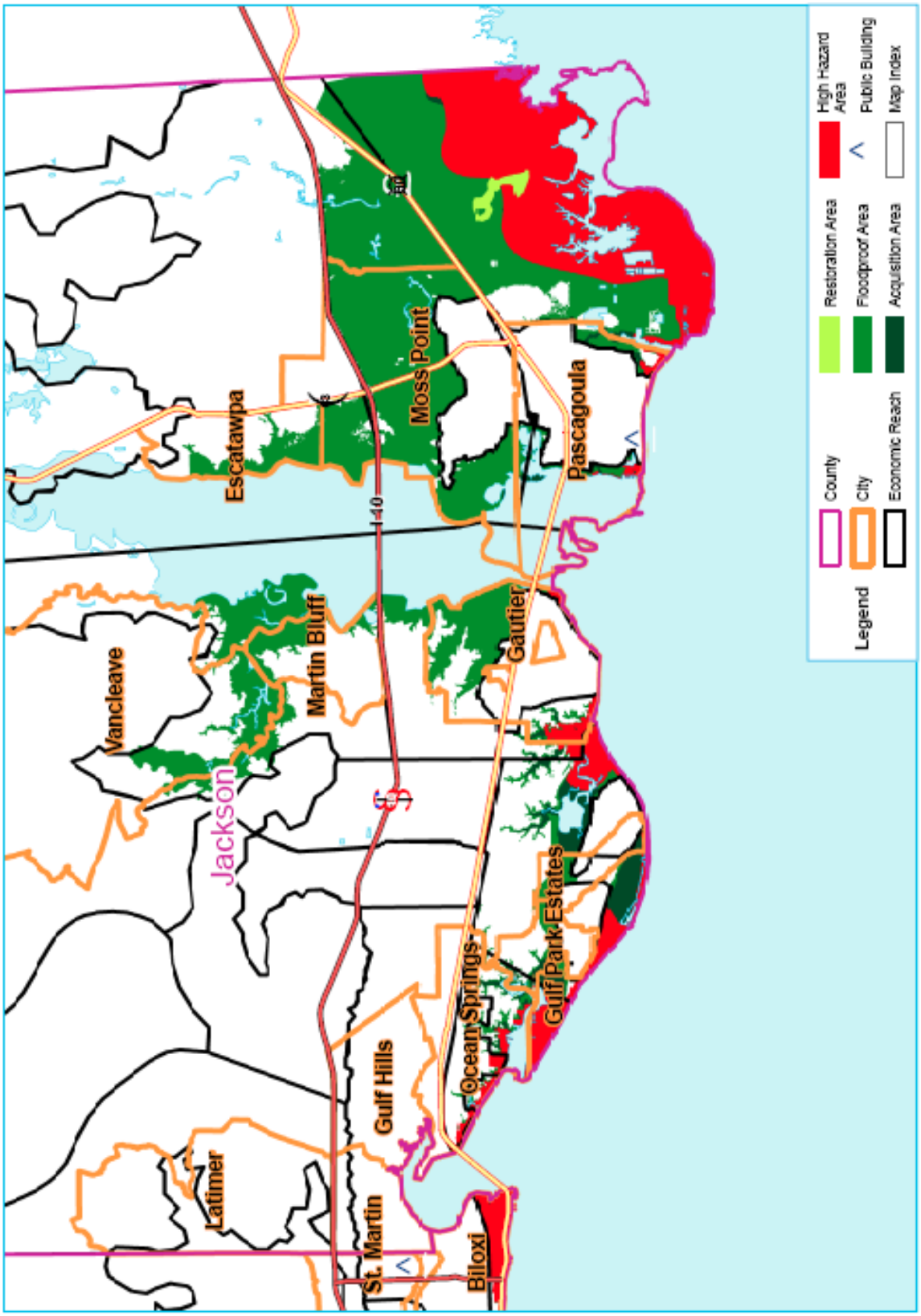


Figure 4 - High Hazard Zone in Jackson County

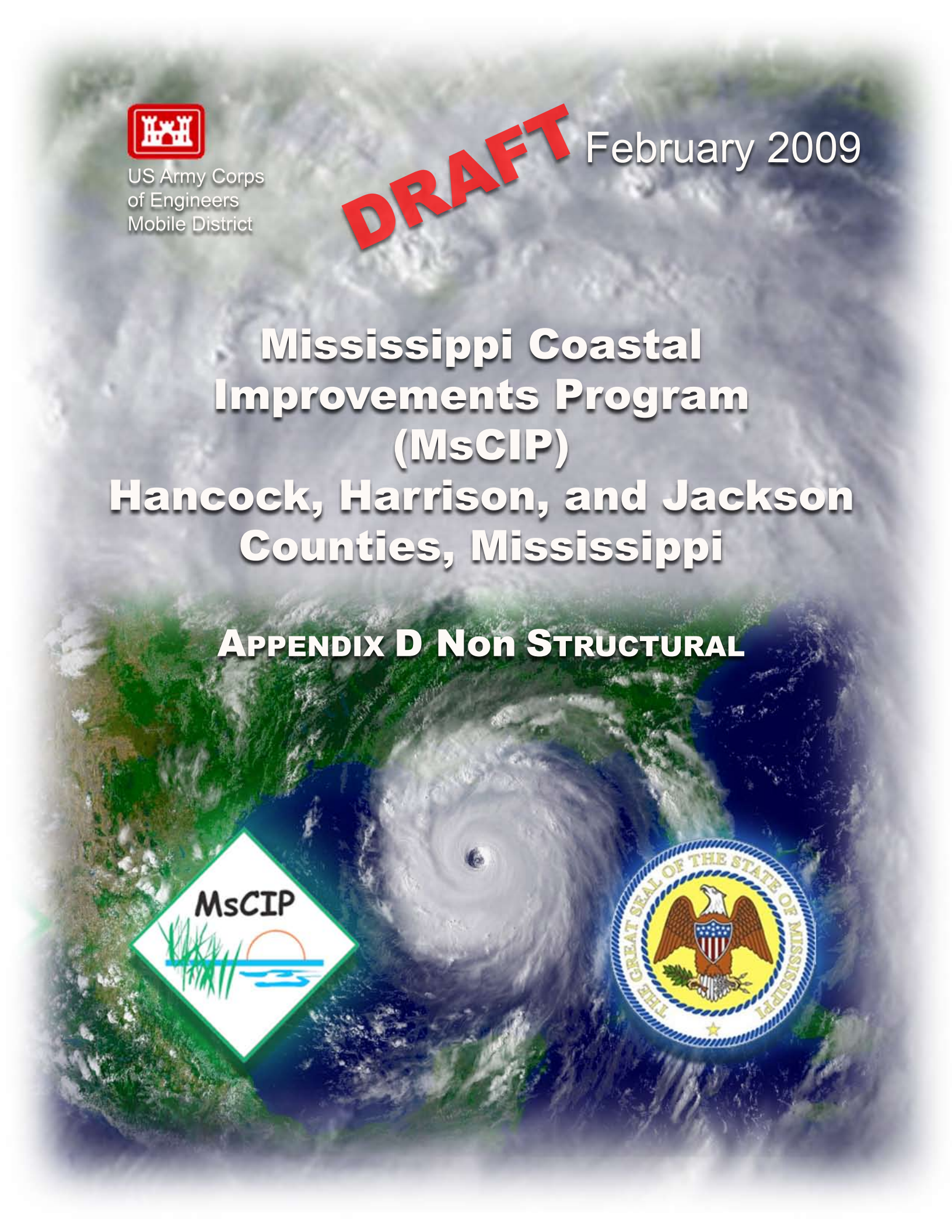
US Army Corps
of Engineers
Mobile District

DRAFT

February 2009

Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

Appendix D Non Structural



FOREWORD

This document is one of a number of technical appendices to the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Feasibility Report and Environmental Impact Statement.

The Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Integrated Feasibility Report and Environmental Impact Statement provides systems-based solutions and recommendations that address: hurricane and storm damage reduction, ecosystem restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion. The recommendations contained in the Main Report/EIS also provide measures that aid in: greater coastal environmental and societal resiliency, regional economic re-development, and measures to reduce long-term risk to the public and property, as a consequence of hurricanes and coastal storms. The recommendations cover a comprehensive package of projects and activities that treat the environment, wildlife, and people, as an integrated system that requires a multi-tiered and phased approach to recovery and risk reduction, irrespective of implementation authority or agency.



The MsCIP Study Area

The purpose of the Comprehensive Plan Report is to present, to the Congress of the United States, the second of two packages of recommendations (i.e., the first being the "interim" recommendations funded in May 2007, and this "final" response, as directed by the Congress), directed at recovery of vital water and related land resources damaged by the hurricanes of 2005, and development of recommendations for long-term risk reduction and community and environmental resiliency, within

the three-county, approximately 70 mile-long coastal zone, including Mississippi Sound and its barrier islands, of the State of Mississippi.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and an External Peer Review (EPR). Both review processes will have been conducted in accordance with the Corps "Peer Review of Decision Documents" process, has been reviewed by Corps staff outside the originating office, conducted by a Regional and national team of experts in the field, and coordinated by the National Center of Expertise in Hurricane and Storm Damage Protection, North Atlantic Division, U.S. Army Corps of Engineers.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing recommendations directed at assisting the people of the State of Mississippi in recovery, recommended actions and projects that would assist in the recovery of the physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

This appendix contains detailed technical information used in the analysis of existing and future without-project conditions, in the development of problem-solving measures, and in the analysis, evaluation, comparison, screening, and selection of alternative plans, currently presented as tentatively-selected recommendations contained in the Main Report/EIS.

Each appendix functions as a complete technical document, but is meant to support one particular aspect of the feasibility study process. However, because of the complexity of the plan formulation process used in this planning study, the information contained herein should not be used without parallel consideration and integration of all other appendices, and the Main Report/EIS that summarizes all findings and recommendations.

Nonstructural measures are proven methods and techniques for reducing flood damages and loss of life in floodplain and coastal areas threatened by storms and hurricanes. Tens of thousands of structures throughout the coastal fringes of the United States have been protected using nonstructural measures found to be effective in preventing damages, cost effective when compared to other measures and acceptable to the general public. Nonstructural measures can be used as a stand-alone program to create disaster-resilient communities.

Prior to implementation of the proposed comprehensive nonstructural plans discussed herein, more detailed project development plans would need to be prepared in close collaboration with the counties, municipalities, the state and Federal agencies for the project area. In any nonstructural program that spans multiple jurisdictions there would be imbalances in tax revenues as displaced landowners relocated to nearby communities coupled with disparities in public service capabilities and school enrollments. Agreements between jurisdictions concerning lost/gained tax revenues and adjusted public service areas as well as school enrollment adjustments must be considered before initiating a full-scale nonstructural project. In addition, changes in the current flood insurance rate maps, establishment of new base flood elevations and enlargement of the VE zone by FEMA would necessitate revision of the designated zones where certain measures have been specified in this Appendix. All of these ongoing changes would need to be incorporated into more detailed project implementation reports to better estimate costs and potential socioeconomic impacts prior to implementation.

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EXECUTIVE SUMMARY

The Mississippi Coastal Improvement Project area contains over 70,000 parcels of property of which a high percentage were, prior to Katrina, occupied by structures. Many of those parcels are now vacant with only slab foundations and FEMA temporary trailers remaining to show where households and businesses once stood. Redevelopment of the project area has been limited due to legal and financial issues with respect to floodplain regulatory determinations and flood insurance payments. Once these issues are resolved, redevelopment of the vacant parcels may accelerate at a feverish pace. The future-without project scenarios of the comprehensive plan contemplate full redevelopment (residential or residential & commercial mix) of the project area by the year 2012 as described in more detail in the Economics Appendix.

The nonstructural PDT, using data from the USACE Mobile District, FEMA, NOAA, county assessor's offices and local sources has formulated nonstructural measures that, working either independently of structural measures or in concert with them, provide substantial reductions in flood damages. Many uncertainties remain in the nonstructural formulation because of the lack of complete structure-specific data. More in-depth planning in collaboration with the counties and municipalities is needed to address the uncertainties regarding the cost efficiency and effectiveness of the nonstructural measures as well as potential mitigative measures needed to offset unavoidable social and economic impacts.

The primary measures identified for the project area include permanent acquisitions, floodproofing by elevation and other means, relocation of public buildings, flood preparedness and evacuation planning, public education, changes in the current municipal and county NFIP and building codes, a transfer of development rights or purchase of development rights program, changes in land use zoning, development impact fees, and redirection of new development. These measures have been combined into 8 separate plans that can be implemented by either agencies of the Federal government or collaboratively by those agencies and state, county and local governmental units. Only local jurisdictions can implement some of the measures identified in the plans through local police powers.

Seven of the 8 nonstructural plans formulated in the following pages are based upon the Advisory Base Flood Elevation (ABFE), in accordance with currently amended local ordinances, to generate comparison of project costs and benefits. The eighth plan (NSC-6) is a combination of structural and nonstructural measures evaluated through the ABFE, 20 feet, 30 feet and 40 feet levels of inundation for ringwalls and ring-levees at certain communities and the LOD 4 structural project. Total nonstructural plan costs range between $6.1 billion for acquisitions of high-hazard properties alone and $19.1B for a full range of nonstructural measures such as permanent acquisitions, floodproofing, relocations of public buildings, NFIP and building code upgrades, and use of TDR or PDR programs.

Due to the iterative nature of the planning process, LOD 4 was screened out after the Nonstructural Appendix was completed. This measure was screened out due to the extreme maintenance cost of the associated surge gates, which was beyond the financial capability of the local sponsor. Therefore, the discussions associated with LOD 4 in the combined structural and nonstructural plans (NSC-6d through NSC-6g) within this Appendix should be viewed only as a reference. The combined structural and nonstructural alternatives that include ring-levees and ringwalls with nonstructural measures and that are labeled as NSC-6 through NSC-6c are still valid alternatives.

Comparison of the 8 plans using metrics such as total plan cost, cost per parcel protected, AAD prevented, effectiveness, sustainability, public safety and environmental quality reveals that several nonstructural plans provide substantial benefits (including substantial non-monetary benefits or

benefits for which monetary measures have yet to be defined in the plan) to the project area. Due to the lack of detailed information for the project study area, several metrics were not commensurable among the plans at this time. Despite this quantification issue, significant qualitative improvements in public safety, environmental quality, potential long-term growth, community disaster-resilience and future damage reduction point to the overall effectiveness of the nonstructural plans.

A planned feature is the High Hazard Area Risk Reduction Plan (HARP) that provides for purchase of properties located in the high hazard zones of the three coastal counties of Mississippi. Acquisition would be in accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, and would be implemented first in the most high risk areas (approximately 2000 parcels)and initially with owners willing to sell.

In addition to the proposed HARP, the plan includes two pilot projects: one for elevation of 25 residential structures in Waveland, MS and another for relocations of essential municipal structures in Moss Point, MS. Each of these two pilot projects would enable testing of key processes and design techniques aimed at reducing flood damages and preventing future loss of life and essential public emergency services during hurricane events. More detailed plans for the pilot projects would be prepared and submitted for approval at Division level prior to implementation.

CHAPTER 1. INTRODUCTION

Although coastal areas of the nation are attractive to commercial, industrial and residential developers, the consequences (as evidenced by Katrina and past hurricanes) associated with locating damageable property and unwary residents along the Gulf coast can be extreme. Despite years of regulation through the Federal Emergency Management Agency (FEMA) and other coastal zone management techniques, damageable property still remains in high-hazard areas and people still drown during surge and flooding from hurricanes.

In short, we must identify strategies and measures that can be used in tandem to both discourage development in high-risk areas and encourage growth in less hazardous areas of the coast. Some strategies and measures may be more appropriate for Federal action while others will be more attuned to local regulatory action and administration. In either case, these measures must be effective, socially acceptable, environmentally suitable and mindful of the existing neighborhood and community social and economic systems within which they would be implemented.

CHAPTER 2. NONSTRUCTURAL FLOOD DAMAGE REDUCTION

2.0 Gulf Coast Development.

According to a NOAA report published in 2003 ("Population Trends Along the Coastal United States – 1980 to 2008"), coastal population within the Gulf Coast region was projected to increase between 10 and 15 percent by 2008. Despite the damaging effects of Katrina, Rita and Wilma in 2005, areas of the gulf coast continue to grow in population and shoreline development. Some areas affected by Katrina in the project area have begun to rebound in large measure due to the reopening and success of the major employers and tourist attractions along the coast. Over 1,600 building permits for new single-family home construction were recorded within the 11 communities in the project area in 2006 (City-data.com).

In addition to the permanent households and commercial businesses that live and work along the Gulf Coast, millions of seasonal tourists visit these same coastal areas giving rise to the boom in vacation rental units, condominiums, second homes, and motels and hotels that populate the Gulf region. Tourist's primal attraction to the Gulf coast also feeds development of a plethora of amusement and recreation related uses that congregate on various boardwalks and beachfront property adding to the potential for high damages. Added to this burgeoning of development along the coast is the presence of millions of transient tourists who may be largely unaware of the threat that hurricanes and storms present to them.

2.1 Nonstructural Measures

Flood damage reduction measures are divided into two distinct components: structural and nonstructural. Structural measures in coastal areas usually concentrate on resisting the surge and wave action of storms and hurricanes. Off-shore and onshore barriers, seawalls, levees, flood gates, pumping systems and other structural measures can provide high levels of protection to coastal development. In-place development (residential, commercial, industrial, and institutional uses) is largely untouched during implementation of structural measures with the exception of acquisitions within the construction footprint of the project features. Much has been written about the positive benefits and negative impacts of structural measures along the nation's coastlines. Generally speaking, structural components have performed successfully during storms and hurricanes, but failures can and do occur when the design parameters of either structural or nonstructural components of a protection system are exceeded by extreme storm events.

Application of nonstructural measures or those measures directly associated with modifying the location, construction or operation of property, structures, and facilities located in hazard areas is one method of reducing storm/hurricane-related damages and saving lives that are at-risk. Nonstructural measures can be applied to both coastal and riverine hydrologic systems and have been proven to be affective in reducing damages and saving lives. Where nonstructural measures have been successfully instituted by local governments through floodplain management or other land regulation processes, the benefits and impacts of the protection process have been largely unreported. This lack of notoriety is due in part to the unit-by-unit or lot-by-lot system of protection (not very newsworthy), the relatively low cost when compared to other protection methods and the lack of massive mobilization of political or financial resources to accomplish these low-tech solutions.

Actions to either modify or remove development from at-risk areas to reduce damages can be applied in two general ways: first is to take direct actions towards the at-risk building or facility so as to modify its structural characteristics or location such that damages are reduced, and second is the application of incentives and disincentives through regulatory or economic processes that cause landowners to re-evaluate the costs and benefits of living in a hazardous location more carefully. Many existing regulatory and land valuation techniques exist that can influence individuals' choice of a building location. All of these techniques need to be considered. Nonstructural measures can be divided into several general categories including:

- Flood Preparedness
    - Hurricane/Storm identification, tracking and early warning
    - Temporary emergency evacuation and sheltering
- Modification of structures, facilities and/or the property on which they are located (a.k.a. floodproofing)
- Building construction regulations (building codes)
- Land use regulation by zoning that affects the type and location of land uses
- Floodplain management regulation, hazards zoning and insurance systems (NFIP/CRS)
- Property taxation, special development assessments and development fees
- Transfer of Development Rights and Purchase of Development Rights (TDR/PDR)
- Permanent evacuation of the hazard areas (permanent acquisition and relocation)
- Relocation of public structures and critical facilities

Each of these general categories of nonstructural measures can be applied as single measures or can be applied in combination with one another or with structural measures to address storm damages and loss of life. The range of benefits, costs and residual damages associated with application of each measure is broad. The extent and severity of social and economic impacts associated with the various measures can be likewise broad and must be identified for any plan. Depending upon the nonstructural measures selected for application and the relative percentage of each applied to the planning area, the future land use pattern of the area could be vastly different than that which existed prior to Katrina's landfall.

Finally, the ability of nonstructural measures to be implemented in very small increments, each increment producing flood damage reduction benefits (structure-by-structure), and the ability to initiate and close a nonstructural program with relatively minimal costs are important characteristic of this form of flood damage reduction. Also important is the ability to "tier" measures over long periods of project time such that a layering of measures, each one providing a higher degree of protection, is possible and given both Federal and non-Federal funding constraints probable. In order to affectively implement multiple layers of nonstructural protection within such a large project area, several tiers applied incrementally may be required before complete protection would be realized. The use of "tiering" will be discussed in more detail during plan formulation.

The following chapters will discuss the various nonstructural measures, program eligibility, nonstructural criteria, nonstructural formulation concepts and the applicability of these various measures in several alternative plans to the MsCIP project area.

CHAPTER 3. PROJECT AREA CHARACTERISTICS

3.1 General Description

Coastal areas of the United States are home to a substantial portion of the total population of our nation. Data published by NOAA in 2003 ("Population Trends Along the Coastal United States – 1980 to 2008") indicated that at least 153 million Americans live within the 673 coastal counties bordering the nation – a land area accounting for only about 17% of the nation's total land surface. This segment of the nation represents 53 percent of the total national population living and working in a continent-sized linear pattern that is subject to frequent and damaging storm events. One of those growing coastal areas has been the Gulf Coast in Mississippi.

The MsCIP project area consists of the Mississippi coast from the western border with Louisiana defined by the Pearl River to the eastern border with Alabama generally defined by Middle Bay. Figure 1 shows the distribution of the 11 municipal areas within the project area and several of the major connecting highways. The area is politically divided into three county governments (Jackson, Harrison and Hancock) and at least 11 municipalities. Three of the eleven municipal areas are grouped into two Metropolitan Statistical Areas (MSA). Prior to the arrival of Katrina in August 2005, the area boasted a population of over 220,000 persons. That population decreased dramatically as a result of Katrina, but is making a come back as local employment increases and the housing market slowly recovers.



Figure 1. Gulf Coast Communities (MRF graphic)

This 75 mile long coast has numerous physical features that make it a prime development location including three main inlets at Bay St Louis, Biloxi and Pascagoula, productive estuaries and wetlands, extensive beaches with flat to moderate topography adjacent to the beach area, and several off-shore barrier islands. The beaches draw millions of tourists each year to this Gulf paradise. The entertainment industry in the form of casinos and tourists attractions has spurred much growth along the beachfront areas. Numerous industries, some directly tied to the Gulf waters, populate the project area and several military and Federal Government-related complexes are dotted across the landscape providing employment and revenues to the local economy.

Several major transportation routes cross through the area including Interstate 10, Route 90 and the CSX railway line each running east-west across the area. The majority of the cultural development is concentrated south of Interstate 10 with agricultural and forested lands mainly north of Interstate 10. Each of the three major embayments associated with tributary rivers has extensive wetland areas associated with them.

3.2 Topography

Among the many characteristics of the project area that directly affect formulation of nonstructural measures, the surface elevation of the landscape with respect to the elevation of the Gulf waters is of paramount importance. Since nonstructural measures generally affect each parcel of property and each structure and facility, the ground elevation at each specific structure location is an important aspect of plan formulation. In the case of the Gulf coast, most structures are constructed on slab foundations therefore the ground surface elevation generally reflects the first floor elevation of the structure as well. For the purposes of data collection and analysis the project area was divided into 54 reaches. Using available GIS information and topographic data layers, the elevation of each tax parcel within the 54 reaches was determined. Table 1 shows the average elevation (NAVD 88) of the identified parcels (geographic center-point of each parcel) within each of the 54 reaches with respect to the Gulf surface elevation. Figure 2 is a graded-color representation of the elevations of the 54 reaches with respect to the Gulf surface. The color differences indicate the relative risks of surge inundation in the reaches. More detailed maps of the project area showing this elevation difference with respect to the Gulf waters are included at the end of this Appendix (See Figures 141 to 145).

Table 1.
Average Land Elevation by Reaches

Reach Number	Elevation	Reach Number	Elevation	Reach Number	Elevation	Reach Number	Elevation	Reach Number	Elevation
1	9.65	12	12.36	23	10.54	34	NP	45	NP
2	11.00	13	16.75	24	10.77	35	7.59	46	15.62
3	13.66	14	17.54	25	12.23	36	10.04	47	15.97
4	5.98	15	16.70	26	10.77	37	17.59	48	15.57
5	5.77	16	13.75	27	11.07	38	15.79	49	15.62
6	8.82	17	NP	28	9.47	39	15.74	50	12.47
7	12.05	18	13.60	29	11.70	40	15.45	51	9.58
8	8.81	19	6.21	30	12.20	41	12.04	52	10.29
9	8.32	20	11.99	31	8.60	42	NP	53	5.17
10	14.54	21	9.94	32	9.18	43	11.73	54	6.81
11	17.54	22	13.45	33	NP	44	NP		

NP – Due to the shape of the reach and parcels none of the identified parcel center-points fell within the reach

3.3 Urban and Community Development

3.3.1 Urban Development Patterns

As mentioned above, the project area is politically divided into11 municipalities contained within three counties. Three of the 11 municipal areas, Pascagoula, Gulfport and Biloxi form two Metropolitan Statistical Areas (MSA's) composed of Pascagoula (37700) and Gulfport/Biloxi (25060).

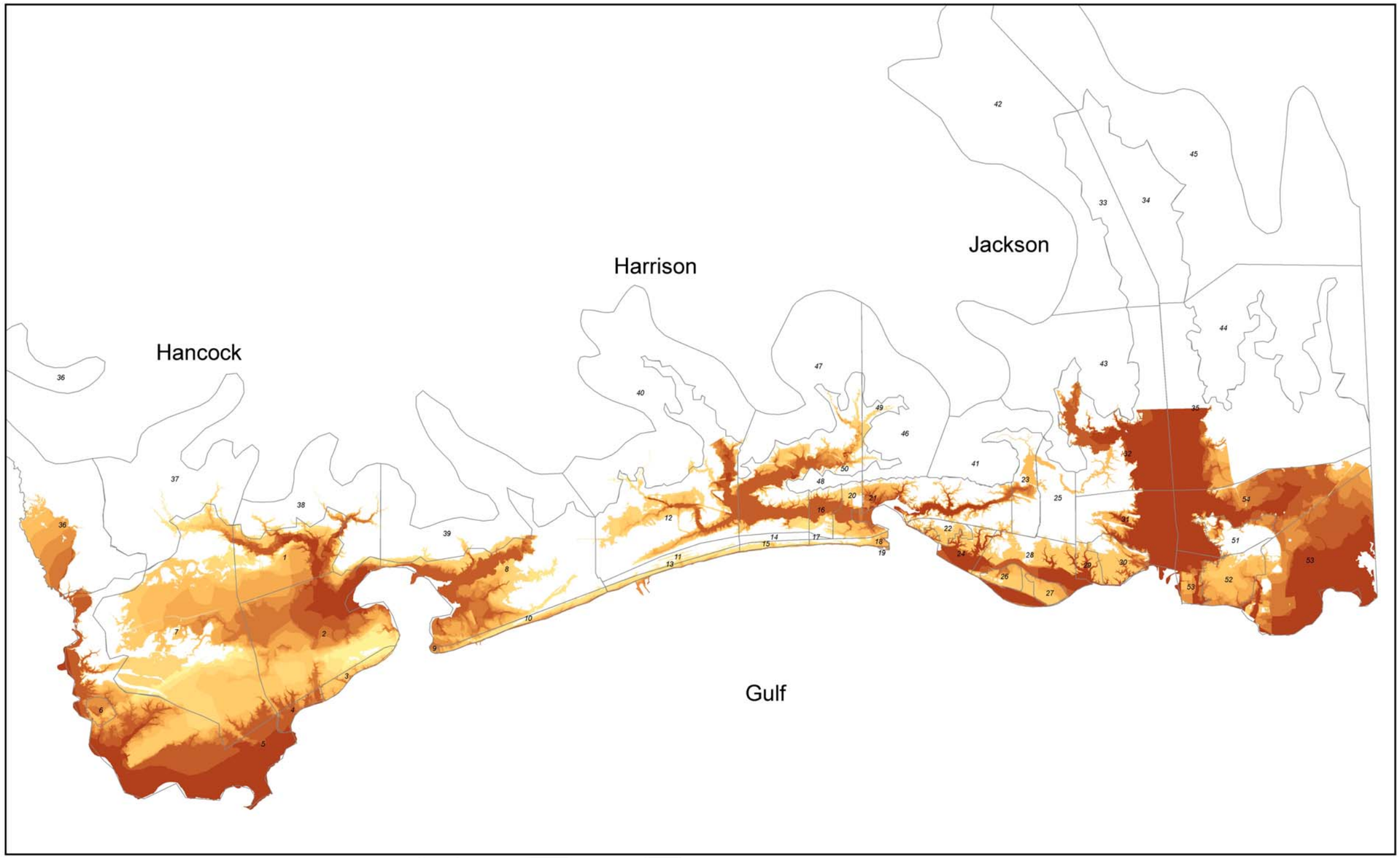


Figure 2. Land Surface Elevations of Economic Reaches w/Respect to the Gulf

MSA's are defined and redefined on a regular basis by OMB, but the basic designation of the MSA is based upon population size. MSA's combine both municipal and surrounding county populations for the purposes of Federal statistics collection. According to the 2000 Census the Pascagoula MSA had a population of 150,564 persons within its economic and social statistical area and the Gulfport/Biloxi MSA had a population of 246,190 persons within that same distinctive boundary.

That statistical designation carries weight when Federal funds are being distributed through social, infrastructure and national security programs. Figure 3 shows the MSA's of Pascagoula and Gulfport/Biloxi (dark green outlined in dark green border) and the 5 county areas included within their statistical boundaries (Picayune within Pearl River County is a separate micro statistical area not included within either the Pascagoula or Gulfport/Biloxi MSA's).

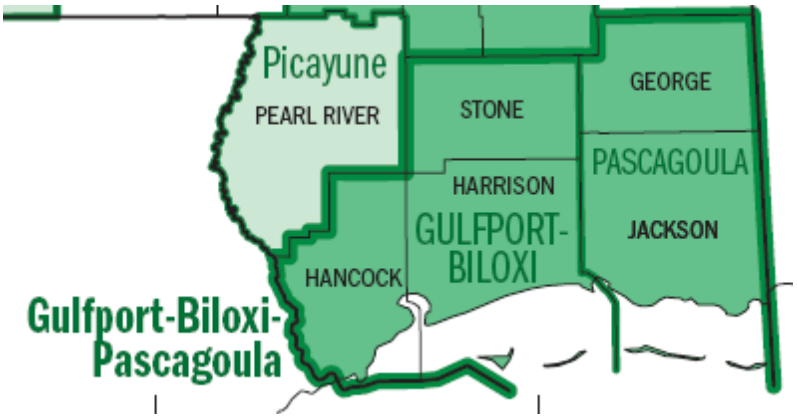


Figure 3. Metropolitan Statistical Areas within the Project Area

These more urbanized communities exhibit relatively large centers of commercial activity and a government core as well as a traditional grid-pattern street layout. All three have older central business districts that have been diminished somewhat by sprawl development that has aligned itself with adjacent transportation corridors (Route 90 and Interstate 10).

The development patterns of the 11 municipal areas are all unique to their location and topography, but most have a defined business/commercial and government center with surrounding various densities of housing and other land uses. Gulfport, Biloxi and Pascagoula have well-defined centers that are conducive to walking and transit services. Primary north-south access corridors from both Gulfport and Biloxi have resulted in a "sprawl" pattern of development emanating from those two centers.

These sprawl corridors have resulted in linear development patterns aligned with the highways. Other communities such as Bay St. Louis, Long Beach, and Ocean Springs have much smaller town centers near the beachfront and conform to a grid-pattern with less apparent sprawl. In some cases, the growing commercial districts of these municipal areas have located away from the beachfront and have aligned with Route 90 and other intersecting highways. Many of the tourist-centered commercial developments (hotels, motels, entertainment areas) migrated to the beachfront highways putting all of them in high-risk locations.

In addition to these older town centers, many of the Interstate 10 intersections bordering the project area have begun to sprout with hotels/motels, service stations, outlet stores and restaurants creating several new centers that attract travelers and offer some competition with the beachfront town centers. Several of the commercial areas near the interchanges have been annexed into the older beachfront municipal areas like Gulfport. Massive residential subdivisions (see below) have sprung up at the interstate intersections creating more flood-safe housing out of the reach of most hurricane

surge events. This recent trend in residential development (north of Interstate10) bodes well for what may have to be a long-term strategy to address future hurricane damages while maintaining the robust economic vitality of the region. Should predictions regarding sea level rise (as described in the future without-project condition scenarios) come to fruition, migration away from the beachfront to higher elevations may be an absolute necessity.

3.3.2 Community Development Patterns

There are several planned development communities (i.e. Diamondhead) in the project area that feature upscale housing and recreation amenities as well as several "golf-course communities" and at least one "fly-in" community within the project area. In contrast to the older grid-pattern urban centers, these newer subdivisions, gated communities and planned unit developments display a more curvilinear pattern with multiple cul-de-sacs and looping streets. These newer community structures are more vehicle-oriented. Additionally, there are several major military or military-related facilities in the project area around which some growth (where allowed) has occurred. These relatively stable employment centers provide a boost to the local economy and an injection of highly-talented people that provide leadership and human resources to local service organizations.

There are several industries and commercial establishments that are more attached to the waterfront than other community land uses. The casino complexes and water-related industries (Ingalls, Chevron, etc.) are required either by law or by function to be at the land-water interface and must remain in that location in order to function. By law the casinos are restricted to an 800 feet wide band along the waterfront, a location which places them in harm's way of hurricane surge, waves and winds. Major industrial employers such as Ingalls Ship Building and the Chevron Company must have facilities at the water's edge in order to either construct vessels or maintain oil platforms. Although these locations are highly hazardous, the continued presence of these major employers in the community is of paramount importance to the social and economic health of the project area.

Both Biloxi and Gulfport have substantial central business districts immediately at beachfront locations. Both of these centers as well as Pascagoula have high densities of commercial, business and residential uses with numerous recognizable neighborhoods. Within the counties there are numerous well-defined neighborhoods (many are named) and a few isolated and unincorporated communities scattered out in the estuaries. The amenities of the Gulf Coast have attracted many hundreds of vacation and second home developments contained in grid-street patterns built upon fills adjacent to the estuaries. Several of these subdivisions have a very low density of housing compared to what would be expected given the grid-street pattern. In contrast to the many upscale vacation housing developments, there are several "fishing-based" communities (i.e. Ansley) nestled into the estuary areas that also are subject to flooding.

3.3.3 Critical Facilities

As with any normal-functioning community, there are a plethora of buildings and facilities that could be classified as "critical facilities" within the project area. Included in this category of facilities are fire stations, police stations, emergency response/management facilities, hospitals, schools, medical clinics, transportation facilities, utilities, and public administrative buildings. All of these facilities, besides being a daily necessity to community life are very critical to the safety and protection of citizens during and after emergencies. Their location with respect to their service areas and inundation limits from storms and hurricanes is of paramount importance in the formulation process.

Both community colleges and state post-secondary educational facilities are located within the project area as well. A large number of churches of many faiths are scattered among the communities and have provided physical and spiritual support to their congregations and others

following Katrina. Much of the rebuilding occurring in the project area is occurring through the work of missions from allied denominations. The usual mixture of social services (welfare, children, clinics, etc.) and public services (utilities, solid waste, communications) account for numerous buildings and facilities throughout the project area – many of which are subject to inundation damages.

3.3.4 Non-Project Communities

In addition to the 11 communities included in the project area, there are numerous villages and unincorporated communities located just north of the I-10 corridor that serve as "bedroom communities" for the thousands of employees that support the tourism industry and commercial businesses along the coast. Few of these communities suffered from inundation damages due to Katrina, but damages to homes and businesses due to wind and rain were significant there as well. Although these communities may not be directly affected by the measures being formulated for the defined project area, they may be affected indirectly by certain measures such as relocations of residents along the coast through a large permanent acquisition program. A more in-depth look at these adjacent communities is included in Section 4.5.9.9.2 and Table 10 of this Appendix.

3.3.5 Historic Districts

A search of the National Park Service database for National Historic Districts identified 18 Historic Districts within the project area (see Table 2). These historic districts are located within the 11 communities discussed above. A Historic District in the United States is defined as a group of buildings, properties or sites that have been designated by one of several entities on different levels as historically or architecturally significant. Buildings, structures, objects and sites within a historic district are normally divided into two categories, contributing and non-contributing. Districts greatly vary in size, some having hundreds of structures while others have just a few significant structures.

Table 2.
Historic Districts on the National Registry

District Name	Community	County
Front Street Historic District	Pascagoula	Jackson
Krebsville Historic District	Pascagoula	Jackson
Orange Avenue Historic District	Pascagoula	Jackson
Indian Springs Historic District	Ocean Springs	Jackson
Lovers lane Historic District	Ocean Springs	Jackson
Marble Springs Historic District	Ocean Springs	Jackson
Old Ocean Springs Historic District	Ocean Springs	Jackson
Shearwater Historic District	Ocean Springs	Jackson
Sullivan-Charnley Historic District	Ocean Springs	Jackson
Biloxi Downtown Historic District	Biloxi	Harrison
Harbor Square Historic District	Gulfport	Harrison
Scenic Drive Historic District	Pass Christian	Harrison
West Beach Historic District	Biloxi	Harrison
West Central Historic District	Biloxi	Harrison
Beach Blvd Historic District	Bay St. Louis	Hancock
Main Street Historic District	Bay St. Louis	Hancock
Sycamore Street Historic District	Bay St. Louis	Hancock
Washington Street Historic District	Bay St. Louis	Hancock

Source: National Park Service Registry data

Some districts cover one or more city blocks while others contain entire neighborhoods or a defined geographic area. The 18 districts identified in Table 2 are listed in the Federal Registry. Other state and local entities may have identified other Historic Districts on the local level that are not included in the NPS database. Those locally significant districts will be identified in coordination with local organizations during more detailed planning of the nonstructural features.

A number of these historic districts are located in the inundation zones most damaged by Katrina and many of the significant structures contained within the districts have been severely damaged by that event. Efforts are currently underway to stabilize (Pilot Stabilization Program) some of the significant historic structures within the project area, some of these structures are included in the designated districts. Should nonstructural measures be formulated that would impact one or more of the Federally-designated historic districts, extensive coordination with the National Park State and the state historic preservation office (SHPO) would be required as part of the NEPA process. Measures that modify buildings or structures within the district to reduce damages (floodproofing) may be considered so long as the architectural or historical character of the structure is not significantly diminished. Options that would relocate large numbers of structures or the entire district to reduce damages would be more problematic.

3.4 Housing Resources

3.4.1 General

Residential units represent a substantial proportion of the total structure categories damaged by hurricane and storm flooding. Because of their relatively light construction (wood frame or masonry over wood frame), residential structures cannot withstand the rigors of hurricane force winds, surge and waves without attention to newer building codes (post-hurricane Andrew). Due to the preponderance of these structure types in the project area and their tendency to be located in high-hazard areas, damages to this category are significant in a major hurricane. More than 60,000 residential units were destroyed by Katrina's fury within the project area (Governor's Commission Report 2005).

As described above, the project area is composed of numerous communities and neighborhoods each having their own personality and character that visually and socially separates them from one another. One of the distinguishing features that separate communities and neighborhoods is the type, quality, quantity, density and age of the housing stock. The project area has a very diverse mixture of older classic-style residences, seasonal vacation cottages, upscale "mini-mansions" and various types of condominiums, townhouses and row-house resources. The more vernacular architectural types are located in the residential neighborhoods of the older urban areas but newer versions of those local architectural styles (i.e. Acadian-Creole) are being constructed in several areas of the project; some even floodproofed by elevation.

3.4.2 Housing Market and Stock Characteristics

Prior to the arrival of Katrina, the housing market in the project area was brisk with many single-family housing construction permits being issued in each of the communities. Table 3 shows the numbers of building permits that had been issued by each community for single-family home construction between 1996 and 2006.

As the table shows, the strong increases in population described in the Socio-Economic Characteristics Appendix during the past decade are reflected in the numbers of housing units being constructed. Of note are the large numbers of single-family residential units for which permits were issued in Ocean Springs, Biloxi and Gulfport during this period. In total, over 10,200 residential

building permits were issued during this 11 year period. Considering that many of these new housing units may have been within the footprint of the regulatory extent of the Base Flood Elevation (National Flood Insurance Program) and constructed so as to reduce flood damages through the local ordinances, the arrival of Katrina (a much greater depth of inundation) probably affected many of these more recent residential structures.

Table 3.
Building Permits Issued for Single-Family Home Construction by Community

Years	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Community											
Pascagoula	22	9	15	30	21	12	7	13	16	30	191
Moss Point	10	16	11	22	19	32	15	28	26	29	28
Gautier	45	54	71	84	55	46	71	95	109	68	145
Ocean Springs	78	79	88	130	121	129	139	152	163	75	87
Biloxi	93	NA	NA	151	139	135	NA	224	NA	120	186
D'Iberville	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulfport	264	265	301	406	346	271	307	291	336	228	484
Long Beach	86	68	63	116	66	76	80	82	87	62	99
Pass Christian	50	40	47	74	100	102	65	68	74	59	237
Bay St. Louis	23	34	34	39	37	37	42	45	45	0	0
Waveland	30	46	49	55	68	47	75	120	88	73	192
Total by year	**701**	**611**	**679**	**1107**	**972**	**887**	**801**	**1118**	**944**	**744**	**1649**

Source: City-Data.com NA = Data not available

This consistent rate of residential construction was not abated in 2007. Through June 2007, approximately 1,938 single-family construction permits were issued in the 11 communities and three counties. For communities that appear to be heavily developed already, this level of new residential construction indicates a very healthy and lucrative market for housing construction, mortgage financing and housing contractors in the area. Table 3 does not include building permits issued for multi-family units or condominiums, but field observations of substantial numbers of relatively new multi-family units by the team indicates a strong market in this type of residential construction as well. US Census data indicates that in 2007 (through June) multi-family building permits were issued resulting in construction of over 1,900 new units in the project area.

The 2000 Census data indicates that the average housing stock age across the project area is relatively young. Table 4 shows the relative ages of structures constructed across the project area. Despite the relatively young age of the housing, data indicates that over 6,000 structures still existed in 2000 within the project area that were built between 1900 and 1939. Built long before the use of modern building codes or floodplain management ordinances, these structures remain susceptible to flood and wind damages. Of note is the number of residential structures built during the period between 1970 and the present. Since the communities in the project area (with the exception of D'Iberville) all entered the NFIP in the early 1970's (See Table 7 on Page 44), many homes constructed in this period were subject to the provisions of the initial floodplain management ordinances. Since the year that the initial Flood Insurance Rate Maps (FIRM's) were identified, over 55,000 residential structures have been constructed in the project area.

Table 4.
Housing Unit Ages (2000-1900)

Years	200-99	98-95	94-90	89-80	79-70	69-60	59-50	49-40	39-00
Community									
Pascagoula	47	129	267	874	3094	3161	1641	1022	707
Moss Point	35	68	87	414	1493	2024	1106	607	435
Gautier	81	344	274	995	2150	652	87	28	34
Ocean Springs	263	576	360	1065	2256	1529	597	134	312
Biloxi	613	1742	1550	3253	4734	3535	3433	1823	1464
D'Iberville	294	382	232	411	851	369	337	119	74
Gulfport	542	2362	1819	4455	7507	6174	3303	1782	1649
Long Beach	185	813	297	1317	1831	1939	506	189	218
Pass Christian	96	425	167	419	682	698	333	162	331
Bay St. Louis	90	236	130	576	687	608	451	258	770
Waveland	71	287	170	751	632	713	366	202	290
Totals	**2317**	**7364**	**5353**	**14530**	**25917**	**21402**	**12160**	**6326**	**6284**

Source: 2000 US Census (Compiled by City-data.com)

Residential densities range from 1 unit per several acres to 10-20 units per acre in more urban settings. Table 5 shows the densities of housing units (single-family and condominiums) in each of the 11 communities and the relative sizes of the communities in square miles. According to the Governor's Commission on Recovery, Rebuilding and Renewal (2005), more than 134,000 homes were damaged by Katrina and at least 65,000 homes were completely destroyed by the storm. Another 50,000 had flood damages and only 35,000 of those homeowners had flood insurance. The 2000 Census indicates over 152,000 dwelling units were located within the three county areas prior to the arrival of Katrina. Of those dwelling units, 136,000 were listed as full-time occupancy and 4,600 were listed as seasonal or vacation homes. Median housing values ranged from $80,300 to $92,500 prior to Katrina.

Table 5.
Residential Housing Densities (Units per Square Mile)

Community Name	Density per Square Mile	Land Area (square miles)
Pascagoula	721	15.2
Moss Point	251	25.0
Gautier	379	12.2
Ocean Springs	609	11.6
Biloxi	582	38.0
D'Iberville	647	4.74
Gulfport	520	56.9
Long Beach	722	10.1
Pass Christian	393	8.4
Bay St. Louis	622	6.12
Waveland	511	6.8

Source: City-data.com

3.4.3 Housing Styles and Patterns

According to the Pattern Book for Gulf Coast Neighborhoods (2005), a section of the Mississippi Renewal Forum report, there are several distinctive, residential architectural styles found in the project area. Those architectural styles include Acadian-Creole, Victorian, Classical, and Arts and Crafts. Most of these styles were constructed based upon pattern books popular prior to World War II. Within those 4 general architectural categories are building types such as side-hall or “shotguns”, cottages, L-shaped, side gable, pyramid (reflects the roof profile), and townhouses (primarily in dense urban areas). These styles and building types are scattered across the entire project area within the denser urban areas (Biloxi, Pascagoula and Gulfport) as well as the more rural areas of Hancock County. More recent developments across the area reflect modern housing styles such as the one-level “ranch”, split-level, and modifications of several classical styles (Georgian, Tudor, and Greek Revival). Nonstructural measures that directly modify the building construction or add structures in close proximity to the building should be aware of the sensitivity of theses types and styles.

As described above, housing is distributed across the project area in a number of interesting development patterns. Urban housing (townhouses) is associated directly with central business districts like Biloxi and Gulfport and is arranged in distinctive and named neighborhoods emanating from the municipal center. Other concentrations of housing occur along linear streets extending from the beachfront to the CSX railway corridor from Biloxi to Pass Christian in Harrison County and in numerous neighborhoods scattered along the back bays. Much of the older housing in Hancock County is concentrated in Waveland and Bay St. Louis between the CSX railway corridor and the beachfront. Many of these older units were devastated by Katrina. Newer subdivision developments are concentrated along Route 90 with the commercial development. Several outlying, isolated communities such as Ansley and Pearlington are located in western Hancock County and are also subject to flood damages. Housing development patterns in Jackson County range from grid-block urban layouts in Pascagoula and Moss Point to the outlying subdivisions of Belle Fontaine, Gulf Park Estates and the golf course development at St, Andrews.

There are a number of exclusive housing developments scattered throughout the project area. Many of these are associated with golf course developments, airfields, or other recreation facilities (marinas). Housing units within these upscale developments are mostly single-family detached units with some single-family attached condominiums as well. The character of the housing market shifts to a more rural farm style north of Interstate 10 with many large farms and large-lot zoning areas. Some new subdivisions associated with constructed lakes or other amenities are also located north of Interstate 10. Most of these areas were not affected directly by the Katrina surge inundation.

3.4.4 Alternative Living Quarters

Although not directly associated with the housing market, but equally important to formulation of nonstructural measures is the distribution of people living in quarters other than the traditional housing discussed above. Table 6 shows a snapshot of these alternative living arrangements within the project area for communities where census data was available. The 2000 Census lists a number of alternative housing situations for people living in the 11 communities within the project area. Among those alternative housing options are nursing homes, military barracks, correctional facilities, and centers for delinquent or disturbed children and adults, hospital wards for long-term chronic conditions, college dormitories, and non-institutional group quarters.

Table 6.
People Living in Alternative Living Quarters

Alternatives	Nursing Homes	Military Quarters	Correctional Facilities	Mental Health Centers	Hospital Wards	College Dorms	Other Quarters
Communities							
Pascagoula	120	827	257	30	8	0	22
Moss Point	126	NA	16	NA	NA	NA	NA
Gautier	NA	NA	NA	28	NA	NA	24
Ocean Springs	98	NA	4	NA	NA	NA	91
Biloxi	219	2587	NA	20	416	73	108
D'Iberville	NA	NA	NA	NA	NA	NA	NA
Gulfport	243	1137	1059	31	74	93	688
Long Beach	30	NA	NA	NA	161	NA	27
Pass Christian	197	NA	NA	NA	NA	NA	NA
Bay St. Louis	157	NA	133	9	NA	NA	26
Waveland	NA	NA	NA	17	NA	NA	7
Totals	**1190**	**4551**	**1469**	**135**	**659**	**166**	**993**

Source: City-data.com, (US Census 2000). NA = not available

Although the data is incomplete for many areas (many NA's) and types of alternative housing situations (these are not popular community marketing statistics), this data shows that over 9,000 persons, many with disabilities, may be living in specialized centers within the project area at any one time. During a hurricane or storm flood emergency that could affect one or more of these centers, evacuating this segment of the population would be at best problematic. As was evident in the evacuations of hospitals, nursing homes, correctional facilities and other specialized populations during Katrina and Rita in 2005, providing the necessary transportation, security and accommodations for these groups takes pre-planning and good coordination between the evacuated area, transportation providers and the shelters. Having sufficient warning time to evacuate these individuals is critical to reducing loss of life during extreme weather events. Although such evacuations have been successful (with some problems) in the past, other options to permanently relocate these less-fortunate or quartered individuals to less flood-prone areas should be considered in the nonstructural formulation.

3.4.5 Historic Homes and Buildings

A search of the National Register of Historic Buildings database for the 11 communities within the project area identified at least 114 structures, homes, schools, libraries, churches, theaters, hotels, public buildings, taverns, railroad depots, banks, fire stations, commercial and military buildings and sites. Many of these structures were damaged by Katrina and efforts are underway through a MS Pilot Stabilization Program to save the damaged historic structures. Table 37 in this Appendix shows a listing of these historic buildings and sites in the project area. Of those listed, only "Beauvoir" in Biloxi is considered a National Historic Landmark by the NPS. The "site" listings refer to archeological sites for which nonstructural protection measures would not be considered.

In addition to those structures listed in the National Register, there are a number of structures considered by the State of Mississippi and local organizations to be significant to the region's history. Although not considered important enough to be listed nationally (some may be in that process currently), their importance from a state or local perspective warrants consideration in the nonstructural planning process. Coordination with the state and local organizations to determine the locations, flood-risks, and potential protection measures for these important structures will continue during more detailed planning for the nonstructural measures.

Although unconfirmed at this level of planning analysis, it is possible that a significant number of structures listed on either the National Register or on state and local historical lists are located within inundation hazard zones where nonstructural protection options (wet or dry floodproofing) may be limited by wave action and surge depths. The numbers of historic structures being considered in the MS Pilot Stabilization Program indicates that many of these precious resources were damaged by Katrina. Floodproofing historic structures by elevation may be possible but maintaining the historic and architectural significance of a structure while raising the first floor 10 feet would be problematic. For obvious visual reasons dry floodproofing such a structure by constructing a ringwall or veneer wall around the building would be limited to a very low level of protection (4 feet or less). In areas where floodproofing would not be considered (high-hazard wave/surge zones), acquisition and relocation could be used to protect the building in another suitable location, but that option would require extensive coordination with the National Park Service and the SHPO. Replicating the building site so that the historic or architectural character of the building is not significantly diminished would be difficult.

Extensive coordination with the Mississippi SHPO and the National Park Service would be required during more detailed planning and engineering studies for implementation of nonstructural measures that would potentially affect structures or sites listed on the National Register.

3.5 Other Federal Disaster Assistance Programs in Coastal Mississippi

In addition to the nonstructural flood damage reduction program outlined in this Appendix, there are at least two other significant Federal programs currently operating within the communities of the project area. Both the Federal Emergency Management Agency (FEMA) and the US Housing and Urban Development Administration (HUD) have ongoing programs within the project area that are designed to reduce future damages or to compensate landowners for damages as a result of the Katrina event.

3.5.1. FEMA Assistance Programs

FEMA has been operating several post-Katrina programs designed to compensate landowners for storm-related damages, reconstruct and repair damaged structures and reduce future flood damages and loss of life due to hurricane surge and other storm-related threats. FEMA administers the Individual Assistance Program (IAP), Public Assistance Program (PAP), Other than Housing Needs Assistance Program, Debris Removal Program, Temporary Housing Program and the Hazard Mitigation Grant Program within the project area. Each of these programs targets a specific need for either individuals and families or the public sector (public buildings and facilities and infrastructure) and portions of the programs are administered locally by The Mississippi Emergency Management Agency (MEMA). To date over 350,000 individuals and families have been helped by the assistance programs. Most of these grant programs cover losses or needs over and above any flood insurance payments that may be available to the landowner and the grants are provided tax-free.

The individual assistance program provides grant funds to individuals and families for temporary housing, the repair, replacement or reconstruction of homes damaged by Katrina. Those repairs must be made in conformance with NFIP requirements according to the local floodplain management ordinances and the funds do not cover losses to second or vacation homes in the project area. This disaster assistance program is implemented under the Individuals and Households Program (IHP) and provides grant assistance for re-establishment of households in the affected areas. Opportunities for applying flood damage mitigation measures to damage homes are encouraged by FEMA administrators but for those landowners without flood insurance, but receiving

disaster assistance, the mitigation measures are optional. Additional long-term recovery funding can be provided through low-interest loans from the Small Business Administration.

MEMA is also administering the Mississippi Alternative Housing Program that places dislocated families into new “Mississippi Cottage” as alternative housing solutions to travel trailers and mobile homes. The Mississippi cottage is a 308 square foot home that has been designed to withstand hurricane force winds and be constructed for about $35K. Based upon FEMA sources, about 2,400 families and individuals have been moved from temporary trailers into the Mississippi Cottages.

As of April 2008, over 200,000 individuals and families have received Housing Assistance payments and over 130,000 have received Other Needs Assistance grants. Total payments to these two components of the FEMA assistance program have reached $1.2 billion to date. In addition, more than $2.8 billion has been obligated by FEMA in their Public Assistance program helping to reconstruct public buildings and facilities, utilities, roads and bridges and recreation facilities. The Corps’ debris removal funds were included in this total as well with additional funds provided to the US Coast Guard for marine debris removal (data source: http://www.fema.gov/news).

The Hazards Mitigation Grant Program is also being administered in the project area through the Mississippi Emergency Management Agency (MEMA). This program provides grant funds to address flood damages for structures and property that are subject to repetitive flooding or were damaged by Katrina and had been identified for acquisition in the state All-Hazards Mitigation Plan. Projects must show savings greater than costs. A recent $96.5 million hazard mitigation grant to Louisiana was provided to elevate 3,000 structures in accordance with NFIP. Some of the activities that can be implemented under the HMGP to protect either public or private property from future flood damages are:

1) Acquisition of real property for willing sellers and demolition or relocation of buildings to convert the property to open space use

2) Retrofitting structures and facilities to minimize damages from high winds, earthquake, flood, wildfire, or other natural hazards

3) Elevation of flood prone structures

4) Development and initial implementation of vegetative management programs

5) Minor flood control projects that do not duplicate the flood prevention activities of other Federal agencies

6) Localized flood control projects, such as certain ring levees and floodwall systems that are designed specifically to protect critical facilities

7) Post-disaster building code related activities that support building code officials during the reconstruction process

In addition to the HMGP, FEMA offers grants for flood damage reduction through the Pre-Disaster Mitigation Program (PDM) as well. Project components are similar to those described above for the HMGP but can be implemented prior to a disaster event. Again, the PDM is administered through the state and local governments in a designated area and projects must be included in the state all-hazards mitigation plan to be eligible for grant funds.

3.5.2. HUD Assistance Programs

The Homeowner Assistance Grant Program (a.k.a. HAP) is a disaster recovery program being implemented through the Mississippi Development Authority for those areas specifically damaged by Katrina hurricane surge inundation. The program is generally available to low to moderate income households (up to 120% of the median household income) with limited funding for higher-income households. The program is being implemented in two phases – phase 1 for those structures located outside the 100-year flood zone established in the Flood Insurance Rate Maps (FIRM) but were flooded by the Katrina surge and phase 2 for those structures damaged by hurricane surge and located within the 100-year flood zone mapped in the FIRM.

The program has two components. The first component is a compensation grant of up to $150K (phase 1) to compensate homeowners for losses to single-family, owner-occupied duplexes or mobile homes due to flooding by surge that were not covered by insurance. The percentage of the total grant available is dependent upon the insured value of the home times the percentage of damage determined in a damage assessment. Homeowners may repair, replace or reconstruct homes as they choose with the funds. No local permits for home repair or construction or evidence of the use of the funds for those purposes is required by HUD or MDA. Homeowners having flood insurance must comply with NFIP requirements for elevating the structure and may apply for the second component of the program – the elevation grant – to defray the costs of elevating the home. In phase 2 of the HAP, the compensation grant amount is limited to $100K.

The second component of the HAP is the elevation grant and is available to homeowners who did not have flood insurance through the NFIP. The $30K grant helps to defray the cost of elevating the home and is payable in two installments - $15K when the elevation permit is obtained and $15K when an occupancy permit is obtained. This grant is available to homeowners also receiving the $100K compensation grant for residential structure damages under the phase 2 program. Neither HUD nor MDA are providing direct oversight for the elevation design or construction processes, but are relying on local NFIP and building code inspectors to assure compliance with the local ordinances.

Neither the compensation grant program nor the elevation grant program restricts any homeowner from rebuilding a destroyed or substantially damaged structure or elevating a damaged/repaired structure in the new DFIRM-designated V or VE zone. The only requirements are compliance with current NFIP guidelines as described in local floodplain management ordinances and current building codes. Any structure being elevated under either program would be raised to the new BFE established in the DFIRM flood zone mapping. This new BFE elevation may be several feet lower than the surge elevation that came ashore with Katrina. Residual damages during a Katrina-like storm as a result of implementing these elevation and compensation programs could be significant.

As of May 15, 2008, the HAP has received 19,401 applications for Phase 1 and 8,534 for Phase 2 of the program and has distributed grant funds to 20,437 of those applicants totaling more than $1.4 billion.

In addition to the Homeowners Assistance Program discussed above, the MDA is implementing, through the HUD Community Development Block Grant (CDBG) program, the Long Term Workforce Housing Program. The purpose of this program is to provide grants and loans for local jurisdictions, non-profits and for-profit organizations to provide long-term affordable housing in the three coastal counties and Pearl River County. These funds can be used to repair, rehabilitate, or reconstruct housing units for low and moderate income families and must include at least 40 dwelling units for each grant or loan request. The program projects that as many as 5,800 housing units may be created in these four counties.

Among the program requirements are adherence to local building codes and the NFIP for determining first floor elevations of new or rehabilitated structures. Existing structures considered for repair or rehabilitation that suffered damages more than 50% of the structure value by hurricane surge flooding must comply with elevation requirements through the NFIP and local floodplain management ordinances. Applications for Phase 2 of this program are being taken currently.

Sections 4.5.8 and 4.5.9.7 of this appendix address the opportunities for integrating the FEMA and HUD programs with the formulated plans in this report.

CHAPTER 4. IDENTIFICATION AND PRELIMINARY SCREENING OF NONSTRUCTURAL MEASURES

4.1 General

There are a number of measures that can be classified as “nonstructural”. In some cases such as dry floodproofing by the use of ringwalls or ring-levees, a nonstructural measure can approximate a structural solution when expanded to protect a large contiguous complex (college campus, industry, or commercial area). When judiciously applied, nonstructural measures can result in reductions in inundation damages and losses of life to structure occupants. Corps of Engineers documents and regulations as well as the technical papers and bulletins of other Federal and state agencies that address flooding from storms and hurricanes contain lists of possible nonstructural measures. Generally speaking, each of these identified measures can be applied either singly or in combination with other nonstructural or structural measures to attain project goals and planning objectives. Screening of the measures can be accomplished in a preliminary fashion by considering lessons learned from previous nonstructural projects, potential socio-economic impacts, environmental justice issues, and political realities of implementing certain measures at the local government level.

4.2 Damage Categories

Prior to identifying potential nonstructural measures, a quick review of the damage categories to which the measures may be applied is warranted. These categories generally represent the sphere of land uses and property ownership options in the project area. These categories include:

1. Private properties occupied by residences (single-family and multi-family)
2. Private properties occupied by commercial structures and facilities
3. Public properties occupied by public buildings and facilities (Federal, state, municipal and county owned) or other damageable items
4. Private properties occupied by entertainment structures and facilities
5. Private properties that were vacant prior to the Katrina event
6. Private properties that were made vacant by the Katrina event (total structure or facility loss.
7. Public properties that were vacant or made vacant by Katrina.
8. Public properties occupied by industrial development
9. Private properties occupied by industrial development
10. Public utility corridors and installations (substations)
11. Public properties occupied by transportation modes
12. Private property occupied by transportation modes
13. Public parks and open space

Each of these damage categories (listed as either private or public property and attendant structures or facilities) can be addressed by one or more nonstructural measures and several categories of land use include contents damages as well. These land uses and associated structures and facilities are already addressed in county and municipal zoning ordinances, comprehensive plans and floodplain management ordinances. However, there remain a substantial number of at-risk structures and facilities subject to flood damages from hurricanes and storms.

4.3 Loss of Life Issues

Damages to private, corporate and public property along the Mississippi coast were in the billions of dollars, but the most compelling losses were those to human life in the state due to Katrina. Estimates are that more than 250 people perished during the storm in the project area and more than 60 were unaccounted for following the storm and presumed to be missing or dead. The combination of surge, waves and wind overpowered many who either attempted to ride out the hurricane or were trying to escape the storm and waited too long to avoid the surge and waves.

Many who were able to ride out Camille in 1969 believed that they could weather Katrina inside their homes only to discover too late that the surge depths far exceeded previous storms and they perished as their homes were destroyed or as they were fleeing in desperation. Personal interviews from survivors during the planning process revealed numerous people were unable to escape because key evacuation routes were submerged during the storm. Many survivors clung to roofs and trees to escape the surge flooding and waves.

Detailed information on the number of dead within each community or neighborhood, locations of the recovered bodies with respect to their place of residence and the cause of death (drowning, heart attack, impact injuries, etc.) are unavailable at this time due to the sensitivity of that information. Hopefully that information can be disclosed by state agencies during later more detailed planning so that identified high-hazard zones where permanent evacuation may be the most advantageous option and the need for timelier hurricane warnings and safe evacuation routes can be better supported for implementation.

Issues of public safety and loss of life during these extreme weather events have become more significant in the planning process since Katrina. The ability to provide timely storm warnings, safe escape routes and safe shelters is a key component of reducing future loss of life along the coast. In some cases, permanent evacuation of some coastal neighborhoods may be the best way to assure public safety and avoid future losses of life. Alternative plans that integrate various nonstructural measures for the purpose of reducing loss of life will be explored during the plan formulation process.

4.4 Goals and Objectives

The main body of the MsCIP report displays a number of project goals and objectives that address the existing conditions listed in the project study authority. Existing problems to be addressed in the study authority include: 1) hurricane and storm damage reduction, 2) prevention of saltwater intrusion, 3) preservation of fish and wildlife, 4) prevention of erosion, and 5) other related water resource purposes. From these problems, the MsCIP team in coordination with project area stakeholders and cooperating agencies developed goals and objectives that would guide the planning process and could be used to evaluate formulated measures and alternative plans. During the study process, one goal began to emerge that summarized the efforts of the team; formulation of alternative plans that as a result of their implementation, would enable the Mississippi coast to become a disaster-resilient community.

Among the many objectives developed to support that emergent goal (disaster-resilient community) are several that can be directly addressed by nonstructural measures. Those include:

1) Reduction of the potential for future storm created flood damages,

2) Reduction of the potential for future storm related threats to life and safety,

3) Reduce costs for storm related emergency services,

4) Provide environmental justice in recommended solutions,

5) Provide complete solutions (in accordance with the P&G),

6) Provide solutions “acceptable” to communities & resource agencies,

7) Provide environmentally sound solutions,

8) Provide solutions that fit within existing laws, policies, regulations, and the general plans of local governments and communities,

9) Minimize impacts to the environment, and

10) Generate opportunities for ecosystem restoration of wetland habitat.

It is for these stated objectives that potential nonstructural measures and their integrated plans are formulated and against which they will be evaluated for effectiveness, cost effectiveness, completeness, acceptability and environmental suitability.

4.5 Potential Nonstructural Measures

The nonstructural measures described below can be grouped into several general categories including:

- Flood Preparedness and Emergency Evacuation
- Floodplain Management, Floodplain Zoning, Flood Insurance and CRS
- Building Codes
- Land Use Regulation and Zoning
- Development Impact Fees, TDR, TPR, and Redirection
- Land Taxation Policies, Special Assessments and Revenue Sharing
- Floodproofing
- Permanent Acquisitions (Evacuation and Relocation)
- Relocations of Public Buildings (Critical Facilities)

In an effort to simplify the formulation of nonstructural plans and reduce repetition of evermore detailed evaluations of the measures, the following paragraphs include a description of the individual measures, how they might apply to the project area given existing conditions, costs associated with the measure, operations and maintenance costs and whether the measure should be carried forward into the more detailed project formulation process (a preliminary screening of the measures).

4.5.1 Flood Preparedness and Emergency Evacuation

4.5.1.1 General

Flood Preparedness includes a multitude of management activities and features that all contribute to a reduction of flood damages and reduced losses of life due to hurricanes and storms. These management activities can apply to the emergency operations of Federal, state and local agencies as well as to the response actions of individual property owners. During the days and hours that preceded the arrival of the identified and tracked storm known as Katrina, agency emergency operations and landowner responses were already taking place that saved countless lives and reduced property damage. That many more did not perish in the event is a testament to the fact that sound flood preparedness and emergency evacuations were successful.

Generally speaking, storm warnings and emergency evacuations fall under the purview of the National Oceanic and Atmospheric Administration (NOAA) and the Federal Emergency Management Agency that includes offices at state and local levels of planning and deployment. Although the Corps of Engineers is not a direct player in these types of flood damage reduction components, the Corps does support these activities as an important part of reducing flood damages and reducing losses of life. The following measures outline the types of storm/hurricane warnings and emergency evacuation management activities that could be implemented by Federal, state and local managers.

4.5.1.2 Research Findings

Among the many post-disaster studies of hurricane-readiness in the project area, a study conducted by the Harvard School of Public Health (2007) using a random sample of 513 residents by telephone interview revealed interesting attitudes and concerns of the local population regarding flood/hurricane preparedness. Besides the 8 demographic questions included in the survey, each respondent was asked 48 questions regarding their individual or household preparations and specialized needs for evacuation in the event of a future hurricane. Most of the respondents (95 percent) had experienced Katrina and either suffered damages to their residence or were aware of damages in the area.

Many of the respondents indicated a renewed interest in preparedness and had equipped their households with substantial resources and supplies in the event of a future storm. A majority of the respondents indicated as well that they would evacuate the area if told to do so by government officials. If an evacuation were necessary, many indicated that they would leave by personal vehicle and would stay with family or friends up to 200 miles away from the coast. For those who indicated that they would evacuate many concerns were expressed about the safety and capacity of evacuation centers to handle the evacuees. Issues of water and food supplies, safety, sanitary facilities, over-crowding, and medical care were expressed by respondents.

For those who may have chosen to remain in hazardous areas during a hurricane, the primary reasons for staying at their residences included: 1) considered home to be well-built and would be safe staying, 2) concerns about theft and damages to the evacuated home, 3) believed that the roads would be too crowded to safely evacuate, 4) believed that evacuation would be dangerous and 5) needed to take care of someone who would be physically unable to evacuate. All of these issues should be addressed as revisions to certain aspects of the evacuation system to assure that residents who may be in serious peril do not feel compelled to remain during a hurricane and those who choose to evacuate can do so safely and with limited stress.

Studies, such as the one described above, give valuable information regarding the concerns and issues confronting the project area population who would face more hurricanes in the future. Formulating a robust flood preparedness and evacuation system that addresses these concerns is

one of the objectives of the nonstructural PDT. The many components of flood preparedness and potential upgrades of that system are discussed below.

4.5.1.3 Storm/Hurricane Identification, Tracking and Forecasting

Generally, the majority of hurricanes and coastal storms capable of inflicting significant damages to structures in the V-zone develop over days within the Gulf basin. Fortunately, this developmental period allows the National Weather Service and the National Hurricane Center the opportunity to provide ongoing information on the formation of the storms and their probability of making landfall at one or more areas of the Gulf Coast. The opportunity to identify the storm threat, forecast its probable movements and issue advanced warnings for temporary evacuation of high-hazard coastal areas can lead to substantial lessening of loss of life and property damages.

One can only imagine with horror the potential loss of life and property losses that would have occurred had not Katrina been so well tracked and advanced warnings issued for mandatory evacuation of portions of the Gulf coast. Regrettably many who survived Camille in 1969 decided to weather out Katrina rather than evacuate – their names were listed among the dead or missing. This sad fact points out that a flood warning and emergency evacuation program has many facets - any one or combination of which left uncompleted or unheeded can lead to disaster.

The warning and evacuation system is composed of several components: 1) Threat identification and analysis, 2) Forecasting, 3) Dissemination of threat warning, 4) Threat understanding, 5) Evacuation and 6) Sheltering. Today the ability to see the development of hurricanes and major storms within the Gulf is aided by a great number of sophisticated technology and data sources. Weather satellites, Doppler radar imaging, hurricane hunter aircraft, reports from ships at sea, reporting oil rigs, moored buoys, Caribbean weather stations, and many other proven data sources can track an approaching hurricane, tropical storm or major low-pressure system in real time and generate reliable data upon which forecasts of direction, speed, and intensity can be based. Both polar orbiting and geostationary weather satellites provide storm images in visible light and infrared, as well as showing water vapor images of these storms.

Land, ship or aircraft-based Doppler radar provides a detailed picture of rainfall intensity, speed and circulation characteristics within the storm. NEXRAD or “NEXt generation doppler RADar” is much more sophisticated allowing closer examination of rainfall intensity, storm direction and speed as well as measuring wind speeds (motion of dust particles within the storm) in the absence of rainfall. NEXRAD, with a range of more than 140 miles from the radar site, provides much better information on the intensity and speed of hurricanes and other storms in the gulf. There are NEXRAD stations in New Orleans, LA, Biloxi, MS (Kessler AFB), and Mobile, AL. Radar imagining from these three stations overlaps the entire Mississippi coastal area.

In addition to satellite imagery and land and ship based radars, the on-station telemetric data and information generated by the hurricane hunter aircraft provides forecasters a more complete picture of hurricanes and other major storms in the gulf. Flights into major storms begin when storms are still classified as tropical depressions and tropical storms by their pressure and wind speeds. Using Doppler radar and “dropwindsondes” that are dropped from the aircraft during the flight, readings of barometric pressure, wind speed, air and water temperature, storm direction, and speed are delivered at regular interval flights into the storm. These aircraft

The National Weather Service (NWS), a department of the National Oceanic and Atmospheric Administration (NOAA), operates and maintains a series of moored buoys in the Gulf of Mexico that provide a real-time stream of weather and oceanic data. The buoys range in size between 12 meter diameter discus buoys and 3 meter diameter buoys and most are tethered to the ocean floor. Other buoy types include spar buoys with multiple moorings and wandering buoys (NOMAD). Because of their size and sturdier construction, the 12 meter discus buoys are more reliable in hurricane and storm conditions resisting capsizing and wave damage to the structure and instrumentation. Figure 4 shows a 12 meter discus buoy being serviced. Larger buoys such as the 12 meter discus buoy are towed into position by Coast Guard vessels. Spar buoys although more expensive in capital and O&M costs are more stable platforms for satellite telemetry than the discus buoys. Information on air and water temperature, atmospheric pressure, wave heights and wave period, wind direction and speed, and other weather data is up-linked to communication satellites and weather stations along the Gulf.



Figure 4. 12 Meter Discus Buoy (NBDC Photo)

This “hurricane DEW Line” system provides reliable data to the National Weather Service on the speed direction and strength of approaching storms, tropical storms and hurricanes. In addition to the hurricane hunter aircraft that provide atmospheric and ocean condition data from within the storm itself, these buoys relay constant data on weather and ocean conditions at the water surface. The National Buoy Data Center (NBDC) Web Site provides ongoing updates of the buoy data in the Gulf. That web address is: http://www.ndbc.noaa.gov/.

One component of this measure could be buoy system upgrades in the Gulf coordinated with NOAA. Consideration should be given to whether or not additional reporting buoys in the gulf would provide a better picture of the strength, direction and speed of hurricanes, tropical storms and other ocean phenomena that would endanger the coastal area of the state. Having better and more reliable information on the expected height of the storm surge and associated waves would assist emergency personnel in making more informed and quick decisions about which coastal inundation zones are at risk from a particular storm. The inability to correctly select which inundation zones should evacuate quickly erodes the public’s confidence in the warning and evacuation systems.

During Katrina’s relentless approach to the coast, a number of reporting buoys in the middle of the hurricane broke free of their moorings and drifted from their known positions. Although the buoys kept reporting data, without a reliable position, the NWS had no way to locate where those conditions were in relation to the eye of the storm. Consideration should be given to modifying the existing buoys through NOAA programs so that “break-a-ways” during extreme hurricane events due to huge waves or extreme surge depths will not void the valuable data being relayed to the NWS.

Based on information gleaned from NOAA online sources, the installation of the 12 meter discus buoys cost in the range of $2.5M to $3.5M per buoy depending upon water depth and towing

distance. This cost includes buoy construction, installation of instrumentation, towing to the Gulf site and anchoring the buoy. Annual O&M cost for the 12 meter discus buoy is approximately $500,000. Capital and installation costs could be shared between implementing agencies or with a project sponsor and annual O&M cost would be borne by NOAA (cost data supplied from NOAA publications).

Having more precise information on the intensity, location, track and anticipated landfall of severe storms is the basis for any storm warning and emergency evacuation system. Since these measures all contribute to having more precise information on the level of threat that any particular storm or hurricane poises as well as better information to determine where and when the effects of the storm will make landfall, all of these proposed measures should be retained for more detailed formulation.

4.5.1.4 Warning Dissemination

One of the most important factors in being able to successfully and safely evacuate coastal areas is allowing sufficient time between the determinations that a particular storm's track will make landfall at designated locations along the gulf coast and fully disseminating the warning to those in the target area. These predictions are based upon numerous factors of storm speed, direction, intensity, other weather conditions (low pressure and high pressure land systems) in the region. Generally hurricane threat information is distributed to the public as "hurricane watches" and "hurricane warnings" by the NWS. According to NOAA information, a hurricane watch is an announcement by the NWS for specific coastal areas that hurricane conditions are possible within 36 hours. A hurricane warning is a public announcement by the NWS that sustained winds 74 MPH or higher associated with a hurricane are expected at a specified coastal area in 24 hours or less. These watch and warning times are not adjusted according to the strength of the hurricane as the physical radius of the hurricane-force winds from the eye of the storm is usually closely correlated with the strength of the storm (more intense the storm (Safir-Simpson scale) the larger the radius of the storm). In the case of Katrina, the radius of the storm was much larger than previous storms of that intensity (such as Camille).

Information gleaned from various web sites and the three county emergency evacuation plans indicated that at least 36 hours may be required to safely evacuate threatened zones along the coast prior to the larger storm events (categories 4 and 5). Although there is much concern over issuing evacuation orders too soon without sufficient information to accurately determine where landfall will occur, the potential for many people to be trapped on crowded roads when the storm surge arrives or to wait till that last possible moment before evacuating gives some credence to the possibility of issuing a warning in advance of 24 hours when hurricanes reach Categories 4 and 5. A considerable number of people lost their lives while fleeing from Katrina. In addition to the existing dangers of evacuating high-risk project areas, should a nonstructural plan featuring thousands of elevated structures be implemented, having sufficient time available for those households to evacuate safely will be a major component of that plan.

Due to the number of large recreation facilities and operating industrial plants that cannot be moved from high hazard areas, specific warning systems should be developed that notify these people-filled facilities on an ongoing basis about potential threatening storms and expected hazards at their specific locations. Specific evacuation procedures for each of those facilities would be prepared in close coordination with the facility management and local emergency management personnel.

One of the many warning measures that should be investigated further with NOAA and the NWS is the possibility of extending the hurricane warning time from 24 to at least 36 hours in the advance of landfall for the larger more powerful storms with hurricane force winds and surge that extend across larger areas. Especially for any hurricanes in the 3, 4 and 5 categories that affect larger areas of the

coast. Based upon all accounts of Katrina's approach to the coast, its size and the extent of damages and loss of life wrought by the surge, a longer warning time may have saved lives.

Other forms of emergency notification of the population living along the coast in hazardous areas are available. Reverse 911 systems that generate phone calls to homes and businesses in selected sections of the coast that are correlated to the current emergency evacuation plans would be an effective way of issuing storm warnings or evacuation orders. In addition, these same systems could use cell phone technology (voice mail, text messaging, paging, etc.) to contact individuals with that service. In either case such notification systems could be effective in issuing evacuation orders and if repeated on a regular hourly basis in advance of storm landfall may decrease the chances for loss of life. Given the diversity of the population within the project area, hurricane/storm warnings should be issued in several languages as well as sign language on public television stations. Other warning dissemination methods should be explored that would address physically and mentally disadvantaged populations in the region as well.

Despite all of the various forms of media available to the population within the project area (i.e. television, radio, internet, cell phones, broadband, etc.), there is no guarantee that individuals will have access to the media, that the media systems will be functional at these critical times, or that individuals would be aware of impending threats from storms or hurricanes at all times. For this reason, other less sophisticated systems should be in place that would provide unmistakable evidence that there is an impending threat approaching the coast.

As a nonstructural measure, a system of sirens located across the project area could provide an emergency signal whose message would be unmistakable given sufficient education of the population of the purpose and meaning of the sirens' use. Mounted on wind-resistant poles located at intersections and serviced with underground power, the sirens could be used in conjunction with other media and communications systems to alert the population to the coming threats. For the hearing impaired, flashing strobe lights could also be installed in neighborhoods so that all segments of the population could be notified of impending danger.

Warning sirens installed on a pole mount range in costs from $15,000 to $25,000 depending upon the anticipated coverage area and required pole height. Battery backup systems are available for that price range. Costs include the siren, pole and wiring plus installation costs. Annual O&M costs are approximately $500 per siren. Flashing strobe lights range in costs from $250 to $500 installed depending upon the wattage and mounting location. Annual O&M costs for the flashing lights would be contingent upon instances of vandalism and theft and would be limited to purchase of a new strobe light and its installation.

Generally the majority of the population within the project area has access to various media (television and radio) that would be carrying information from the National Weather Service on local news stations regarding the threat levels of oncoming storms and hurricanes. However, there are sectors of the population who do not have ready access to media resources and therefore may not be made aware of these impending threats. In light of this situation, a nonstructural measure could be to distribute weather service radios that continually provide weather related information on an impending hurricane or storm event. Considering the growing diversity of the population in the project area, announcements of impending weather-related emergencies need to be broadcast in multiple languages.

The National Weather Radio (NWR) system is a nationwide network of over 900 radio stations broadcasting continuous weather information directly from a nearby National Weather Service office. NWR broadcasts National Weather Service warnings, watches, forecasts and other hazard information 24 hours a day. There are three NWR stations in the project area including Mobile, AL, Gulfport, MS and New Orleans, LA that provide full coverage of the project area through the weather radio system. The special radio receivers or scanners that pick up the NWR information can be

purchased from the NWS or many other commercial outlets. For the hearing or sight impaired population, these alert systems can be connected to other alarm systems (flashing lights, sirens, etc.) in the home or business. Standard NWR receivers cost approximately $80 and could be purchased in bulk for distribution to identified sectors of the project area population that would be at risk and lacking the resources to purchase the radios. A significant number of those needing these resources could be addressed with a modest project investment at the current unit price. Annual O&M costs would be limited to battery replacements unless rechargeable batteries are chosen (slight increase in purchase cost).

The ability of emergency services agencies to quickly and decisively issue credible warning is a key element in an effective storm/hurricane warning system. Since all of these measures contribute to that system's effectiveness, all of them are carried forward into more detailed formulation.

4.5.1.5 Evacuation Planning & Public Education

Once the threat of an approaching storm has been determined by the NWS, specific steps can be taken by local communities and emergency services personnel to begin evacuating those families and individuals and their movable contents to safe areas. Emergency evacuation zones of the coastal region have been mapped based upon surge depths, wave action and FEMA flood frequency data. Those families and individuals as well as concentrations of special populations (hospitals, assisted living, schools, jails, etc.) in structures subject to inundation are notified by county or city emergency services to evacuate to safe areas designated by the counties. Specific evacuation routes have been identified by the three counties that will assist evacuees in finding the safest and quickest way to flee the approaching storms.

Each of the three counties has developed emergency evacuation plans that indicate when the various zones must be evacuated, the best available evacuation routes (streets, roadways and highways) and where safe temporary evacuation centers are located. Theses plans need to be better coordinated with Federal and state agencies and departments and better disseminated to the public at large. Telephone, short-wave and cell phone communications enable emergency personnel to coordinate these activities with local police and fire units in the cities.

One of the most important features of any emergency evacuation plan is the education of both the emergency personnel responsible who will be implementing the plan and the citizens who must respond to the emergency evacuation orders posted by local authorities. Many people perished during Katrina because of their lack of information or understanding of the deadly threat that the storm surge and waves would pose for anyone staying within the expected surge inundation zones.

Regardless of the amount or quality of pre-emergency planning and preparation accomplished prior to the next weather-related emergency, the one constant random element remains the reactions/responses of the at-risk population when mandatory or voluntary evacuation orders are issued. Reducing the potential loss of life and injuries to the evacuees depends largely upon the population's understanding of the threat and what appropriate responses to that threat will be effective for each household or individual. Knowing where evacuation routes and safe evacuation centers are located can make the difference between safety and tragedy.

In order to better equip the at-risk population, a series of training and information seminars, media presentations, and other public forums assisted with easy-to-read and understand materials could be implemented as a nonstructural measure. Information on these emergency subjects can be placed in libraries, community centers, hotels and motels, managed-care facilities, hospitals, banks, credit unions and post offices. Applicable web addresses, phone numbers, radio station frequencies, and emergency evacuation routes could be stressed in this public information. The costs of these

materials would be minimal since they are already available through Federal and state agencies. Training and information seminars could be hosted by FEMA, MEMA or USACE at minimal costs.

In addition to educating and training the general population, the most effective education for the project area's future would be at the elementary, middle school and high school education levels. Education materials including textbooks, coloring books, workbooks, posters, computer programs and role-playing games could be distributed throughout the school systems to increase the awareness and understanding of all school-aged children (in a non-threatening way) about hurricanes, flooding and emergency responses to these conditions. Generally parents of children made aware of threats at school seem to respond in a more affective and positive way out of concern for their children's safety. Additional resources available through FEMA for children can be found at: http://www.fema.gov/kids.

Obviously this education process cannot be a one-time affair as new citizens move into the coastal area over time and emergency personnel change jobs, retire or move elsewhere for employment opportunities. More importantly is the fact that the project area is visited by millions of tourists each year – people who may be unaware of the potential threat from these storms and who may not have adequate transportation (such as fly-ins) to evacuate safely. Education of the public must occur on a regular basis about the threats that hurricanes and other large storms present and what steps the public can take to protect themselves and their property. Certainly this public awareness needs to be heightened with the approach of each new hurricane season. At a minimum, annual emergency drills and testing of the warning system are the measures that assure quick and affective response to these threats. Education at all levels (elementary through elderly) is important to assure public safety.

An additional concern would be for the many facilities that are inextricably tied to the water's edge either by legal restrictions (casinos and associated facilities) or by their need to operate at the water's edge (Ingalls Shipbuilders, Chevron Oil, MS Power Company, Port of Gulfport, etc.). Special evacuation plans for these major industrial and recreation facilities will need to be developed in close cooperation with the local emergency management offices and the individual facilities themselves. Costs for development of these individual plans would be shared between USACE and a non-Federal sponsor.

The effectiveness of any threat identification and warning system is inextricably tied to the timely and correct response by the general public, agencies and organizations who will be most effected by the threat. An unheeded warning or a warning not taken seriously is a formula for disaster. Since effective and ongoing education of the public to the seriousness and reliability of the warnings that may be issued in the future is the key to a successful evacuation, all of the above measures regarding public education and evacuation planning are being carried forward into more detailed formulation.

4.5.1.6 Evacuation Routes and Signage

4.5.1.6.1 Evacuation Routes

The population of the communities within the project area is increasing daily as households and commercial businesses re-establish in the area. When a hurricane warning is issued by the NWS for certain reaches of the Gulf Coast and particular areas known to be at-risk from surge inundation and waves are notified to evacuate, there would be a massive migration of people in vehicles from the coast. The massive vehicular evacuation experienced in areas of Texas during the approach of Hurricane Rita in 2005 illustrates the importance of having designated routes.

During an emergency evacuation situation, identified evacuation routes are critical to assuring that those families and individuals that are at risk in identified evacuation zones can safely and efficiently leave the danger zone(s) and seek shelter in designated areas. In addition, the evacuation routes provide efficient routes for evacuation of people by buses or other transit vehicles that may not have access to personal vehicles. Generally the routes are streets, arterial roadways and highways designated by the county emergency services agencies in cooperation with the State Department of Highways which in this case is the Mississippi Department of Transportation.

Figure 5 shows the MDOT Hurricane Evacuation Routes (in red) that extend northward from the coast. In selecting the appropriate routes, the distribution of the population within the hazard zones, highway capacity (lanes and roadway width), critical intersections, bottleneck areas (reduced lane-widths) and other parameters are all critical factors. Planned improvements to those critical components of the evacuation routes can dramatically improve the efficiency and safety of the evacuation process.

Of most importance is ongoing education of the public as to the location of the routes and the locations of designated shelters. This process can be woven into the everyday activities of the state DMV regional offices from the testing of new drivers (drivers test manuals) to the annual vehicle registration renewal, (information included in the registration package) and license renewal processes. Public service announcements (television and radio and published media) identifying the evacuation routes by highway number, name and/or by graphics could begin prior to the start of hurricane season (June) and continue on a regular basis through November.

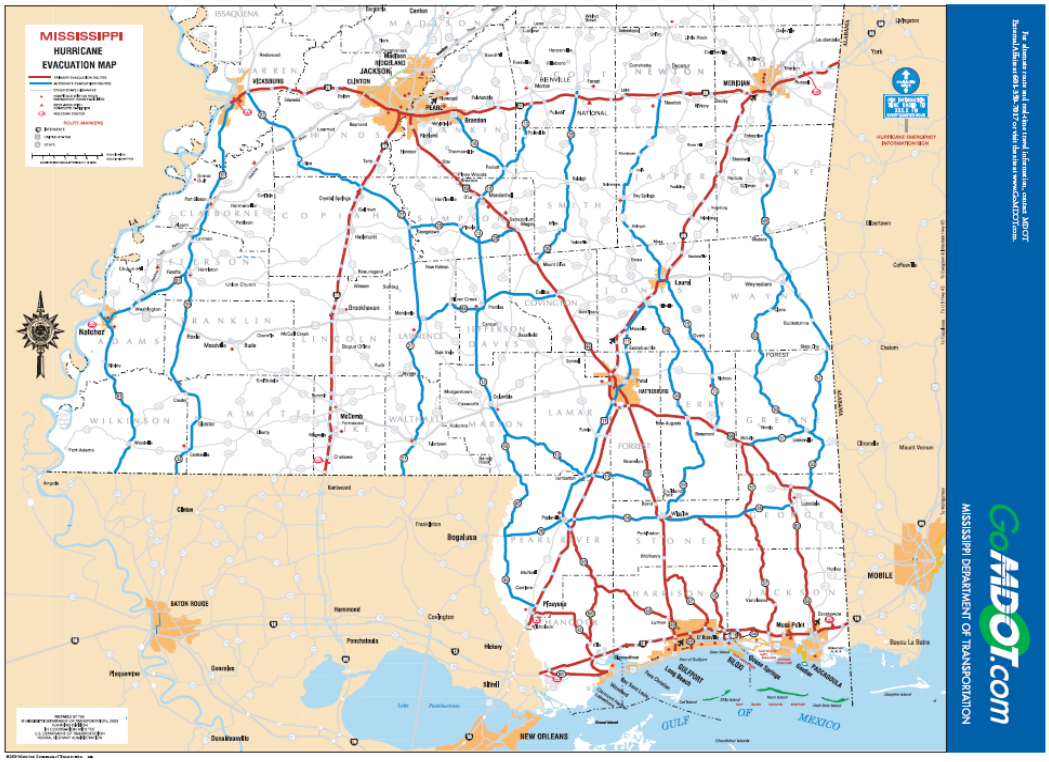


Figure 5. Evacuation Routes MDOT

4.5.1.6.2 Evacuation Route Signage

As important as selecting safe and efficient evacuation routes is the signage of the selected routes such that citizens can quickly identify the appropriate routes and be assured that they are still on an approved route as they travel away from the hazard zone. In addition to full-time residents fleeing an approaching hurricane, a great number of tourists and out-of-region visitors are living in temporary residences (rentals, motels, time-shares, etc.) in hazardous zones as well. Since hurricane season begins in June, the areas beaches and oceanfront properties may be crowded with families and individuals who are ignorant of the threat and the evacuation plans. Their unfamiliarity with the local highways and roadways can make evacuation for everyone a nightmare. Having carefully conceived and wisely installed highway signage that clearly identifies evacuation routes is of paramount importance to successful evacuation. Figure 6 shows a basic hurricane evacuation route sign using the cyclonic logo that is commonly used to designate hurricanes throughout the nation. Placement of theses signs at appropriate intersections and frequently along the evacuation routes could be initiated through a Federally-funded program (Homeland Security) using MDOT as the local sponsor and installer of the signs.



Figure 6. Hurricane Evacuation Route Sign

Costs for the signs range from $250 to $350 installed depending upon the number produced and the installation methods used. Annual O&M costs for the signage are limited to replacement of a percentage of signs due to vandalism or theft.

In addition to the standard metal post signs, other types of signage can be installed that would provide fleeing motorists with information on traffic accidents, available shelters and other important information. Dynamic information signs that flash messages to approaching motorists can be installed along major evacuation routes at strategic locations. Installation options range from smaller pole-mounted roadside signs to multi-lane towers that span 3-4 lanes of traffic. Costs for these installations range from $100,000 (roadside) to $400,000 (multi-lane tower) and annual O&M costs range from $4,000 to $7,000 for the messaging board itself. These signs could be located along the main evacuation routes from the coast to convey up-to-date emergency information to motorists.

4.5.1.6.3 Highway Routing

Reverse-flow traffic routing (also known as “contraflow”) of highways during emergency evacuations is an effective method of moving large numbers of vehicles away from the coast in a relatively short period of time. Successful implementation of this measure requires the full cooperation of the MDOT and adjacent states, and local and state police in planning and administering the reverse-flow routing of traffic during these emergencies. Pre-planning of the target routes away from the coast, modification of intersection signaling, additional turning and travel lanes, dynamic messaging boards and highway signs are all components of this measure. As in the case of other flood preparedness measures, public education is a valuable component of this measure and would require repetitive application to maintain preparedness.

Costs for additional traffic lanes, turning lanes or intersection improvements (see below) are not available without more detailed planning and coordination with MDOT. Annual O&M costs would be commensurate with annual O&M costs experienced by MDOT for lane maintenance.

4.5.1.6.4 Intersections and Modal Crossings

During a major hurricane storm event that would initiate substantial numbers of evacuations from the coast, three primary modes of transportation along the coast would be energized to move damageable assets further inland. In addition to the obvious highway routes already identified above that would attract personal cars, trucks, buses, military vehicles and other vehicles exiting the coast, CSX railway and gulf vessels would also be attempting to move valuable assets away from the coast. Where these various transportation routes intersect (at-grade crossings, bridges, overpasses, etc.) evacuation conflicts can occur. Although major highway intersections can be signaled to reduce conflicts between local and emergency evacuation traffic, at-grade railway crossings occupied by railway stock being relocated in advance of a hurricane event can effectively block thousands of fleeing motorists.

Likewise, fishing fleets and pleasure craft seeking shelter in safe anchorages within tributary rivers and embayments that result in raised drawbridges can also block thousands of fleeing families. These inter-modal conflicts can be resolved along major evacuation routes through an intentional program of expenditure by state and private companies. In addition to these inter-modal crossing conflicts, most of the evacuation routes cross multiple streams and rivers that can be reaching flood-stage as pre-landfall precipitation swells these intersecting drainage-ways. A MDOT-led assessment of all culvert sizing at small stream crossings and maintenance of debris removal in stream/creek channels would help to assure that the major evacuation routes are indeed available during an emergency.

Determining costs for eliminating at-grade crossings, drawbridges and other intersection conflicts require more detailed planning and engineering investigations than are possible given the time and resources available for this appendix. Intensive coordination with MDOT could determine capital and O&M costs for these measures.

4.5.1.6.5 Evacuation Route Resources

As Hurricane Rita so vividly pointed out to the residents of Louisiana and Texas and the rest of America through CNN news, there are a myriad of possible accidents and crises that can take place during a full-scale Gulf coast evacuation. Accidents, vehicle fires, breakdowns, medical emergencies, insufficient fuel supplies and many other on-roadway emergencies can occur during the movement of thousands of households and residents. Contingency plans that address possible needs along each designated evacuation route from the Gulf need to be prepared based upon lessons learned from Hurricane Rita and the needed resources (fuel, emergency responders, repair facilities, etc.) either put in place by state emergency offices or county emergency services or provided for through joint agreements with local resource providers. Annual emergency evacuation tests should include mock activation of these in-route resources to assure their availability in the event of a real emergency.

As in the case of other evacuation activities, determining capital and O&M costs for developing these resources along the evacuation route are not possible at this level of planning detail.

The largely successful evacuation of the Texas and Louisiana coasts preceding the landfall of Hurricane Rita in 2005 is a testament to the need for good evacuation route planning, signage and other measures discussed above. Many of the unexpected incidents that occurred during that evacuation and were highlighted on national media can be avoided and measures for that purpose are included above. Since these measures can contribute to a more orderly and safe evacuation from coastal areas, they are all carried forward into the more detailed formulation process that follows.

4.5.1.7 Evacuation Centers/Shelters

In addition to those evacuation centers that may already be listed by the local emergency management agencies, a series of alternative centers should be identified for use by the coastal population. In consideration for the numbers of people that attempted to evacuate the MS coast immediately prior to landfall by Katrina and later Rita in Texas, having an oversupply of evacuation centers available is important. Should there be a number of schools and other large facilities relocated as a part of the implementation of this comprehensive plan, then these additional "safe" resources need to be added to the list of evacuation centers. Location by GPS coordinates and mapped in GIS format would help all emergency managers and resources (police, National Guard, etc.) manage the evacuations. Additional information on the design and construction of community shelters can be found in the publication: FEMA 361 – Design and Construction Guidance for Community Shelters.

Emergency evacuation of families during Katrina and Rita identified needs for accommodations for specific populations requiring special medical care (elderly, children, chronic illness, and hostels) as well as family pets. Provision for these "special" evacuees should be considered at the identified evacuation centers.

Once identified, emergency-use agreements between local emergency managers and facility owners need to be executed for use of evacuation centers so that administrative processes or finances do not hinder the evacuation process when an emergency is declared. Annual review of those agreements as a part of the annual emergency system test would assure updating of the agreements and any financial considerations.

In addition to the identification of usable evacuation centers and execution of use agreements, provision of basic necessities for a relocated population for up to a week need to be considered. Caches of storable food, water, medical and bedding supplies need to be established at or near the evacuation centers. As with other components of the emergency evacuation system, these resources should be evaluated on an annual basis when the system is tested.

Determining costs for rental of potential evacuation centers and their supply with basic necessities requires a more detailed study of the center capacity needs and coordination with owners of available centers.

Generally speaking, sufficient, safe accommodations of sufficient capacity to handle thousands of evacuees in the face of an impending hurricane landfall are not readily available within the project area. The many hotels and motels within the project area are usually booked during a significant portion of the hurricane season and many of those are currently subject to surge flooding or wind damages. Moving north from the coast, sheltering options (hotels and motels) are limited to small communities located along the identified evacuation routes. Other sheltering options are limited to larger schools and community facilities located away from the coast. Being able to locate these optional facilities, pre-arrange for their use in the event of emergencies and assure that sufficient supplies are on hand in the event of a hurricane landfall are all key components of a safe and efficient evacuation. Since all of these measures contribute to those objectives, they are carried forward into more detailed formulation.

4.5.1.8 Safe Harborages/Anchorages

Of the many commercial enterprises that exist along the Mississippi coast, the commercial fishing and seafood industry is one of the most enduring, most profitable and most threatened by hurricanes and storms in the Gulf. Besides the significant affects that these storms can have on the aquatic life and their habitat that these industries depend upon (fish, oysters, scallops, shrimp, etc.), protecting the fleets of corporate and individually-owned fishing boats and trawlers during these damaging

storms is a challenge. During Katrina, many of these large vessels were swept into the coastal forests and residential neighborhoods and the waterside infrastructure destroyed by the storm surge and waves. With the approach of large hurricanes that carry significant surge heights, damaging waves and high winds, this fleet is faced with certain annihilation if it stays within unprotected waterfront anchorages. The options are to either move laterally across the coast to eastern or western Gulf ports outside of the storms' fury or move further inland using available tributary channels. In many cases, upstream anchorages away from the coast are blocked by bridges and shallow channels and sailing either east or west along the coast to avoid the storms significantly wears on machinery and crews and increases operating costs.

A solution to this temporary relocation problem may be the establishment of safe harbors or anchorages that fleet, charter, and pleasure craft can seek temporary shelter within. In addition to the commercial fishing and private vessels, charter fishing boats, and rescue/emergency response craft could be berthed at these harbors to allow quick response rescue operations following a hurricane event. A number of these "safe-harbors" could be established within the existing embayments by special authorities or through existing Corps of Engineers' authorities such as Section 107 of the Continuing Authorities Program (CAP).

This standing authority provides an opportunity for the Corps to participate in the development of small boat harbors and navigation improvements. The current maximum limit of Federal participation in this program is $7.0 million per project (WRDA 2007). Local sponsors pay a share of the project cost based upon the depth of the harbor. At a minimum, three safe harborages could be located within the project area. In accordance with the regulations governing this program, the estimated project cost for each of the three safe harborages would not exceed $7.7 million. More detailed analysis of the safe harborages' cost and features would be developed in CAP feasibility study documentation.

Safe harbors could be designed as excavated slips or longitudinal channel-side berths with tie-ups designed to accommodate significant rises in water levels (surge inundation). Landside development would be minimal with security fencing, lighting and roadway access. Prime safe harbor sites would be located adjacent to channels or deep water within the embayments that avoid excavation within sensitive estuary habitat. Extensive coordination with natural and marine resources during site selection and excavation design and construction would minimize ecosystem impacts.

A safe harbor could be developed in conjunction with the Pearlington community redevelopment scenario as part of the required borrow material excavation along the Pearl River. Requirements for channel depth and needed dredging would need to be coordinated with the fishing industry as well as natural resources agencies. Coordination with MDOT plans for any future bridge replacements or elimination of drawbridges for evacuation purposes may benefit the safe harbor selection process. See Figure 7 for an example of a safe harborage or safe anchorage. The provision of safe harborages as a method of reducing damages to commercial and pleasure vessels was suggested in the "Potential Projects List" (item HRR1-06) developed during round one of the public workshops on the Comprehensive Plan.

Costs for safe harborages or anchorages would depend upon the expected number of evacuating vessels and their sizes, draft depths being accommodated, intervening channel deepening requirements and needed security facilities. Determination of the capital and O&M costs for these facilities would require extensive coordination with fleet owners and boating associations in the project area. Annual O&M requirements would be limited to dredging the harbor area and any modified channels between the Gulf and the harborage site.

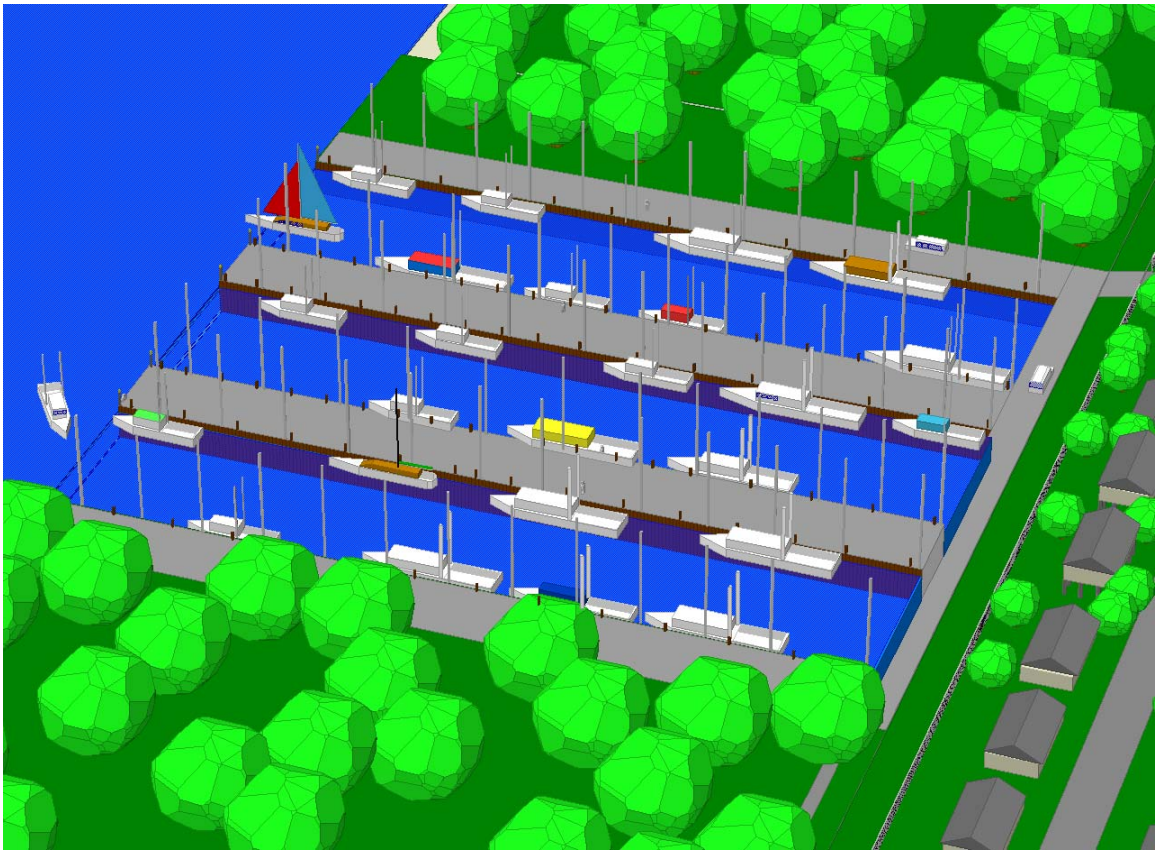


Figure 7. Safe Harborage/Safe Anchorage

The seafood and boating industries are major contributors to the region's economy and are a key component of the tourist trade along the coast. Severe losses such as occurred to the fishing fleets and recreation watercraft during Katrina pointed out the necessity of having sheltering areas for this equipment and facilities. Since safe harborages and anchorages would provide such shelter for this equipment, these measures are all carried forward into more detailed formulation.

4.5.2 Floodplain Management, Floodplain Zoning, Flood Insurance and CRS

Riverine and coastal floodplain management through the auspices of the Federal Emergency Management Agency (FEMA) is one nonstructural measure that has proven to be very effective in reducing damages to structures and losses of life. Generally floodplain management does little to reduce damages to structures grandfathered in their present at-risk location at the time of enactment of the required ordinance, but the awareness that the delineation of the flood hazard zone has upon at-risk residents may lead to retrofits of the structure under existing programs (FEMA HMGP) or other measures that can reduce damages or loss of life.

Floodplain zoning which can be viewed as a distinct overlay zone applied to a standard land use zoning map was established and is regulated by the National Flood Insurance Program (NFIP) under FEMA, an agency within the United States Department of Homeland Security. Under the floodplain zoning program, municipal and county governments can establish flood hazard zones along watercourses or ocean/gulf shorelines according to an analyses of the flood hazard by FEMA. The Flood Insurance Rate Map (FIRM) established for a municipal or county area indicates various levels of flooding, the regulatory floodway or coastal V-zone and elevations of the various flood events. The

availability and cost of Federally-subsidized flood insurance to the landowner are based upon this hydraulic data.

4.5.2.1 Existing NFIP Ordinances, Zoning and Insurance

Each of the three counties within the study area and all of the municipal areas are participating in the regular program of the NFIP. Table 7 shows the progressive entrance of these governmental units into the NFIP. In 1969, Hurricane Camille ravaged the Mississippi coast resulting in over 130 deaths,

Table 7.
City and County Participation in the NFIP

Community or County Name	Initial FHBM Identified	Initial FIRM Identified	Current Effective Map	Regular or Emergency Date
City of Pascagoula	09/18/70	09/18/70	03/15/84	09/18/70
City of Moss Point	09/18/70	07/01/74	09/04/87	09/18/70
City of Gautier	09/18/70	04/03/78	08/18/92	11/13/86
City of Ocean Springs	-	09/11/70	08/18/92	09/18/70
City of Pass Christian	05/26/70	05/29/70	08/19/87	05/26/70
City of Biloxi	06/27/70	06/30/70	03/15/84	09/11/70
City of Gulfport	05/26/70	05/29/70	10/04/02	09/11/70
City of Bay St. Louis	07/01/70	09/11/70	11/16/83	09/11/70
City of Waveland	06/27/70	09/11/70	11/16/83	09/11/70
City of D'Iberville	-	08/04/88	08/04/88	11/14/88
City of Long Beach	07/17/70	06/19/70	05/04/88	09/11/70
Hancock County	-	09/09/70	08/18/92	09/09/70
Harrison County	09/18/70	06/15/78	10/04/02	06/15/78
Jackson County	09/18/70	04/03/78	04/16/93	04/03/78

Source: FEMA NFIP data

over 3,800 dwelling units destroyed and damages exceeding $900.0 million. In the preceding year, Congress had enacted the National Flood Insurance Act of 1968. Although in its infancy, the National Flood Insurance Program was beginning to assist counties and communities across the nation that suffered repeatedly from riverine and coastal flooding when Camille hit the coast. Following the catastrophic affects of Camille, the three coastal counties (Hancock, Harrison and Jackson) and all 11 municipal areas affected entered the regular or emergency program of the National Flood Insurance Program by 1978. According to FEMA data, approximately 20,200 flood insurance policies were in affect in the project area prior to the arrival of Katrina.

In the early stages of the NFIP, information on appropriate methods of protecting coastal structures (V Zone) was limited, but engineering standards for raising structures on piling or piers were available and had been proven in many cases to withstand the savage pounding of surge, waves and wind from hurricanes along the Mississippi coast. Hundreds of structures were elevated along the coast to a theoretical 100 yr storm level established by FEMA. As Table 7 shows, most of the 11 municipalities and 3 counties in the study area had initial Flood Insurance Rate Maps (FIRM) in place by 1978. In the intervening 26 years between Camille and Katrina, the study area has been visited by several hurricanes and tropical storms (Cindy 05, Elena 85, Georges 98 and Hanna 05) that tested the flood damage reduction measures instituted through the NFIP.

Fortunately, none of these storms was severe enough to cause extensive damages to coastal structures. Not until the arrival of Katrina in 2005 was the Mississippi coast confronted with another powerful hurricane that would test the flood damage reduction efforts of the local population. Post-

event assessments and visual images of the damages to both seemingly protected and unprotected structures indicated that not all types of protection schemes were successful in the face of a combination of significant surge depths, wave heights and high winds.

Katrina's storm track traveled squarely over the mouth of the Pearl River at the Louisiana/Mississippi border and across the unincorporated community of Pearlington in Hancock County. This track put the coastal communities of Waveland, Bay St, Louis, Pass Christian, Long Beach, Gulfport, Biloxi, Ocean Springs, Gautier, and Pascagoula at the mercy of the northeastern quadrant of the hurricane where sustained hurricane-force winds, a massive storm surge and powerful waves demolished most unprotected structures. Unfortunately, hundreds of structures raised on various types of piers and pilings were likewise demolished as the huge surge (mimicking Camille in 1969) carried battering waves to the first floors and exterior bearing walls of wood-frame structures. Hundreds of these structures raised in compliance with local coastal management ordinances and constructed according to adopted building codes were unable to withstand this onslaught. Figures 10 through 17 on Pages 67 and 68 show the remnants of structures raised to the 100yr flood elevation (BFE). Observations of the Katrina damages showed that all concrete block and brick masonry columns founded on slab foundations failed. Most failures occurred at the junction of the column and the slab. In some cases, reinforcing bars were bent or ties failed at the junction between the column structure and the slab foundation (see Figures 38 and 39 on Page 79). Generally all wooden pilings and post foundations survived the Katrina surge and waves although in almost all cases the structure was washed off the top of the raised foundation by surge and waves.

As a result of the extreme damages and losses of life caused by Katrina, FEMA immediately began to re-evaluate the current BFE and other established flood levels upon which the existing coastal floodplain management ordinances along the Gulf Coast had been founded. Based upon this re-evaluation, FEMA issued a set of "Advisory Base Flood Elevation" (ABFE) maps for the Mississippi and Louisiana coasts. The new ABFE significantly raised the previous BFE elevation along the coast and inlets to acknowledge the potential damages that could be generated by a second storm that mimicked the surge, waves and wind generated by Katrina and to provide guidance for those who would be immediately rebuilding structures and facilities along the coastal areas.

Several project area communities adopted the ABFE's as the basis for their existing floodplain management ordinances and new construction has been held for the most part to those modified base flood elevations. In some cases, the communities just increased the amount of freeboard between the existing BFE elevation and the first floor of a raised structure to compensate for the differences in the new ABFE elevations. A few communities chose to use both techniques according to the flood threats within their area. Table 8 lists those municipalities and counties in the project area that either adopted the ABFE or modified the freeboard requirements for new construction or structure elevation in their existing ordinances. In addition to adoption of the new ABFE, participation in the flood insurance by area residents increased by 165 percent to around 53,600 policies.

Table 8.
Municipalities and Counties Modifying Existing Ordinances to ABFE

Community/County Name	Adopted ABFE	Modified Freeboard Requirements
Jackson County	X	X
Pascagoula	X	
Moss Point	X	
Gautier	X	X
Ocean Springs	X	X
Harrison County	X	X
Biloxi	X (proposed adoption)	X
D'Iberville	X	X

Community/County Name	Adopted ABFE	Modified Freeboard Requirements
Gulfport	X	X
Long Beach	X	X
Pass Christian		X
Hancock County		X
Bay St. Louis		X
Waveland		X

Source: FEMA Document dated March 2007

FEMA is generating a new set of Digital Flood Insurance Rate Maps (DFIRM's) that will be published for public review and comment by the affected counties and municipal areas. The revised maps will show modified boundaries and heights for the BFE (1% annual chance event) and 500 year (0.2% annual chance event) including revised water surface elevations associated with these zones. It is possible that the revised mapping may include adjustments to the V and VE zone boundaries as well. Once comments are received from the affected county and municipal areas, FEMA will publish the new FIRM's and the local governments will modify their existing floodplain management ordinances to incorporate the new zones and any additional text changes in the ordinances.

In view of these coming changes in the existing floodplain ordinances and recent FEMA design guideline initiatives, there are two potential early-action measures that could be instituted by local jurisdictions to reduce damages to future development along the coast. Each municipality and county should adopt the new DFIRM mapping and ordinance information when published by FEMA. In addition each municipality and county should adopt the *FEMA 550 Recommended Residential Construction for the Gulf Coast* guidelines that describe building methods and flood-resistant materials to be used in elevating or otherwise floodproofing structures in the coastal and inlet inundation zones. These guidelines could be adopted as a part of the undated building codes (see Section 4.5.3 below) or by reference in the floodplain management ordinances. Use of the FEMA 550 guidelines for future coastal construction could substantially reduce damages from future storms. Costs for both of these measures are minimal and are local administrative and legal costs.

4.5.2.2 Community Rating System (CRS)

The Community Rating System (CRS) is a voluntary program for communities that participate in the regular program of the NFIP. The primary objectives of the CRS are to reduce flood losses, facilitate accurate insurance ratings, and promote the public's awareness of flood insurance. The rating system provides a list of incentive activities that would take a community beyond the basic requirements of the NFIP to provide a higher level of protection to at-risk structures. Application of the incentive activities by the community results in discounts on flood insurance premiums for all insurance holders. The rating system ranges from 10 (lowest ranking and a 0% discount on premiums) to 1 (highest ranking a 45% discount on premiums). The incentive activities are grouped into four categories including Public Information, Mapping and Regulation, Flood Damage Reduction and Flood Preparedness. As a community implements incentive activities from one or more of these categories in their community, all participating landowners receive greater insurance premium discounts. Table 9 below shows the communities and counties within the project area that are included in the CRS program and their current ratings. Of the three counties and 11 municipal areas in the project area, one county and 8 municipal areas are participating in the program.

Table 9.
Municipalities and Counties Participating in the CRS

Community Number	Community Name	CRS Entry Date	Current Effective Date	Current Class	% Discount for SFHA	% Discount for Non-SFHA	Status
285251	Bay St. Louis	10/1/95	1/01/00	7	15	5	C
285252	Biloxi	10/1/96	10/1/03	7	15	5	C
280332	Gautier	10/1/94	04/1/00	8	10	5	C
285253	Gulfport	10/1/96	10/1/01	8	10	5	C
285255	Harrison County	10/1/03	10/1/03	8	10	5	C
285257	Long Beach	10/1/00	10/1/00	8	10	5	C
285259	Ocean Springs	10/1/92	10/1/02	8	10	5	C
285261	Pass Christian	10/1/93	10/1/03	6	20	10	C
285262	Waveland	10/1/93	10/1/06	5	25	10	C

Source: FEMA documentation

An effective nonstructural measure would be to encourage the remaining counties (Jackson and Hancock) and the 3 municipal areas (Pascagoula, Moss Point and D'Iberville) to participate in the CRS and realize the discounts in insurance premiums for their participating landowners. Implementation of several of the identified nonstructural measures would significantly increase the participating communities and counties current ratings and further reduce their insurance premiums. Costs for entering the CRS and complying with the requirements are minimal and local.

4.5.2.3 Potential Modifications to the National Flood Insurance Program in Coastal Mississippi

The NFIP is a complex Federal program of floodplain zoning regulations, construction and retrofitting guidelines and flood insurance requirements that is largely administered by local jurisdictions. In general the availability of government subsidized insurance for structures located in the nation's floodplains is contingent upon a county's or municipality's willingness to establish a local floodplain management program based upon the identified flood risks and to accept establishment and enforcement of floodplain zoning ordinances. Over the years since the program first began (1970), there have been numerous modifications of the NFIP based upon changes in insurance coverage, percentage of government subsidy, experiences in enforcement of the program nation-wide and major flood damage events such as Katrina. In view of these changes, other modifications to the NFIP could be possible in the project area that would, over time, result in changes to the development pattern and therefore reduce the potential for flood damages in the project area. These modifications would be affected through Congressional legislative and Federal agency administrative actions. Some of the possible modifications to the program that can be considered as nonstructural measures are discussed below:

4.5.2.3.1 Suspension of the Flood Insurance Program

Many structures along the nation's coast are only located in a hazardous location because of the opportunity to have the costs of flood damages offset by claim reimbursements from FEMA through the NFIP. Although FEMA has established limitations on the amounts of insurance coverage (more about that feature below) and significant structure damages require certain building modifications to reduce future damages, many structures only remain on a hazardous site because of the presence of insurance. In many cases, without that insurance coverage, landowners would eventually abandon their high-risk sites for more flood-safe locations. Usually, federally subsidized home mortgages and business loans require flood insurance on the structure when it is located within a defined hazard zone. In view of this, removing the flood insurance program either in part or totally for

the entire coastal area in MS would have a direct impact on individual landowner's decisions to locate or remain in these hazardous areas. The insurance program for all zones could be dropped or just in the high-hazard zones (VE and BFE zones) or the zones could be dropped in a multi-year phase-out program starting with the VE zone.

Although somewhat "Draconian" in nature, this measure would place the full burden for repairs and recovery solely on the landowner whose home or business was damaged and on public institutions in the case of damaged public buildings. Certainly, removing the flood insurance coverage for homes and businesses in these areas would impact the lending institutions which have based their financial investment in the at-risk structure on the existence of flood insurance coverage that offsets the financial losses to the property and maintains the value in case of future ownership transfers. Depending upon the reaction of the lending institutions to the loss of flood insurance, the movement away from the coast could be rather sudden as at-risk mortgages were voided or remaining mortgage balances were required of the owners.

Should the reaction of the lending institutions not be quite so sudden, in time, gradually and based upon the number and severity of future storm events, landowners who were faced with a severely damaged home or even with frequent minor damages to their home would look for other flood-safe locations. Without a specific timeline for removal of these structures from the flood risk area, there is not an accurate method of determining when the flood damage benefits of this measure may occur. Since the gradual movement away from the coastal area would be event determined and since most large hurricane events are very infrequent, flood damage reduction benefits generated through this insurance driven migration from the coast could take decades to realize.

Although from a theoretical standpoint, abandoning the NFIP for this project area would in time result in a movement away from the hazard areas and a realization of flood damage reduction benefits, the administrative and political actions required to affect such a change in the NFIP would be loathsome to local officials and political interests. The billions of dollars of investment in coastal development within the project area supported by this insurance system would be left at the mercy of Gulf storms and the financial losses could be disastrous to the local economy. Therefore, suspension of the NFIP for the project area will not be carried into the formulation process as a realistic measure.

4.5.2.3.2 Reduced or Suspended Federal Subsidy

Another NFIP-based measure would be to significantly reduce or drop the federal subsidy on flood insurance policies for structures grandfathered into the NFIP when it was enacted within each community or county. Reductions in the Federal subsidy for flood insurance have occurred in the past. Without the federal subsidy or a substantially reduced subsidy, landowners would be faced with paying the full or nearly full actuarial rate for the insurance based upon the risk level for their home or business. This increased "land rent" cost would influence many to move away from the high-hazard areas. For wealthier landowners whose structure is located in a relatively low-risk zone (i.e. 500 yr zone), this reduction or loss of the subsidy would be a moderate impact on their disposal income, but for those less fortunate with a home or business in a higher risk zone (VE or BFE zones), this loss of subsidy may result in "forced" relocation to a less expensive piece of land.

This difference in measure impact calls up issues of equity and environmental justice in its application (may disproportionately affect low-income, fixed-income and minority populations) and may not be justified for that reason. Therefore reducing or suspending the Federal subsidy as a flood damage reduction measure is not being carried forward into the formulation process as a realistic measure.

4.5.2.3.3 Skewed Premium Rate Structure

Current flood insurance rates are based upon actuarial rates founded on the risk of damages from a series of flood events. When the insurance rate is established, landowners are required to pay a set-rate monthly or annual payment to cover the risk. Unless there is some change in the insurance program or flood risk, the monthly or annual payment remains consistent throughout the term of the insurance policy. Under this flat-rate policy it is possible that an insurance provider could suffer a significant loss on a damaged property early in its coverage period that would not be covered by paid insurance premiums.

To provide more protection for the insurance provider and challenge the landowner's decision to build a structure in a high-risk zone, the insurance payment schedule could be modified to require much higher up-front payments based upon the risk. For example, if a normal policy would require an annual payment of $2,500 ($208 per month) over a term of 10 years ($25,000 total), the revised policy (as a nonstructural measure) might require $10,000 in the first year, $7000 in the second year and the balance ($8,000) over the last 8 years. Under this method, the insurance provider would recover a larger amount of the total payment sooner to cover possible early-term losses and landowners would be faced with a financial disincentive to develop in a high-risk zone. The skewed rate structure could be based upon the increased level of risk with development in the VE zone or BFE zones having greater payments up front and structures in lower risk zones (500 year) having less premiums up front.

Again like the option of increasing the landowner costs for flood insurance by reducing the subsidy, skewing the payment schedule to collect a larger percentage of the total premium up-front may have a disproportionate impact on the low-income, fixed income and minority sectors of the coastal population and brings up issues if equity in its application. Wealthier landowners could absorb the larger initial payments while low income owners would be unable to afford such payments. Adjustments to the skewed rate schedule could be made to account for disproportionate impacts on low-income and minority populations, but surge inundation and wave impacts do not take into account one's bank statement. For these reasons, measures that would adjust the flood insurance premiums payment rate will not be carried forward into the formulation process.

4.5.2.3.4 Mandatory Flood Insurance

Although not an effective method of reducing flood damages or reducing losses of life, flood insurance is an effective way of reducing the financial impacts of flood damages to landowners and public entities. Many structures exist within the project area that do not have flood insurance and were damaged by Katrina. Not only does that uninsured condition place landowners in a difficult financial position regarding repair and re-occupancy of the structure but impacts the community by loss of property value (reduces property tax revenues over time) and potentially loss of business taxes.

In most cases, new home construction and occupancy is financed by a mortgage from one of a number of various financial institutions (banks, credit union, etc.). Under Federal law, new homeowners of structures determined to be within a flood hazard zone are required to secure flood insurance to protect the investment of the financing institution. Failure by the financial institution to assure the purchase of flood insurance for the new structure exposes that company to severe financial penalties. For this reason most new home and business construction found to be in a flood hazard zone is covered by flood insurance. However, in certain circumstances where a mortgage is not required to construct the building, this flood insurance step may be circumvented by the landowner.

In addition to the financial necessity of acquiring flood insurance, all county and municipal areas that participate in the NFIP will require a floodplain permit for any structure placed or constructed in an identified flood hazard zone. That permitting requirement will normally trigger the requirement for purchasing flood insurance by the building owner. However, in some areas of the coast, the oversight and enforcement of the existing floodplain management program is not at a level that assures full insurance coverage and many structures are placed or constructed without a permit and without insurance.

In some areas either dated flood hazard mapping or the lack of sufficient mapping results in new structures being placed or constructed in heretofore unidentified flood hazard zones. These structures, located in ignorance of the hazard, remain unprotected by insurance or appropriate building methods commonly used in flood hazard zones. This problem could be reduced by updating the flood insurance rate mapping in previously unmapped areas, but funds for that FEMA-supported process are limited.

In order to assure that all new and existing construction is adequately protected from the financial losses associated with storm and hurricane inundation and waves, all structures located within defined flood risk zones could be required to purchase and maintain flood insurance on the building and its contents. This mandatory feature would need to be instituted by the state, the counties or municipal jurisdictions for the project area as a more restrictive requirement over and above what is required by FEMA on a national scale. Such action by the local jurisdictions would provide financial benefits to the at-risk property owners as an upgrade to the local floodplain management ordinances through the CRS (see above). This mandatory requirement (no exceptions and regardless of the structure financing arrangements) for flood insurance in all zones with associated severe penalties (financial or administrative) for non-compliance would at least reduce the financial losses associated with large storms and hurricanes.

Mandating flood insurance for all structures located within an identified flood zone would reduce financial losses to landowners and other charitable organizations that frequently shoulder the financial losses due to flooding. However, merely having flood insurance coverage does not in and of itself reduce flood damages or the chances of loss of life. Many insured structures and their occupants were lost during Katrina. Since the objectives of the project are to reduce flood damages, not just to recover the financial losses due to flooding, mandating flood insurance coverage on all structures is not carried into the detailed formulation process.

4.5.2.3.5 Reduction in Maximum Insurance Coverage for Eligible Structures

Currently, the maximum flood insurance coverage per structure through the NFIP is $250,000 for residential structures (plus an additional $100,000 in personal property (contents) damages) and $500,000 for commercial business structures (plus an additional $500,000 for commercial building contents). Special options are available for condominium structures whereby blocks of unit coverage at $250,000 each can be purchased with the additional $100,000 contents damages coverage for each unit as well.

These upper limits on insurance coverage promote construction of large and expensive residential structures as well as condominium units and relatively large retail and office structures in high hazard zones. A modest condominium development of 50 units located in a high hazard flooding zone could place upwards of $12.5 million dollars worth of potential structure damages and $5.0 million dollars worth of personal property damages in jeopardy of loss. The recorded insurance losses from Katrina and similar storms along the Gulf Coast are a testimony to these liberal limits placed on individual structures and contents.

An affective nonstructural measure could be a significant reduction in the insurance coverage allowed for all structure types and personal property (building contents). Were insurance coverage limits to be reduced to a more moderate level ($80,000 per residential structure with $32,000 contents coverage - same ratio of contents to structure coverage as provided presently), there would be far less expensive residential structures and condominiums located in high hazard flooding zones. Similar reductions in insurance coverage for commercial structures (for example…$100,000 per structure with $50,000 contents coverage) would significantly reduce high value commercial/business development in high hazard zones. Although flood damages would still be possible, the financial losses to the flood insurance program would be lessened significantly in time and the lower limits may steer some types of development away from the waterfront entirely.

An alternative to reducing the overall coverage limits for all hazard zones would be reducing the insurance coverage commensurate with the level of flooding threat. For example, reductions in insurance coverage could be greatest in the VE zone with lesser reductions in the BFE and 500 yr zones. This method would better recognize the varying levels of risk associated with flooding along the coast and allow substantial growth to occur in the less risky areas.

Reductions in insurance coverage could be phased in over a 5 year period allowing landowners the opportunity to adjust their structures, contents, and locations to account for the percentage of structure and content value that would actually be covered by insurance in hazard areas. Concurrent changes in mortgaging terms by financial institutions to account for the reductions in insurance coverage would further encourage development to abandon the high hazard flood zones.

Reducing the insurable limits on floodplain development so that high value development is not encouraged in high-hazard areas and thus subject to loss would be a good method for reducing the financial losses due to storms and hurricanes. Reducing the limits of insurance coverage on residential and commercial structures would not directly result in a reduction in actual flood damages due to these storms but only compensation of the landowners for their losses. This measure also does not directly result in reduced risk of loss of life and in some ways may contribute to those losses in the future. Since the project objectives emphasize reductions in actual flood damages and loss of life rather than compensation for losses, reducing the insurable limits of flood insurance as a nonstructural measure is not carried forward into the formulation process.

4.5.3.2.6 Cumulative Damages or Cumulative Improvements as a NFIP Compliance Trigger

Currently under the NFIP regulations, any structure suffering storm/hurricane damages whose dollar value is greater than 50 percent of the assessed value of the structure triggers the requirement that the structure come into compliance with the NFIP regulations and the local floodplain management ordinance. That requirement could include elevation of the first habitable floor of the structure to the base flood elevation (BFE) identified in the current FIRM. Generally that damage calculation is completed and measured on an event-by-event basis and is not cumulative over several events.

Information from MEMA indicates that the State of Mississippi requires that counties and municipalities in the NFIP gather information on the value of structure improvements in the project area. When the dollar value of those improvements exceeds 50 percent of the assessed structure value, the structure is required to meet the requirements of the NFIP and local floodplain management ordinances. In addition to this state requirement, based upon information also from MEMA, the City of Pascagoula requires under their local floodplain management ordinance that storm-related damages used to trigger compliance with the NFIP and local floodplain ordinances be accounted for cumulatively over a ten-year period. Should the dollar value of the damages accumulated over that ten-year period exceed 50 percent of the assessed dollar value of the structure, that structure must be brought into compliance with the NFIP and local ordinances regarding the elevation of the structure's first floor with respect to the BFE.

Given the potential for a series of storm/hurricane events to result in significant but not substantial damages (as defined by FEMA to be greater than 50 percent of the assessed value of the structure) to a structure, thus indicating a structure in a location where repetitive damages may be possible, using the accumulation of damages over a period of time (say ten years or the lifetime of the structure) may result in more structures being brought into compliance or more structure owners deciding to move out of areas that receive more frequent flooding.

In light of these existing requirements, a modification of the local ordinances of each of the three effected counties and 10 effected municipalities (Pascagoula already using the cumulative damages process) would be to adopt the process of cumulative damages (over a period of time chosen by the local community or county) as a trigger for requiring compliance with the NFIP and local floodplain management ordinance. According to MEMA, the state requires collecting cumulative costs of improvements for each structure, local jurisdiction information that is made available by owners through the building permit process. The fee amount for the building permit is based upon the value of the improvements and there are financial penalties for undervaluing the cost of improvements. Using the dollar value of cumulative damages as a NFIP compliance trigger in combination with improvement values would help to assure that more structures come into compliance with the NFIP and that future damages are reduced.

4.5.2.4 Training and Education of Floodplain Ordinance and Code Administrators and Officers

Each of the three counties and 11 municipalities in the project area is participating in the regular National Flood Insurance Program. Under the regular insurance program, each of these governmental units has an adopted floodplain management ordinance and floodplain zoning maps of their jurisdiction. Once adopted by the general population of the city or county, the ordinance and all of its requirements (floodplain development permits, zoning variances, mapping, etc.) must be enforced and administered by a designated individual (Floodplain Administrator, Building Administrator, Zoning Officer, etc.) or office of that jurisdiction. In some cases communities contract out these services to specialized firms in zoning and ordinance administration, but generally this work is accomplished by the hired staff of the jurisdiction (i.e. planning and zoning department, public works, community development, etc.). In some cases, staff assigned to these positions are newly hired or do not have all of the up-to-date training available from FEMA and other sources.

Interpretation and administration of the zoning ordinances and use of the flood insurance rate maps requires specific skills and training to be proficient in their application and to avoid unnecessary legal actions. In addition to the basic tenants of the floodplain management program, changes in the NFIP occur on a regular basis requiring someone at the local level to be responsible for making necessary changes in the local ordinances and mapping to maintain compliance with the newest FEMA requirements.

FEMA provides ongoing training for local floodplain management officials as well as real estate brokers, insurance agents and those seeking certification in floodplain management and administration. Training classes are offered at selected sites throughout the USA as well as in FEMA regional offices. Some training is offered on the Internet or through home study by FEMA supplied materials.

A nonstructural measure that could be implemented at a relatively low cost would be jointly sponsored USACE/FEMA training classes for local floodplain management staff, mayors, county supervisors, city councils, Chamber of Commerce, hotel/motel associations, real estate brokers, surveyors, architects, engineers, and financial institutions. This training could be held on an annual basis or as new regulation or mapping changes emerged that affected the project area.

Costs for this measure would be confined to USACE and FEMA employee labor and travel costs to attend and administer the training classes. Annual O&M costs would be repeat training costs for new floodplain managers entering the system.

Considering the relatively low cost of providing this training and the potential benefits to the coastal residents that a better educated cadre of floodplain managers and zoning administrators would generate, these measures are all carried forward into more detailed formulation.

4.5.3 Building Codes

Like land use zoning, the adoption and enforcement of building codes is a police power of local governments enabled by state legislation. Building codes normally are limited to structure design and construction methods and materials selection to meet building use requirements and both environmental and weather conditions at the building site. Structure foundations, structural integrity, site grading to promote positive drainage, and utilities are all part of a comprehensive building code. Provisions for addressing flood-prone locations in the design and construction of structure foundations are an important feature of a well-prepared code and make its use in coastal areas imperative.

Application of building code requirements to the design and construction of structures has been proven to significantly reduce damages due to inundation, wave action and winds. Generally, building codes are enacted and enforced through municipal and county ordinances. In some cases code application and enforcement occurs through city and county planning offices, community development departments or public works departments. Local adoption of building codes is encouraged by insurance companies, fire marshals, building contractors, mortgage financing institutions and real estate brokers. In flood hazard areas including V-zones, FEMA encourages all communities to enact and enforce these codes as a preventative measure in reducing insurance losses under the NFIP.

Over the years of code enactment and enforcement, a number of different code standards have been promoted. At the turn of the century, the insurance industry developed what many consider to be modern building codes in response to major urban fires in the United States. The National Board of Fire Underwriters published its National Building Code in 1905 as a model code; that is, a standard code that could be adopted by any locality. Localities could add additional construction restrictions but the basic model was the minimum standard for building construction.

During the first half of the twentieth century, three major regional model code organizations evolved. Building Officials and Code Administrators International, Inc. (BOCA) founded in 1915, International Conference of Building Officials (ICBO) founded in 1926, and Southern Building Code Congress International, Inc. (SBCCI) founded in 1940. The International Code Council (ICC) was established in 1994 as a nonprofit organization dedicated to developing a single set of comprehensive and coordinated national model construction codes. That ensuing “International Building Code” is now generally accepted as the national standard for building construction and its requirements for building construction in flood hazard zones (including V-Zones) is widely acclaimed as a major step in construction technology.

As a nonstructural measure that would be effective in reducing future flood damages, each of the 11 municipalities and three counties should adopt the latest version (2006) of the International Building Code (IBC) and Residential Building Code (RBC) as their standard building codes and especially enforce those sections (or Appendices) of the codes that pertain to construction of residential and commercial buildings in flood hazard areas. Adoption and enforcement of the IBC would assure to a certain extent (with qualified inspections during construction) that structures built or additions to

buildings in flood hazard zones are able to withstand the forces of water, waves and wind generated by storms and hurricanes and that water-resistant materials are being used in the construction.

Based upon a search of the city and county government Internet sites within the project area, several of the municipalities and counties have already adopted the 2003 version of the International Building Code as their standard building code. The code administration offices of each county and municipality should be encouraged to adopt the updated 2006 IBC (residential and commercial versions) which includes special considerations for flood-resistant construction. Based upon the ICC publication "Code Changes Resource Collection – 2006 IBC" dated June 2006, there have been numerous code changes between the 2003 and 2006 versions of the IBC. Many of these changes are specifically aimed at reducing damages to structures that would be located in flood hazard zones. Additional changes have been incorporated into the 2006 version of the IBC and RBC that address wind damages as well.

In addition to the adoption of the updated IBC in the project area, special education classes should be established in local Vocational/Technical Centers, universities and colleges that offer training in the use of the updated IBC to code administrators, contractors, architects, building inspectors, and landowners contemplating significant repairs to their structures that would require a building permit.

As a nonstructural measure, the recent publication of the FEMA guidelines for construction in Gulf Coast flood hazard areas should be adopted by the counties and municipalities as a part of their floodplain management zoning code and/or their building codes., The FEMA 550 *Recommended Residential Construction for the Gulf Coast* provides valuable design and construction guidelines for various types of residential buildings including building and site evaluations, construction processes, foundation designs, flood resistant materials, engineering data and information sources. In 5 chapters and several appendices this publication provides sound technical information for elevating structures in flood hazard zones.

The FEMA 550 guidelines give technical information on elevating residential structures in the V zones although the recommendations in this nonstructural plan are to strictly to avoid that practice because of the dangers posed by storm surge, waves and hurricane-force winds that would be prevalent in the V zone. In view of the potential for storms and hurricanes larger than the design event used to formulate the nonstructural plan in this appendix, elevating residential structures in the V zone could lead families to occupy their homes during an event that would exceed the design specifications of the construction resulting in total failure of the building foundation or walls and loss of life.

Costs for upgrading building codes is confined to purchasing the new codes from the ICC or other sources and administrative and legal costs for incorporating the codes into the existing municipal and county ordinances. Annual O&M costs for this measure are administrative (enforcement and variances) and local. Since local jurisdictions can charge fees for building permits, their costs to update and maintain the IBC and perform inspections of construction can be recovered.

The revision of existing building codes is a relatively inexpensive method of assuring that new construction, building additions or rehabilitation will be constructed in such a manner as to significantly reduce flood and wind damages to structures in the project area. Since the revision of building codes contributes to reducing hurricane and storm damages they are carried forward into more detailed formulation.

4.5.4 Land Use Regulation and Zoning

Land use regulation, more commonly referred to as zoning, is a measure frequently used by local entities (counties and municipalities) to arrange and regulate various land uses within their jurisdiction. Enactment and enforcement of land use zoning helps to avoid conflicts between uses (i.e. industrial and residential), reduce traffic congestion, maintain property values and promotes other social, economic and environmental objectives.

Zoning of private property, like building codes and other land use regulation is one of the police powers granted to local jurisdictions by the states. This method of land use control has been upheld in the judicial system (State, Federal and US Supreme Court) and has helped to shape the physical, economic and social pattern of many cities and counties in the USA. Local zoning is usually required by state enabling legislation to be preceded by a comprehensive plan for the community or county area that includes an official map or plan of the community's land uses and projected development pattern. Also, significant rezoning of property normally requires a preceding, and approved change in the approved official map in the comprehensive plan.

Title 17 of the Mississippi Code authorizes the dividing of property within any municipality or county into specific zones to accomplish the goals and objectives set forth in the comprehensive plan (or official plan) and to fulfill other purposes as described in the Code. In particular, Section 17-1-7 states *"Except as otherwise provided in Article VII of the Chickasaw Trail Economic Development Compact described in Section 57-36-1, for the purposes set forth in Section 17-1-3, the governing authority of each municipality and county may divide the municipality or county into zones of such number, shape and area as may be deemed best suited to carry out the purposes of Sections 17-1-1 through 17-1-27, inclusive. Within the zones created, the governing authority of each municipality and county may, subject to the restrictions with respect to agricultural lands and farm buildings or structures as set out in Section 17-1-3, regulate and restrict the erection, construction, reconstruction, alteration, repair or use of buildings, structures or land. All regulations shall be uniform for each class or kind of buildings throughout each zone, but regulations in one zone may differ from those in other zones."*

Zones or districts are labeled by the predominant land use type allowed within that zone such as residential, commercial or business, industrial, institutional or public, parks and recreation, transportation, vacant, and open space. Each general use zone can be further divided into density sub-zones (R-1, R-2, C-1, B-1, etc.) denoting units per acre or floor area ratios of each use type. Special overlay zones can be added to the normal zoning pattern to address sensitive environments, architectural aesthetics, economic development, environmental hazards, agricultural or historic issues or developmental programs. Zoning ordinances normally describe the types of uses allowed in each zone or district and prescribe certain other limitations or development requirements for each zone. Zoning ordinances can be used to limit development in certain high-hazard areas or areas with sensitive environmental resources.

Under the umbrella of this state enabling legislation, each of the three counties and 11 municipalities being studied in this report may (and have) established land use zoning ordinances for their jurisdictions to fulfill the goals and objectives of their comprehensive plans. As an example, Figure 8 shows the land use zoning map for the City of Biloxi, MS. The color coding identifies the various land uses (residential, commercial (business), industrial, central business district, waterfront and others) and the interfaces between the uses. In the example below, shades of yellow denote residential uses; red and orange indicate commercial uses and dark blue denotes the Biloxi central business district (CBD) at the Gulf shoreline. The designations of B-1, B-2, RM-10, etc. for each color indicate land use densities such as dwelling units per acre or as an expression of floor area ratio for commercial uses on the parcel.

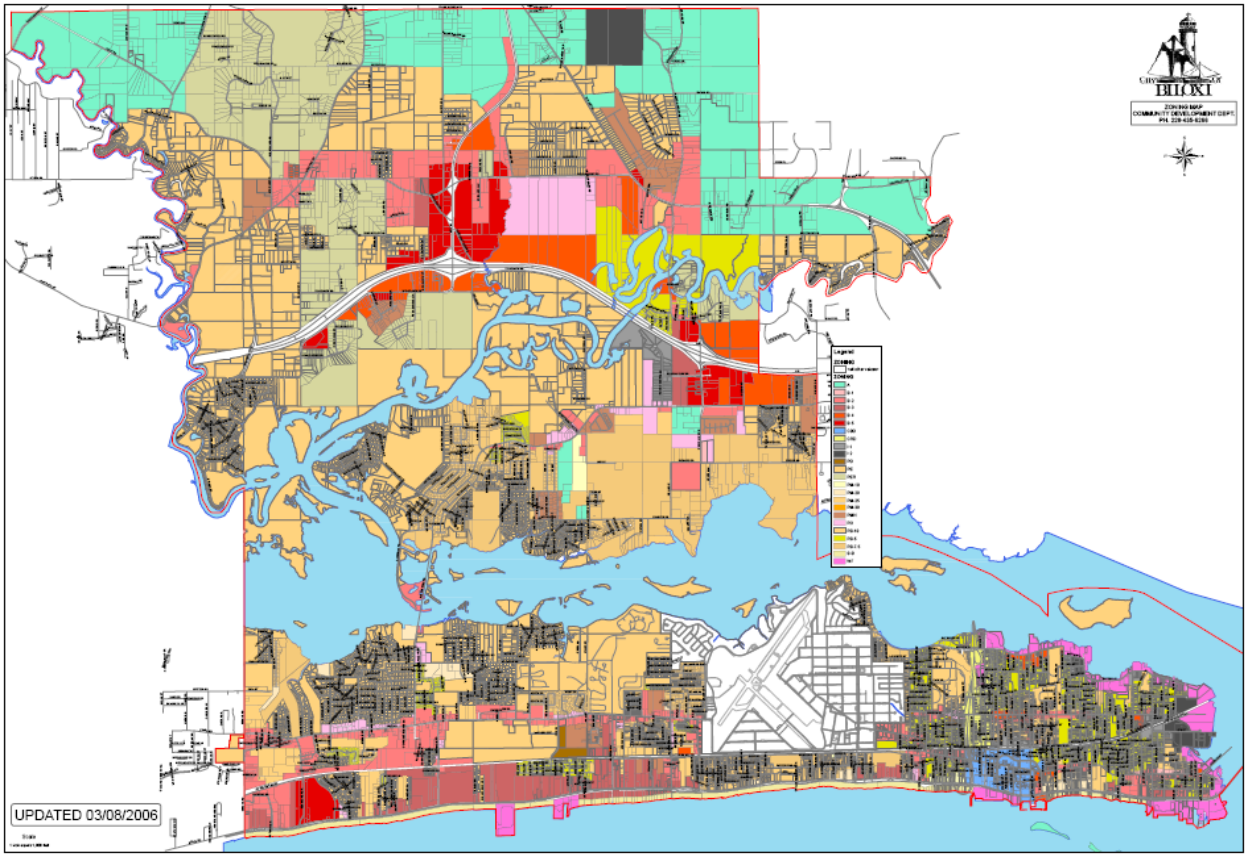


Figure 8. Biloxi Zoning Map

The courts have overturned numerous zoning ordinance determinations by communities and have stricken numerous zoning ordinances where zoning restrictions on private property have literally removed all reasonable use or economic value of the property to its owner. Courts have ruled that such Draconian zoning ordinances constitute a "taking" of private property and require reimbursement of the property value to the owner or retraction of the ordinance itself. Zoning private property that is subject to natural hazards (flooding) such that its value is significantly reduced borders on a taking that may require acquisition of the property at fair market value. See Section 4.5.2 - Floodplain Management, Floodplain Zoning, Flood Insurance and CRS on the application of zoning measures in the floodplain.

Generally speaking, land use zoning or rezoning as a measure for reducing flood damages is largely ineffective in many cases because of the amount of existing at-risk development that has been "grandfathered" into the zoning ordinance at the time of its enactment. These "non-conforming uses" cannot be totally removed through the zoning ordinance process unless they are destroyed (declared unsuitable for occupancy or a hazard) and then reconstruction is possible so long as the new structure and its use conform to the zoning district requirements. Again, overly restrictive covenants on the property would constitute a taking and require compensation of its value to the landowner. Only in the application of floodplain zoning and then only in the case of the regulatory floodway can such absolute redevelopment restrictions be upheld in the courts.

In areas where no development has taken place (vacant land) or where development has been largely removed (total loss areas), zoning or rezoning of the property could accomplish several project objectives. Property devoid of structures only retains its basic land value as dictated by market forces. That land value is influenced to some extent by the natural hazards that may

endanger any development that would be constructed on the property. In the case of the study area, there are vast numbers of privately-owned tracts where the structure has been totally destroyed leaving only a concrete slab or wood pilings from the previous foundation. In these cases, rezoning the property for other land uses more adaptable to and compatible with the natural hazards may indeed accomplish several program objectives.

Zoning of high-risk properties bordering the coast and some of the inlet areas could be used to reduce the incidence of damages to certain types of development or all development. As discussed earlier, overly restrictive zoning that removes all economic opportunity of the property to its owner would be found to be a taking under the 5th Amendment and require just compensation. Attempts to rezone property previously zoned as residential or commercial uses for which the land may bear an economic return for its development or sale to park, open space or environmental uses zoning would raise that red flag of a taking.

Although a single zoning action that would prohibit all development within a specified area along the coast would significantly reduce flood damages in the project area, without full compensation of the fair market value for the property such zoning could be stricken in court. Significantly reducing the density of development from four dwelling units per acre to one dwelling unit per acre may be possible, but a court ruling may still consider that action to be a taking and the current ownership pattern may void any opportunities for actual implementation of such a rezoning change. In effect such restrictive zoning is no different than a complete mandatory buyout of the high-hazard zones.

Another option for rezoning the high-risk coastal and inlet areas may be to recognize the ability of higher density type development (development which commands a higher economic return for the property) to financially meet or exceed the restrictive building codes and extra requirements imposed by FEMA guidelines for development in these high-risk zones. While single-family homes, private-owner motels and chain restaurants generally do not have the financial resources to meet the restrictive construction guidelines or cannot be architecturally adapted to the guidelines, a mixture of high-density commercial and residential units may be able to meet those guidelines and still return a significant economic return to the owners.

Zoning the coastal areas for mixed-use commercial and residential at per-acre densities that would force building construction to be predominantly vertical combined with FEMA guidelines for first floor elevation could result in a number of multi-story buildings perched above parking garages along the beachfront. A mixture of residential condominiums, casinos, retail shopping and other associated uses perched on multi-decked parking garages would allow intensive reuse of what is now largely vacant land except for residential single-family foundation slabs and FEMA trailers.

In addition to reuse of these uneconomic properties, this form of redevelopment would generate significant tax revenues, employment opportunities, windfall profits for existing beachfront landowners and produce a significant structural wind break for development landward of this corridor. The nonstructural team observed these “wind-shadow” effects (as well as surge/wave-shadows) along the coast where more substantial building construction along the beach protected numerous residential and commercial structures located just landward of that building line – in effect a building “line-of-defense”.

More importantly than the potential benefits to intensive use of the beachfront properties through rezoning is the fact that such zoning would not be viewed as a taking requiring compensation. This rezoning would be considered as a financial windfall for existing landowners whose property would become exceedingly valuable to new developers. Similar in some respects to the TDR concept, coastal land otherwise of little value would have far higher value in this new market situation thanks to rezoning. Properties found to have potential for ecosystem restoration as wetlands could be purchased and developed as buffer areas landward of the high-density beachfront and integrated with golf-courses or other passive uses (trails, etc.).

In addition to zoning, another frequently used land regulation mechanism is Subdivision Regulations. These regulations prescribe requirements for the subdivision of land into individual lots for construction of either or both residential and commercial uses. The regulations address design and construction of all land improvements within a subdivision including platting of subdivided land, site grading, drainage, streets, utilities, site hazards, right-of-ways, easements, and lot setbacks. Developers wishing to subdivide land into individual lots for residential and/or commercial use must submit development plans (prepared in accordance with the subdivision regulations) to the Municipality or County where the site resides for approval. Usually both a preliminary plat and final plat that address all of the concerns listed in the regulations must be submitted for approval before any construction may begin.

Subdivision regulations can be modified such that the inundation threats for each lot can be delineated on the developer's submitted plat map and the regulations themselves can place certain restrictions or requirements on the developer to assure that the future landowners within the subdivision are either protected from defined inundation depths or made fully aware on their property map of the potential inundation threat on their lot. Since construction of any subdivision (where such regulations exist) depends upon approval of the submitted plat map by the local government, these restrictions and requirements with respect to inundation threats can be very effective for any new growth in the project area.

Costs for changes to zoning ordinances or subdivision regulations are local, administrative and minimal in nature compared to other alternative measures. Normally, municipal or county planning or engineering staff personnel, or planning commission or zoning board members administer zoning actions (variances, meetings, reviews, etc.) and subdivision application reviews.

Considering the level of control that these land use regulations can assert on the development and use of land within each jurisdiction in the project area, land use regulation (zoning and subdivision regulations) have been carried forward into more detailed formulation of nonstructural plans.

4.5.5 Development Impact Fees, TDR, PDR, and Redirection

4.5.5.1 Development Impact Fees

Communities nationwide use monetary development impact fees to address external costs resulting from land development projects that impact associated community services and amenities. Normally these impact fees address additional loadings on school systems, libraries, infrastructure (utilities, roads, collection services), fire, police and emergency services and other public services that support new development (especially residential and commercial development that use those services most).

Generally development impact fees have been upheld in the courts provided that they are levied fairly by an governmental entity legally able to collect such fees, that they are collected for addressing a legitimate public purpose, and that the method of collection most closely resembles the objective for the fee so as to not approximate a taking. In this case, support of a redeveloped and robust emergency services system that would be applied to many types of hazards (especially hurricanes and floods) would be a legitimate purpose for the fees. As such an emergency facility would be directly related to structures and families living on the flood-prone lots from which fees were collected, the legal nexus would be sound.

These monetary impact fees could be applied to new land development or subdivision development on a per lot basis to address municipal or county costs associated with flood emergencies and the aftermath cleanup in damaged areas. The level of fees assigned per lot would be directly related to the level of flood risk at the individual subdivided lot – greater the flood risk, the higher the fees (i.e.,

V/VE zone - $10,000/lot, A/AE Zone - $8,000/lot, B zone $4,000/lot). Developers of the subdivided sites could reduce the fees by receiving local planning commission approval on specific, bonded measures that reduced the flood hazard on the lots.

Costs for instituting development impact fees are local and administrative in nature.

4.5.5.2 Transfer of Development Rights (TDR) and Purchase of Development Rights (PDR)

Transfer of Development Rights (TDR) and Purchase of Development Rights (PDR) are land use control mechanisms predicated on the concept that landowners' rights to develop their property can be separated from other land rights (mineral, air, surface, etc.) and traded or purchased within a market-like system. Generally speaking any land use controls (zoning, etc.) that significantly decrease the market value of property or remove an opportunity to receive some economic value or use from the property have been considered a taking under the Constitution and require compensation to the landowner. TDR has been found in the nation's courts to be a legal device for transferring that portion of a landowner's rights to the property for compensation in a market-like process that avoids the "takings" issue. As the programs are strictly voluntary in nature, the takings issue is set aside. The ability of local governments to establish and operate either a TDR or PDR program is normally enabled by enactment of state legislation.

In TDR, the landowner's right to develop certain property (sending lot) that may be environmentally sensitive, historic, scenic, prime agricultural land or flood-prone, can be offered as a market item to be purchased (monetary transaction) by other landowners whose land (receiving lot) is not restricted by the same environmental, hazard or historic parameters. Normally the receiving property is provided a density bonus whereby more units of housing or commercial floor space development can be permitted on the same land area with the purchased development rights. TDR programs are popular within the United States and have been used successfully (i.e. Maryland) to reduce losses of sensitive environmental landscapes, historic buildings, and agricultural land or restrict development on hazardous property while allowing land development and the tax revenues associated with growth to increase.

A TDR program can be established by a local unit of government, such as a county within which both the sending and receiving property are located. Based upon documented parameters, sending properties are identified and values associated with the development rights are established. A number of properties in the sending area can be formed into a "sending district". Landowners of potential receiving properties (which are designated as "receiving districts") are given the opportunity to purchase (monetary transaction with the sending landowner) those rights. The owner of the sending property retains ownership of the land but is not able to develop the property under the terms of the transaction. Normally, property taxes on the sending lots are reduced substantially to reflect the loss of potential development. The sale of the development rights is documented on the property deed and encumbers the deed in future land transfers.

Establishment of a TDR program in the project area would require the enactment of state enabling legislation. Examples of that legislation are available from other states and the costs for instituting and operating the program are local and administrative. All other costs are contained within the land development rights transfer market. The establishment of a TDR program was one of the 180 suggestions offered by the public and cooperating agencies.

Purchase of Development Rights (PDR) accomplishes the same objectives as TDR but requires a unit of government (county or municipality) to purchase all or some (development easements) of the development rights of the subject property. Generally the value of the development rights reflects the appraised value of a structure type (residential or commercial) that would be permitted under

existing land use zoning. The value and limited use of the land and its reduced property tax burden remains to the landowner. This development rights purchase program is unlike the TDR program in that the development rights are not resold or traded through a market mechanism, but held in a public trust and used for public uses (recreation, etc.) or left in their present land use (historic preservation, ecosystem, scenic easement). A successful PDR program is operating in Lexington, Kentucky where development rights of horse and agricultural farms surrounding the metropolitan area are being acquired to preserve the scenic quality of the landscape and forestall subdivision development outside of the municipal water and sewer service area. The value of the development rights is being established through a comparison of tax assessments displaying both with and without future development values of the tracts.

As is the case with TDR, a PDR program would require enactment of state enabling legislation. Costs for instituting the program would be local and administrative or could be operated through a non-profit organization. Costs to operate a PDR program would require sizable sums of capital with which to purchase the development rights of vacant lands in the project area. Funds could be secured from the state or through local taxes or assessments to fund the land purchases.

Both TDR and PDR could be used in the project area to acquire development rights of parcels subject to frequent inundation or that are environmentally sensitive. Properties subject to inundation by surge and waves or that are prime ecosystem habitat could be designated as the sending district and property located above the 500 year event or the Maximum Probable Intensity Hurricane surge-plain could be designated as receiving districts. Monetized property development rights could be designated in the sending district and sold by the administrating agency to eligible property owners in the receiving district – a transaction that restricts development in otherwise hazardous or environmentally sensitive areas with compensation provided through a private market process. More dense development in the receiving district would offset property tax losses in the sending district. Tax-sharing agreements between the sending and receiving districts could offset losses in the TDR sending areas.

Since both of these programs are voluntary in nature and are essentially market-driven processes, they are not easily scheduled as other more proscribed measures (acquisitions or floodproofing). Given this characteristic, both TDR and PDR may be more applicable to high-hazard properties that were vacant prior to the Katrina event where development pressures are not as high. These properties are less likely to be redeveloped in a short period of time giving the process time to acquire the development rights. Using either TDR or PDR to restrict development of these properties would accomplish many of the planning objectives without direct Federal expenditures.

Both of these measures should be carried forward into a more detailed nonstructural plan formulation process. Requirements for state enactment of the required enabling legislation would have to precede implementation of the measure by local governments.

4.5.5.3 Land Development Redirection

Land development redirection considers that rational Federal, state, county, municipal, corporate and private landowners when confronted with ongoing natural or man-made threats that result in damages to fixed assets will over time migrate to locations that avoid such continuing losses. In situations like Katrina, where physical damages are catastrophic and there are losses of life, some migration out of necessity would occur at least temporarily. Reconstruction back within hazardous areas does occur so long as the risks of future events can be mitigated or the risks are ignored by landowners due to cultural, social or financial influences. As discussed in Section 4.5.2 above, certain loss off-setting programs such as flood insurance can delay that long-term permanent migration so long as the insurance carrier chooses to continue reimbursements for damages. As is

now evident by the many court battles between landowners and insurance carriers along the coast, that continuing reimbursement for damages may be ending soon.

For public facilities (schools, fire stations, police stations, hospitals, emergency services, public works facilities, etc.) that are: 1) more expensive than residential or commercial uses to repair following damaging events, 2) that need to maintain continual services (some emergency services) to thousands of citizens, and 3) have to be repaired with either disaster mitigation money or local taxes, maintaining such facilities in hazardous areas becomes a burden on the financial and political resources of the community. Both county and municipal governments can, over time, successfully relocate certain public facilities out of hazardous areas through judicious use of funding authority in their Capital Improvement Programs.

Capital Improvement Programs (CIP) are enabled by state legislation and allow local governments to construct new facilities or rehabilitate existing facilities to serve public purposes or in some cases purchase very expensive equipment (vehicles, pumps, electronics, etc.) that would be beyond normal purchase limits under local annual operation and maintenance fund accounts. Local governments establish capital improvement programs based upon approved public facilities plans either through a comprehensive planning process or some other process provided for in the state enabling legislation. Under this CIP, a county or municipality could issue bonds, borrow funds or use tax receipts to fund relocation of public facilities that are located within hazardous flood zones and have been repeatedly flooded or are reaching the end of their useful design life. Generally, substantial redevelopment/relocation of public facilities by local governments is a long-term process due to the high costs involved and the political processes necessary to resolve service area disputes and other social issues.

Although careful exercise of land development policies, regulations and programs (such as the CIP) can result in eventual changes in land use that decrease development in high hazard zones and increase growth in less threatening areas, more direct action can be taken that accomplishes the same objectives in a much shorter time period. Specific actions that redirect growth and redevelopment into less hazardous landscapes can be supported with capital investments in land acquisition and infrastructure development and either Federal or State supported mortgaging assistance.

In a relatively stable housing market such as existed prior to the landfall of Katrina in the project area, new housing starts away from the coastal floodplain were sufficient to handle consumer demands for larger and more amenity-filled homes. Relatively new developments such as Diamondhead and other PUD's away from the coastal floodplain were based upon an exclusive housing market demand and lack of sufficient and affordable vacant land within walking distance of the beachfront.

Prior to Katrina, residential development along the coastal floodplain was required by ordinance to adhere to FEMA regulations and the latest version of the municipal or county FIRM. Following Katrina, the establishment of the Advisory Base Flood Elevation by FEMA, disagreements on insurance settlements, lack of flood insurance and insufficient personal capital have resulted in little redevelopment of destroyed housing along the coast. Katrina and the loss of tens of thousands of homes resulted in a severe housing shortage to accommodate displaced landowners and any new arrivals. The past demand turned overnight into a housing need that did not have sufficient available flood-safe residential lots, infrastructure, construction capital, or mortgaging funds. Fortunately many of the displaced population left the area entirely reducing some of the burden on the already damaged housing market.

In order to address the shortages of available residential lots and selected commercial redevelopment that would support construction of new residences, a government-assisted program (county, state or Federal) of new redevelopment sites could assist in redirecting growth away from

the coast and to flood-safe sites. This method of redirecting growth has been used successfully in other flood damaged areas where the housing market is unable for whatever reason to recover and provide needed replacement units. Adding flood-safe units to the housing market not only opens up additional resources for displaced homeowners to return to the project area but provides relocation housing for those whose property may be purchased as a result of applying either structural or nonstructural measures as part of a Corps project. Increasing the availability of reasonably priced development lots also eases the cost pressure on limited market opportunities.

Numerous redevelopment sites can be selected, planned, designed and constructed at a designated flood-safe elevation that would entice people living in FEMA trailers on property where only a concrete slab remains to move upland and away from future flood damages. Necessary site improvements (land clearing, grading and drainage) and infrastructure (utilities, roads, etc.) would be provided with mortgage assistance available through government-sponsored relocations and housing programs. These types of relocation and redevelopment projects have been successfully implemented in other regions as part of nonstructural and structural projects.

In-fill developments within existing communities that are less flood-prone could help to reduce the social and economic impacts of relocations. Several opportunities for in-fill developments were identified during the community assistance design charrettes conducted in 2005 and 2006 under the Mississippi Renewal Program. These in-fill projects would absorb a number of relocations with floodproofed structures within urban areas featuring existing infrastructure and services. Collaboration with local planning commissions and development authorities for in-fill projects would help to assure successful integration of relocatees into the existing community fabric. Care must be taken to assure that in-fill relocations do not overtax schools or other public services within receiving communities. Section 4.5.9 - Permanent Acquisitions contains a more in-depth look at infill developments as a redevelopment concept.

In some communities such as Waveland, Pass Christian and Bay St. Louis where a mandatory acquisition plan applied to high hazard properties along the coast would result in large scale relocations of the population to less-flood-prone areas, another redevelopment plan may be in order. In these special cases, relocating whole neighborhoods or communities as an intact social entity should be considered. In the absence of planned community relocation, these municipal areas would merely be dissolved in time due to a lack of human resources and a crippled economic base.

Planned community relocations would provide the opportunity to accommodate all existing flood-prone land uses into a flood-safe location in a coordinated way that would maintain many of the basic social and economic associations now thriving in the present community. Developing planned communities could also reduce the impacts of a dispersed population impacting public facilities (schools) and services (police, fire, garbage, etc.) in the destination communities.

The challenges in planning large-scale relocation communities in a developed region center on aggregating sufficient land on which to design a coherent community layout. A review of available aerial photography for the project area shows limited development opportunities of any appreciable scale south of Interstate 10 except for a few isolated parcels. Moving north of Interstate 10, there are opportunities that can be explored for relocation communities. These sites would be investigated in greater detail for their possible use as Housing and Community Redevelopment Sites as an adjunct to the permanent acquisition measures.

Obviously redirection of land development can be more successful in coastal areas that are less urban in character, where sufficient flood-free land is available for the redirected community development to occur and where recent events such as a major hurricane have resulted in significant damages to coastal structures and communities. In areas of the Gulf coast that were not directly affected by Katrina or other recent hurricanes, this strategy would be more difficult to implement given the lack of incentives or necessity to move away from these high-hazard areas. The

inertial forces associated with a non-threatening, highly aesthetic coastal location are formidable. Formulation of protection strategies for these non-impacted, urban areas may concentrate on measures that emphasize protection in place rather than redirection of development.

Costs for redirection of growth in the project area would be substantial. Site acquisition, site improvement and infrastructure costs could range between $25,000 and $45,000 per subdivided lot. Depending upon the number of lots developed and the amenities provided redevelopment communities (500 units) could cost between $10.0 and $20.0 million each. Implementation of this process would take several decades depending upon funding constraints and the willingness of the project participants. In view of the potential for "tiering" of the nonstructural measures, land development redirection would fall into the later tiers of implementation.

Development impact fees, TDR and PDR and Land Development Redirection are all techniques that act as incentives or disincentives to redevelopment in hazardous coastal areas. Because they are proven methods for reducing damages to potential future growth they are carried forward into more detailed plan formulation.

4.5.6 Land Taxation Policies, Special Assessments and Revenue Sharing

4.5.6.1 Land Taxation Policies

The taxation of private property through the *ad valorem* tax process, besides being a method of raising revenues with which to operate county and municipal services, can be used as an economic system of incentives and disincentives for directing land use development. Normally, private property taxes are established based upon categories or classes of land use (residential, commercial, agricultural, industrial, and vacant) and their location within or outside of municipal areas. Property taxes are a reflection of the assessed value (a percentage of fair market value determined by the tax assessor) of the land and improvements and locational aspects of the property. Normally property is taxed at a percentage of its true assessed value. Properties are divided into taxing districts that reflect values and which taxing authorities (schools, services, etc.) apply to that location. Different millage rates are applied to each district.

Property taxes are calculated using millage rates determined by the tax assessor's office. The millage rate is determined by dividing the amount of total revenues needed to operate and maintain county and or municipal services (that portion supported by taxes) by the total assessed value of all property within the county (excluding exemptions) or a particular district. The millage rate or "mill" represents one dollar of tax per $1,000 of value of assessed value on the property. Adjustments to the rates are made based upon the property classifications and units of government (county or city) where the property is located.

Since revenues derived from property taxes are a reflection of the costs of maintaining services that support that property, additional costs for maintaining certain classes or locations of property could be defrayed by increasing the assessments or millage rates applied to those "high-maintenance" properties. In other words as the tax district budget increases due to responses to flood events, the millage rate is adjusted to capture those costs from property taxes. Properties located in flood-prone areas that require a higher percentage of public services for support could be taxed at higher rates to reflect that increased service demand. This economic disincentive on development would in time discourage growth in that area. Likewise, for certain aspects of property maintenance provided by a municipal or county that are cheaper because of their location (flood-safe), taxes on those properties could be lowered as an incentive to encourage building in those safer (less-costly) areas.

Costs to modify tax millage rates are local and administrative/legal in nature. The costs to modify the rates are not as compelling as the public reaction would be to making the changes.

4.5.6.2 Special Assessments

In addition to modifying existing millage rates for property taxes in high hazard areas, special assessments on flood-prone property could be used as a disincentive to further development. In theory, taxes from individual land uses should be set such that the costs of delivering public services to that use are offset by the annual taxes accruing to each parcel. In practice property taxes rarely collect sufficient revenues to fully capture all of those costs, but in situations where a property or properties are subjected to recurring damages (such as flooding) including damages to infrastructure that services that property, those costs far exceed the property tax revenues. In these cases, special assessments can be levied against those properties to capture additional revenues for the higher costs of services delivery, infrastructure repairs or to capture windfall benefits accruing to property due to some public improvement that services that property. A special assessment tied to the higher costs of services delivery in a hazardous taxing district would raise the tax burden on properties in that hazard area and in time redirect growth away from those higher cost properties. The special assessments would be added to the existing millage rate of that tax district to support higher costs of service delivery or repairs to infrastructure. Basically used as an additional revenue producer for the public services provider, special assessments can also act as a disincentive for future growth in hazardous areas.

Like modifying tax millage rates, the costs of enacting special property assessments are local and administrative/legal in nature. The public reaction to the assessments (perceived by many as a tax burden) would be much more problematic.

4.5.6.3 Revenue Sharing

An ongoing malady confronting many municipal governments is the rush of downtown businesses and residential growth to more rural county locations. This shift of property tax revenues from municipal to county areas further exacerbates the plight of deteriorating downtowns. This process has been occurring for many years as new transportation opportunities and development sprawl extend growth into non-municipal areas. The affects on the nation's cities are evident everywhere as the thresholds of commercial and public services for losing and gaining communities are approached. Many unique strategies to mitigate the economic and social effects of these migrations have been implemented across the nation. Those strategies include establishment of metro-governments and revenue sharing.

In the case of the project area, use of TDR, PDR, rezoning, taxation polices, changes in the NFIP, planned acquisitions and relocations, all affective nonstructural methods of reducing damages, would in time gut the economic hearts of the existing cities on the coast. Municipal areas like Pascagoula, Biloxi, Gulfport, Pass Christian, Bay St. Louis and Waveland could experience massive reductions in private property ownership and the taxes produced by that property as development is acquired and/or redirected north towards the I-10 corridor and beyond. In an effort to offset these losses, two strategies are possible.

First is the establishment of metro-governmental structures whereby the county and municipal governments are joined into a more regional structure that can address the equitable delivery of public and social services and more evenly distribute tax revenues collected throughout the new jurisdictional boundary. Metro-governments are used across the nation to address the economic effects of sprawl and migration of business and residential taxes from municipal to county governments. Another strategy that can be instituted to defer the heavy losses of revenues associated with business and residential migration is revenue sharing. Municipal/county agreements could be negotiated whereby all or portions of tax revenues generated by relocated facilities could be shared between the receiving counties and losing municipal governments. Sharing of the tax revenues would enable municipal areas to maintain a minimum level of services to remaining

households and businesses that have not been removed. At a later date when the relocation of the majority of the taxable base has been accomplished, the revenue sharing ceases and the municipal area as a separate jurisdiction is abandoned.

Although revisions to local property taxation rates and special property assessments can be formidable methods of discouraging continued land occupancy in high-hazard areas, they tend to be regressive in nature. Given the wide disparities between the income levels of occupants along the coast, increasing property taxes as a financial disincentive to maintain occupancy in a high-hazard area would fall heavily on low-income and fixed-income households. Low-income residents consistently expend disproportionate shares of their limited income to pay property taxes and other land occupancy costs than do their wealthier counterparts. Using the property tax rates to accomplish changes in the land uses and occupancy of high-hazard areas may result in environmental justice issues with a disproportionate share of the costs falling upon the low-income and fixed-income segments of the general population.

In addition, property tax rates are normally capped at certain levels set by state codes, local ordinances or through popular referendums and substantially extending those limits to accomplish a project objective may entail major revisions to already politically sensitive legislation or ordinances. For these reasons, modifications to the property tax rates and the application of special property assessments to discourage development in high-hazard zones will not be carried forward into more detailed formulation. However, should permanent acquisition and relocations of residential, commercial and institutional structures be part of a final nonstructural or combined plan, measures for sharing tax revenues between the counties and municipal jurisdictions are being carried forward in the formulation process to offset tax revenue losses.

4.5.7 Floodproofing

4.5.7.1 General

Floodproofing is a very broad term that describes an array of building construction techniques that can be used to reduce flood damages to structures. This method of protection can be applied to new building construction or can be applied to existing buildings commonly referred to as retrofitting. Structures of different construction types (wood frame, masonry over frame or solid masonry), sizes, uses (residential, commercial, and institutional) and foundation types (slab, crawl space, or basement) can be floodproofed in one of several ways described below.

Unlike permanent acquisition and evacuation (discussed below), floodproofing measures result in the continuation of the structure's functions on-site in some modified condition so that normal functions of that structure or facility can continue (with post-flood cleanup) shortly after the conclusion of a storm event. Although this rebound capability is a plus for families and communities attempting to recover from a major storm event, the risks associated with the determination of appropriate levels of protection and both design and construction parameters are many. Full consideration of risks and uncertainty in establishing the appropriate level of protection and building design parameters is important in the formulation of the floodproofing measures.

Also important to floodproofing is a reliable and timely flood warning and emergency evacuation program so that residents of floodproofed structures can safely evacuate their protected structures. Generally speaking, occupants of floodproofed structures and facilities should not inhabit the building during a flood event. The uncertainties surrounding the prediction of surge depths, wave heights, and other deadly components of approaching hurricanes and storms are too great to risk weathering such events in an at-risk location. Regrettably when the threat of building failure is greatest, rescue is nearly impossible and any rescue attempt would place responders in extreme peril.

Floodproofing has been used extensively across the nation within government-sponsored mitigation programs, as a component of local floodplain management plans or as a private structure owner initiative for communities in both coastal and riverine situations. Thousands of homes, commercial and institutional buildings along the nation's coasts have been retrofitted or newly constructed so that the first habitable or sales floor (commercial) is elevated above a specified flood level.

4.5.7.2 Floodproofing Types

Floodproofing is generally divided into two types: 1) dry floodproofing where no water enters any portion of the structure, and 2) wet floodproofing – where water (floodwaters or clean water) is allowed to enter some portion of the structure temporarily without damages to the structural components of the building or the contents.

Methods of dry floodproofing include constructing watertight enclosures surrounding the building including veneer walls, applied sealants to existing walls and either ringwalls or ring levees that prevent water from reaching the interior of a structure and its contents. Placing fill materials on the building site as a means of elevating the first floor can also be effective although the NFIP requirements for the use of fill materials on individual lots in V zones is very restrictive (erosion concerns). Several structures in the project area that had apparently been raised on engineered fills withstood the storm event with moderate water damages to the first floor. Ringwalls and ring-levees can also be effective methods of dry floodproofing but calculating the appropriate level of protection is full of risks and uncertainties.

Wet floodproofing can include allowing floodwaters or clean municipal water to enter portions of the structure that are so designed that immersion does not damage flood–resistant building materials or contents. The most common method of wet floodproofing is raising or elevating the first habitable floor of an existing building (a.k.a. retrofitting) or constructing a new building on a foundation that elevates the first floor above the specified flood level. Figure 9 shows an elevated residential structure that weathered the surge and winds of Katrina with minor damages.



Figure 9. Elevated Residence in Project Area

Under the National Flood Insurance Program, that specified flood level is normally referred to as the Base Flood Elevation (BFE) which normally has an annual recurrence probability of 1 percent (known commonly as the 100 year frequency flood event). Structures can be elevated to higher levels providing greater levels of protection and further reducing risks, but the BFE is the minimum level specified by FEMA to be in compliance with the NFIP.

In accordance with the NFIP and regulations promulgated by FEMA, many structures in the project area had been wet floodproofed by elevating the structure on wood pilings, piers, masonry columns and other foundation types thereby elevating the structure's first habitable or sales floor to or above the BFE. Areas beneath the raised first floor whether enclosed or not remained subject to flooding. The majority of structures was residential uses and was wood frame or masonry over wood frame construction. Prior to the arrival of Katrina, these structures were able to withstand other high-water events (surge and waves) generated by less powerful hurricanes and tropical storms with minimal damages. Their survival depended upon the elevation of the first floor and vulnerable residential-type stud-wall construction above the storm surge and waves.

Generally, when structures are elevated to a level where the storm surge and pounding wave action cannot impact the building's first-floor substructure or the first floor walls, their survivability increases dramatically. In an elevated condition, only wind forces become a threat to the structure. Application of hurricane-tested building code construction methods and materials use can reduce wind damages to raised structures.

4.5.7.3 Katrina Damages to Existing Floodproofed Structures

The massive surge and waves associated with hurricane Katrina either swept (lateral forces) or lifted (buoyancy forces) many elevated structures off their foundations or the pier foundation itself failed resulting in loss of the structure during the storm. Although hundreds of residential and commercial structures had been elevated according to acceptable FEMA standards proscribed in the NFIP guidelines, the combination of surge levels far exceeding the BFE and waves transported on the surge into the first floor walls and substructure of those elevated structures resulted in their destruction. Several elevated structures that survived Katrina showed signs of wind damage and inundation damages, but they were largely intact. Figures 10 through 13 show the damages to elevated structures resulting from Katrina.



Figures 10, 11, 12 and 13. Damages to Elevated Structures

Observations of the structural damages due to Katrina indicated that many of the unit masonry construction columns and piers failed resulting in total loss of the elevated structures. Improper design and construction methods may have contributed to some of the failures, but in many cases even what appeared to be well-designed and constructed foundations failed due to the extreme forces brought about by Katrina. In these cases, the proscribed level of protection (BFE) was insufficient to prevent the battering forces of waves and debris from crushing the sidewalls of standard residential construction. In several cases concrete block columns and poured concrete, steel-reinforced cylindrical columns both failed resulting in total building loss. Based upon field observations, driven wood piling and deeply set wood poles seemed to survive the combined forces of surge and waves. In most cases the elevated structures themselves had been destroyed, but the wood post foundation, main supporting beams and cross-bracing survived the storm event. Figures 14 through 17 show these remnant foundations and the extent of damages inflicted by surge and waves.



Figures 14, 15, 16, and 17. Remnant Foundations

4.5.7.4 Floodproofing by Elevation (Raising-in-Place)

4.5.7.4.1 General

Elevating the first habitable or sales floor of a structure above specified flood levels is an effective way to reduce damages to a structure and its contents. This method of floodproofing can be applied to both new construction and existing structures (retrofitting) using several techniques including an extended foundation system or an engineered fill. Extended foundations can be accomplished by the use of pilings, piers, columns, or solid walls. The particular type of foundation used is dependent upon the building construction type (wood frame, masonry), building weight, and height of raise, the location of the building with respect to wave action and surge, and cost effectiveness.

In accordance with NFIP guidelines, solid wall foundations are not permitted in V-zones due to the destructive wave forces that can be brought to bear on wall surfaces resulting in foundation failure. However, solid wall foundations could be used in areas where flood damages would only be caused by inundation of the structure (no waves).

In addition to extending the foundation to elevate the structure, floodproofing requires extension of utilities serving the structure (electric power, water, sewerage, gas, telephone, and telecommunications) and modification of access from the ground surface up to the elevated first

floor. In special cases (handicapped or elderly) some options for assisted access (chairlifts) can be included in the elevation design. Although these associated construction components constitute a smaller proportion of the total floodproofing construction process and cost, they are sensitive to the height of raise and determine the livability of the structure. NFIP regulations for coastal areas allow a maximum 300 square feet on enclosed space beneath an elevated structure for securing access to movable storage and as a utility chase.

Closely allied with retrofitting existing structures by elevation is the concept of "rebuilds" on site. In many cases, existing structures that have been found to be eligible for elevation with regard to the allowable water depths at the site cannot be raised because of structural integrity issues due to storm damages or building deterioration. In these cases, rebuilding a new elevated structure on site may be cheaper than either acquisition or rehabilitation of the existing structure. Successful "rebuilds" accomplish the basic objective of reducing flood damages to structures as well as increasing the value and conditions of the housing stock in the project area. All "rebuilds" are designed and constructed to building code specifications and elevated according to local floodplain management ordinances.

This additional option for landowners makes the floodproofing measure very attractive. Opportunities for "rebuilds" are probably numerous throughout the project area, but without detailed data on the conditions of individual structures, an estimate of their number is problematic at this level of detail. More detailed documentation of eligible structures within the project area would be able to capture the number of these potential rebuilds. Costs for rebuilds have been included in the floodproofing section of this appendix since they are identical to elevating new structures on eligible vacant lots.

4.5.7.4.2 Level of Protection

Floodproofing through elevation of the structure is very sensitive to the selected level of protection and storm hazards of the building site. In coastal V-zones and riverine floodways, floodproofing by elevation is generally to be avoided due to the immense physical forces that moving water can exert on building foundations and both building floor and wall systems. In addition to these dynamic water forces, the presence of water-driven debris adds to the extreme battering that standard residential wood-frame construction can be exposed to during a hurricane. Normal wood frame and masonry on frame building construction cannot withstand the dynamic forces imposed by wave and run-out impacts and surge. Even solid masonry construction built to accepted building codes can sustain significant damages and even experience failure under these extreme conditions.

The determination of the appropriate level of protection is a significant parameter for floodproofing by elevation. The NFIP standard requirement for floodproofing is elevation of the first habitable or sales floor (commercial) to or above the Base Flood Elevation (BFE). Additional elevation of the structure above the BFE, where practical, reduces the probability of damages thus reducing premiums on an owner's flood insurance. Although additional elevation of the structure's first floor above the BFE can substantially reduce insurance premiums and improve community ratings under the Community Rating System (CRS), this additional increment of protection is rarely undertaken by landowners. All of the local floodplain or coastal zone management ordinances in the project area indicate the BFE as the minimum level of protection for structures within the flood zone.

Immediately following Katrina, FEMA published the Advisory Base Flood Elevation (ABFE) mapping for the project area. This mapping displayed a revised BFE for the project area that incorporated the affects of Katrina in the new water surface elevations for the purposes of setting the first floors of new construction along the coast. A number of communities and counties in the project area adopted the ABFE into their existing floodplain management ordinances as interim measures. It was anticipated that revised flood mapping (DFIRM) would be issued by FEMA in the near term.

4.5.7.4.3 Building/Structure Elevation within the Identified High Hazard Zones

Due to the immense forces of high velocity water associated with waves, wave run-out and surge inundation, the nonstructural PDT decided that no floodproofing by elevation would be recommended in the project area for the V/VE zones delineated by FEMA. Observations of Katrina damages within the mapped V/VE zones supports the contention that forces in that zone are too extreme to risk residential building construction – few structures survived intact. More importantly, elevated structures in this area could result in their owners attempting to "ride-out" future storms and risk their lives in the process. At the point where the elevated structure may fail, the conditions of surge, waves and wind velocities would significantly reduce the chances for survival by the occupants. In addition, the lives of emergency personnel attempting to rescue those remaining in elevated structures under hurricane conditions would be placed in extreme jeopardy as well.

In addition to the mapped V/VE zone, the PDT identified an additional zone along the coast referred to in post-Katrina FEMA reports as the "catastrophic damage zone" wherein the majority of insured structures suffered damages greater than 50 percent of the structure value. This linear zone included the V/VE zone but extended further inland from the beachfront. Observations of damages within this zone by the nonstructural PDT confirmed that the majority of the structures within this zone were either totally destroyed (only the slab foundation remained) or the remaining structure had been severely, structurally damaged and would probably be demolished rather than repaired. Due to the extent of the damages caused by surge inundation and wave action in this zone the nonstructural PDT decided that floodproofing by elevation should not be recommended in this area.

Since the FEMA designated "catastrophic damage zone" was directly related to the actual Katrina event itself, the nonstructural PDT decided to duplicate that zone (most prominent in Waveland, Bay St, Louis, Pass Christian, Long Beach, Gulfport and Biloxi) along the entire coast within the project area. Based upon measured distances back from the beachfront in those areas, an 800 foot zone extending inland from the normal tide waterline was applied to the coast in Jackson County as well. The nonstructural PDT decided that floodproofing within this 800 feet wide buffer zone would not be safe due to the extreme forces that could attack elevated structures in this zone. These high hazard zones (combined and designated with the acronym HHZ) are shown in Figures 58 through 62 .

Elevation of structures (residential, commercial and institutional) within the FEMA-designated A and B zones (100 yr and 500 yr respectively) could be supported under the current guidelines for coastal construction. Floodproofing through elevation for structures in the FEMA-designated A and B zones is a nonstructural measure that should be carried into the final planning formulation.

4.5.7.4.4 Building Elevation Limitations and Parameters

Limitations on the height that structures can be elevated are based in part upon several factors including cost to elevate the structure (compared with its acquisition cost), high-velocity wind loading on raised structures, structural stability of elevated buildings, occupant accessibility, visual impacts and architectural suitability. Since the costs of protection measures and alternatives being considered in plan formulation would be compared to identify the most cost-effective solutions, the cost of floodproofing a structure would be compared with the cost to either acquire the structure or rebuild a new elevated structure on the same site. Once the cost to elevate the structure exceeds the cost to either acquire or rebuild a new structure on site, the elevation of the existing structure comes into question just based upon economics.

Powerful natural forces during storms and hurricanes place tremendous stresses on all structural components of the building and its supporting foundation. The elevated structure is positioned between the devastating forces of saltwater from the ocean and the equally damaging forces of high-

velocity winds and wind-driven debris. Numerous structures that survived inundation by surge and waves from Katrina were ripped to pieces by hurricane-force winds and wind-driven debris.

Elevation of a structure above the ground places the building in the pathway of hurricane force winds that are undisturbed by ground-clutter. Trees and other surrounding structures (all ground-clutter) can affectively reduce wind velocities at ground level. Constant winds in excess of 120 mph can destroy most unprotected residential construction. Other than structures that have been built to more recent building codes (post-hurricane Andrew) that account for hurricane force winds, most residential structures are not built to handle high-velocity winds. Older structures that can be elevated probably would require some retrofitting of the structure roof and wall systems and windows to survive in the high-velocity wind environment.

The constant battering of wave run-out and surge-transported waves on the supporting columns/pilings and floor substructure of the building during storm/hurricane events raise concerns of sustainability and safety. Among the many forces at work are scouring around the bases of columns/pilings at the ground surface and impact forces of waves on the columns/pilings themselves. Wave run-out that occurs as storm surge brings breaking waves around the base of the structure can easily undermine columns and pilings as well as slabs exposed to this high-velocity water. Waves borne upon the surge can impact extended columns and pilings resulting in material failures or racking of the supporting structure. Assuring that the buried depths of the columns/pilings is sufficient to reduce failure and installing protected-edge concrete slabs surrounding the columns or pilings can reduce the affects of scour. Impact forces on the supporting substructure must be considered in the cross-section design and reinforcing components of the system. Racking can be addressed with cross-bracing between columns/pilings and perimeter stabilization components.

Tradeoffs between the issues of safety and costs of raising buildings to extreme heights and the ability to maintain vestiges of coastal communities in their current location must also be considered. Accounting for the removal of many existing structures and prohibition of rebuilding many structures in high-hazard wave zones (V zone, etc.) discussed below, overly restricting the height of elevation can result in extensive evacuation of buildings and facilities from communities.

In addition, occupant accessibility (especially for physically challenged occupants) to the elevated home is a critical component of the elevation process. Exterior stairways in excess of 12 steps require intermediate landings per the building code and too many steps make the elevation option too laborious for older occupants. For those structures sited on narrow urban lots, situating access stairways with landings may not be feasible. Structures can be relocated on-site to enable easier access options, but these additional operations also increase the cost to elevate.

For those landowners with physical handicaps, an elevated structure poses significant access problems. Although there are several options for addressing handicapped access to an elevated structure, the costs of installing some of these options can be very expensive and require frequent OMRR&R by the landowner. Basic ADA specifications for access ramps for wheelchair users require a maximum slope of 1:12 or 8.33% for the ramp and intermediate landings every 30 inches of rise. Ramps must be at least 36 inches wide and landings must be at least 60 inches long. Using these component requirements, a wheelchair access ramp would have to be approximately 210 feet long to reach a first floor elevated 15 feet. On narrow urban lots, the use of access ramps for handicapped occupants would have limited application.

Although coastal communities around the nation have a somewhat “different” look visually because of the need for elevation of first floors, there are some limits to the visual quality boundaries of an elevated home or business. The overall dimensions of the structure (height versus width and length) can become unbalanced leading to a visually unpleasant building whose value could quickly plummet on the market. In some cases, community association guidelines or local building codes could prohibit extreme elevation of structures. Elevated residential buildings raised in full increments

of one-story (8-10 feet) keep the visual balance of the structure (depending upon the architectural style) up to three-stories. The relationship of the lot size to the building size and the size/bulk of adjacent structures can also influence the visual quality of the raised structure. Visual quality is a significant criteria in determining the market value of structures, and landowners will take the resulting market value of their home or business into account when deciding to participate or not.

There are a variety of architectural styles present in the project area. Those styles include Acadian-Creole, Victorian, Classical and Arts and Crafts. The Acadian-Creole style is indigenous to the local area, but a few of the styles have been imported from other regions, countries and time periods. The more indigenous architectural styles, styles that were developed in recognition of the potential for flooding may be more conducive to elevation while the more classical styles developed in less flood-prone areas would not be as favorable from an architectural viewpoint to elevation. Structural styles that are traditionally multi-story could probably be raised successfully in one-story increments while architectural styles (ranch style) that are traditionally thought of as one floor would not be as favorable to elevation. Consideration for building massing in zoned areas and building proportions of height to footprint in some styles may dictate special requirements in elevation design. In a voluntary program of elevating structures in place, the architectural style of the home or building may be a determining factor in the landowner's choice of program participation.

Many agencies and local governments have proposed raising structures no more than one story (8-10 feet) while others have advocated 12 feet as a maximum height standard. Normally, the one story rule of thumb was applied so that vehicles could be stored beneath a raised structure, one-story increments look appealing visually and to avoid building materials waste. Issues of cost, accessibility, structural stability and visual impacts have been the focus of debates on maximum heights for elevation.

Guidelines established by FEMA in the recent "*FEMA 550 Recommended Residential Construction for the Gulf Coast"* recommend a maximum height of 15 feet for elevating residential structures along the Gulf Coast. This height recognizes the relationship between forces of moving water and hurricane velocity winds that can affect a raised structure. Proven engineering methods for the design and construction of stable, supporting foundations for structures elevated to 15 feet are included in the FEMA 550 guidelines. Since the guidelines are supported by sound engineering principles and field testing results in extreme conditions, the nonstructural PDT decided to accept the 15 feet maximum height limitation for floodproofing in the project area. The FEMA 550 guidelines can be accessed online at: [http://www.fema.gov/library/viewRecord.do?id=1853]

4.5.7.4.5 Mobile Homes

Mobile homes (a.k.a. trailers) present a unique problem in floodproofing by elevation. Generally speaking, mobile home construction is insufficient to withstand the hurricane force wind speeds that would be encountered by an elevated unit. Although the unit may be raised above the surge inundation limit and largely safe from flooding or waves, the raised unit would be subjected to extreme wind loading such that severe structural damage could occur. Comparatively speaking, standard stick-built and manufactured homes built to the International Building Code (IBC) with provisions for hurricane force wind loading would sustain minor damage in an elevated condition. Expending Federal funds to elevate mobile homes that may be totally destroyed by high winds during a future storm event is an unwise course of action and other options are available.

For this reason, the nonstructural PDT recommends that mobile homes not be elevated in the floodproofing program, but that owners of existing mobile homes that were inundated by Katrina and that could be elevated on site (water depths equal to or less than 13 feet) be given the option of an elevated rebuild using a manufactured home constructed to IBC standards. The manufactured home would be of a similar size to the existing mobile home featuring similar amenities and would be

elevated on a driven wood piling foundation (the cheaper form of floodproofing). Since the floodproofing program is voluntary, owners could choose not to participate in the rebuild option or be purchased in which case they would be offered relocation benefits similar to other structure owners. The preferred option would be to maintain a tax-producing land use within the community that keeps the family connected to employment and schools while upgrading the overall housing stock and reducing future hurricane damages.

4.5.7.4.6 Foundation types

There are a wide variety of foundation types and materials used to elevate structures in the project area. The choice of foundation type is based in part on regulatory requirements, construction and OMRR&R costs, visual quality, building size and weight, architectural suitability, and availability of materials. In many cases, the foundations appear to have been constructed as retrofits of existing homes requiring lifting of the structure to construct the supporting foundation. More recent residential construction observed in the area indicates elevated foundations constructed during the building process and those appear to be more integrated in the design of the building. Figures 18 through 21 show some of the foundation types observed in the project area.



Poured Concrete Piers



Stacked Concrete Block



Concrete Block Enclosure



Wood Post and Piling

Figures,18, 19, 20 and 21. Predominant Raised Foundation Types

There are two main foundation types for elevating structures: open and closed. Open types depend upon numerous upright columns or pilings that support critical bearing points beneath the structure. Typically an array of wood or metal beams and joists attached to the vertical members provide support to the first floor. The open foundation allows water to pass through largely unimpeded resulting in less stresses on the foundation members but everything below the first floor is subject to inundation forces. Where moving water may be present, the open foundation is more favorable. Open foundations also maintain good air circulation beneath the structure allowing for more affective drying following a flood event and less potential for mold and mildew growth where sunlight does not penetrate. As stated earlier, NFIP regulations provide for a maximum of 300 square feet of enclosed space beneath the elevated structure for movable storage, access to the first floor and utility chase. Generally in northern climates where cold air circulation beneath the structure can increase heating demands and require insulation beneath the raised first floor, open foundations are not favored. In milder southern climates, the open foundation does not significantly increase heating requirements, so it is more acceptable.

Many examples of open foundations are present in the project area (see Figures 22 through 25). Closed foundation types depend upon solid masonry walls (poured concrete, concrete panels, unit masonry) or some other enclosing, perimeter wall system that supports the exterior walls of the elevated structure. Structure walls are fastened onto wood sill plates anchored into the masonry wall structure. Perimeter bond-beams can be used to tie the top of a unit masonry wall system together



Figures 22, 23, 24, and 25. Open Foundation Types

to avoid racking of the walls during water or wind stress. Interior posts/columns with a system of beams and joints provide support of the first floor. Enclosed foundations do provide a measure of perceived security beneath the elevated structure and movable storage items are not in plain view of passer-bys. Also, closed foundations reduce airflow beneath the structure which can be a good feature in colder climates, but the enclosed foundation does present several problems. First, the closed foundation does represent a large obstacle to flowing water – an obstacle that can create significant impact forces on the wall surfaces from flowing water or wind. These forces can be offset to a certain extent by allowing the enclosed area to be flooded thus equalizing the pressures on the masonry walls. However, in a coastal zone where wave run-out and waves can begin impacting the foundation walls long before surge inundation fills the enclosed area, these extreme forces can result in wall failure and structure loss. The NFIP does not allow the use of solid perimeter wall foundations for elevating structures in wave impact coastal zones (V-Zone). Figure 26 shows a structure raised on a solid wall foundation. This type of foundation can be used in areas where inundation only would occur and then only when sufficient, automatic equalization of water pressures can occur. In addition to the problems of unequal wall pressures, enclosed, damp foundations (common during wet weather or following a flood event) can lead to the growth of molds and mildews that can be life-threatening and hard to control without good air circulation and sunlight penetration.



Figure 26. Structure Raised on Solid Wall Foundation

4.5.7.4.7 Foundation materials

A variety of materials can be used in open foundation systems. The selection of appropriate materials is based upon criteria such as cost, availability, durability, corrosion resistance, strength, reliability and maintenance. An assortment of foundation materials ranging from wood and steel to unit masonry (concrete block) and poured concrete are present in the project area. Some of the materials weathered Katrina's wrath quite well, others did not perform as expected by the owners. A selection of the foundation types is shown in Figures 27 through 30. By field observation, treated wood pilings (square and round) that had been driven or drilled to a sufficient depth appeared to survive the fury of inundation and waves and wind forces. In many cases the supported structure had been totally lost but the wooden substructure remained intact.

Some of the success of the wood pilings may have been due to inadequate strap connections to the supported structure. Had the strapping been accomplished according to the building codes for hurricane force winds, many more of the piling systems may have failed when the structure was destroyed, but that cannot be confirmed by observations in the project area. Based upon post-Katrina observations and data provided in FEMA technical documents, wood piling driven or drilled to sufficient depth to avoid failure due to scour and adequately braced can be used to elevate structures to the maximum 15 feet height. The nonstructural PDT decided to use driven wood pilings as the basic floodproofing foundation for developing costs for floodproofing. This decision was based upon materials availability, relatively low costs for materials and labor to install and their apparent durability under stress.









Figures 27, 28, 29, and 30. Foundation Materials

In some cases elevated foundations were constructed of steel posts with fabricated steel beams and joists. Several of this type survived the storm event, but in most cases the supported structure was destroyed. Again inadequate strapping between the supporting foundation and structure may have spared the foundation when the structure was destroyed. Other than the high cost of steel posts and fabricated components and their availability in large quantities to support the structures' first floor, steel-based foundations systems would be a feasible alternative.

In a number of cases, reinforced unit masonry (concrete block) columns failed along the coast. Some masonry columns were not reinforced adequately and those failed quickly due to wave

impacts. In some instances, reinforced masonry columns failed with the reinforcing steel bars snapped off or bent at ground level where the column met a concrete footing. Figures 31 through 34 show these failed systems. The nonstructural PDT decided not to use standard unit masonry columns (reinforced or not) as supporting foundations for elevated structures due to the number of failures observed in the field. A modified version of the unit masonry column type is described below and will be used to support existing structures that can be raised.



Figures 31, 32, 33, and 34. Failed Supporting Foundations

During investigations of various elevation techniques and materials for the project, the nonstructural PDT became aware of a unique structure lifting system ("segmented piles") that also provided a reliable open-foundation system for raised structures. The system is based upon concrete unit masonry that is stacked around steel rods and driven by a pneumatic jacking system. The segmented piles are positioned at critical load points under the structure (mostly slab foundations) to assure stability of the structure and to avoid differential settlement of the walls and roof systems in the building. Initially the rods and blocks are driven into the soil using the weight of the structure above and the pneumatic jacking system until refusal. Once that solid footing is achieved, the jacking system then begins to elevate the structure as additional blocks and steel rods are added beneath the structure. Figures 35 through 37 show the installation of the segmented piling system and the final result.

According to the contractors working with the system, this system can provide a safe and durable foundation just using the segmented piles up to four feet of first floor elevation. After four feet of elevation, the contractor reverts the structure elevation to a more standard lifting process using cribbing and steel beam supports. The segmented pilings are then removed to the ground surface

and a concrete, grid-shaped footing with steel reinforcing is poured connecting all of the segmented piling footers and reinforced concrete columns are erected beneath the structure with steel beam supports that assure stability and durability of the structure. Elevation up to the limit of 15 feet can be obtained with this system, but due to the increased cost of erecting the reinforced concrete columns after four feet of elevation, this system would only be used in the program up to the four feet of elevation, after which structures would be placed on driven wood piling.







Figures 35, 36, and 37. Segmented Piles Construction Method

Also prevalent were poured concrete columns (square and cylindrical) with either wood or steel beams supporting joists and tied into the structure floor system. In most cases these materials survived the stresses of water and wind, but at least in one instance this foundation material failed. Figures 38 and 39 show a building location where poured, reinforced concrete columns failed at the base where they were connected to concrete footings. Although the concrete itself performed well, the reinforcing design and connection to the footing may have contributed to the failure. In addition, the supported structure had been destroyed leading perhaps to failure of well-connected foundation members. As all of the columns that failed were oriented in a similar direction, the loss of the structure and columns may have been a combination of wind and wave action on the supported structure. Several new rebuilds along the coast are being supported by poured concrete columns (see Figures 40 and 41).

In addition to the use of wood, poured concrete and steel as vertical support components, these materials can be used as supporting substructure beneath the building. Treated wood beams, fabricated steel beams and cast concrete beams can all be used to support the structure first floor.

Selection of the appropriate material for these supporting elements is based upon cost and design requirements. Using building materials that can withstand the rigors of the saltwater environment, wind-driven rain and stresses is mandatory for elevating structures. All metallic connections and fasteners between extended columns/pilings, supporting beams, lateral bracing and stairways must be able to resist the corrosive forces of saltwater and maintain structural integrity during extreme conditions.





Figures 38 and 39. Reinforced Concrete Columns Failure





Figures 40 and 41. New Concrete Column Construction

4.5.7.4.8 Safety Issues

As in all vertical construction, safety is a paramount concern. Besides the normal safety apparatus and equipment that construction crews may use or wear during the elevation of a structure, there is a constant threat of a catastrophic failure of the temporary supporting members leading to loss of the building and serious injuries or death of crew members. Only qualified, experienced and bonded contractors/builders should be elevating structures. In addition to construction of the supporting foundation, new building construction on elevated foundations places the construction crew as much as 15 feet above the ground surface while working on the new structure. The risks for injury or death due to falls or impacts from falling materials or tools are multiplied during this type of construction. All appropriate OSHA safety standards should be followed during this construction process including the wearing of personal safety gear (helmets and safety shoes) and construction procedures that limit the risks of injuries or death during the elevation of the structure and ensuing construction beneath the raised structure.

4.5.7.5 Floodproofing Design – Residential Construction

4.5.7.5.1 Design Assumptions

In view of the comprehensive nature of this protection plan for the project area and the general lack of information on the characteristics of individual structures, a number of assumptions were made in determining what an appropriate elevation design would be and the approximate costs of elevating residential construction structures based upon that standard elevation design. Those assumptions included:

1. Average footprint size of the first floor of the representative residential structure was 1,600 square feet,
2. Floodproofing of commercial uses within residential-type structures would be elevation in like fashion,
3. Floodproofing of public buildings would be estimated as ringwall construction (see Public Buildings Relocations – Section 4.6) rather than elevation,
4. The maximum elevation of the first floor of any structure is 15 feet above ground level,
5. All structures within the floodproofing area were built upon slab foundations that would have to be adequately braced when lifted onto a new foundation,
6. Foundation type for all existing structures elevated between 0 and 4 feet would be segmented piles,
7. Foundation type for all existing structures elevated between 4 feet and 15 feet would be formed concrete columns.
8. All foundations for elevation where no structure now exists on the property will be driven or drilled wood piling,
9. For the purposes of estimating costs, two categories of raise were considered: 0 to 6 feet of raise and 6 to 15 feet of raise. All eligible structures were categorized into these two groups,
10. Each residential structure has two entrance doors that would require access stairways,
11. A 300 square foot enclosed space would be included under the elevated first floor for storage purposes and utility chase for structures raised at least 7 feet,
12. Repairs or rehabilitation of an existing structure in the elevated position would be minimal and financed by the structure owner or through insurance payments,
13. The structure is DSS in its current condition with adequate sewer, water, HVAC and is structurally sound to elevate,
14. Existing floor joists are of sufficient size and quality to adequately support the structure on the new raised foundation,
15. Floodproofing elevation would require new beams to support the existing sub-floor structural system,
16. All rehabilitation of the structure above the first floor to meet building code standards for hurricane construction will be financed by the landowner or the project sponsor.

17. A separate cost for ADA requirements (access ramp or chairlift) was not included in the basic design package, but costs for step access and the contingency amount should cover these additional requirements.

4.5.7.5.2 Floodproofing/Elevation Design – Residential Construction

For the purposes of this nonstructural plan, floodproofing by elevation is only being implemented in areas devoid of significant wave action. Those areas affected by significant wave action are referred to in this Appendix as “high-hazard zones” and are destined for permanent land acquisition or limitation of development rights under the nonstructural plans. Although the FEMA 550 guidelines do provide information on floodproofing by elevation in the V-zone, the minimum level of protection being presented in the nonstructural plan (an approximation of the anticipated DFIRM BFE elevation plus 2 feet) would not adequately protect an elevated structure in the event of a recurring Katrina-type storm. The impacts of waves on normal residential wood-frame wall construction could result in total failure and loss of the structure and its contents. In addition to the tremendous forces exerted by surge and waves, floating and semi-floating debris from other destroyed structures creates a “battering-ram” effect on standing structures that also quickly leads to structure failure. The visual evidence of damages to standing structures and vegetation (especially trees) from this undulating debris pile was noted throughout the project area. The combination of surge, waves and floating debris resulted in total loss of many elevated structures in Katrina. The following preliminary elevation design and cost estimating information is predicated on raising structures only in areas of surge inundation without significant waves or anticipated debris.

Given the large number of structures in the project area, their diversity of size, type, foundation, use and age, and the limited information available on each structure, the preliminary elevation design and estimated costs were based upon a simplified prototype structure (residential in construction type) and two levels of elevation. A 1,600 square foot structure was selected as the most typical residential structure in the project area. Based upon review of aerial photographs, ground observations and data research, this prototype structure footprint-size was selected as being the most representative of the population of all residential structures.

In view of the preliminary nature of the comprehensive plan and the necessity of further, more detailed technical documentation of floodproofing designs and costs prior to implementation, the heights of elevation were divided into two categories 0-6 feet and 5-15 feet. For existing structures the segmented piling technique was used for cost estimating purposes between zero and four feet of elevation. All foundations for existing structures being elevated greater than four feet were considered to be formed concrete columns. Structures with attached slabs would be elevated with hydraulic jacks and supported by steel beams and timber cribbing. The new foundation would be constructed beneath the raised structure.

Following completion of the new foundation, the structure would be lowered onto the supporting beams and all utilities would be re-connected. In the case where a structure was being raised equal to or greater than 8 feet above the ground surface, a 300 square foot storage space/pipe chase on a concrete slab would be provided in accordance with the FEMA 550 guidelines and local ordinances. New decks and steps for access to the elevated first floor would be installed with pressure-treated wood. Grading around the foundation and lot would smooth any remaining construction scars.

In the case of a property that was considered eligible for elevation (inundation depth less than 13 feet and out of a high-hazard zone), but had no current structure, all elevated foundations would be driven or drilled wood piling. Piling would be 12” in diameter and tapered for driving. Driving depth is estimated to be 40 feet in accordance with the FEMA 550 guidelines. Cross-bracing would be standard practice for all timber piling foundations. In accordance with FEMA 550 guidelines, a 300

square foot storage area/pipe chase was included in the designs and cost estimate for all structures elevated 8 feet or greater.

Although any rehabilitation of the structure above the first floor to meet building code requirements for hurricane protection is to be financed by the landowner or project sponsor, hurricane resistant connections (metal strapping and hardware) between the new raised foundation and the first floor substructure (joists or slab) are part of this preliminary design and are included in the preliminary cost.

Using the stated design assumptions, basic elevation designs for the three primary foundation types (segmented piles, poured concrete columns and wood piling) were prepared. These preliminary elevation designs are shown in Figures 42 and 43, 44 and 45 and 46 and 47. Construction materials will be specified according to accepted engineering and architectural practices for coastal construction and in accordance with the provisions included within the FEMA 550 guidelines for floodproofing structures on the Gulf Coast.

All materials used in the floodproofing work would meet ASTM specifications for construction in coastal areas accounting for the corrosive salt-water environment. Non-corrosive, ferrous connectors, fasteners, steel beams and hardware were used throughout the design and all wooden members used would be pressure-treated materials. All concrete and mortar mixes used in the design would meet ASTM requirements and all utility work (electrical, gas plumbing, HVAC, telephone, and cable) will be installed according to local building codes (minimum IBC 2003).

Prior to implementation of any segment of the identified floodproofing work, more detailed guide plans and specifications would be prepared for each eligible, participating structure with a detailed cost estimate suitable for contract negotiation purposes.

4.5.7.5.3 Floodproofing Cost Estimating – Residential Construction

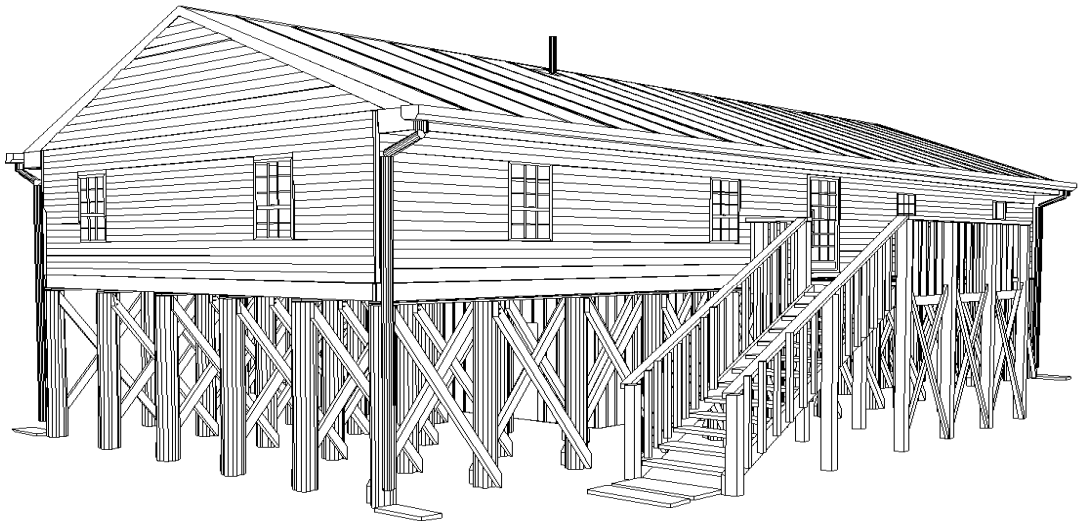
Costs for each of the three primary foundations were based upon the preliminary designs and the assumptions listed above. Since floodproofing contracts are normally negotiated and executed between the structure owner and the contractor (as opposed to a contract between the Government and the contractor), Davis-Bacon wage rates are not required and therefore labor rates in the cost estimate reflect those rates that would be common to the region. Material costs were based upon regional averages for building materials and specialty items. Generally, a 25% contingency was added to all costs unless determined otherwise by the cost engineer. Costs for floodproofing individual prototype structures (structure retrofit and new construction) are shown in the Cost Estimate Appendix.

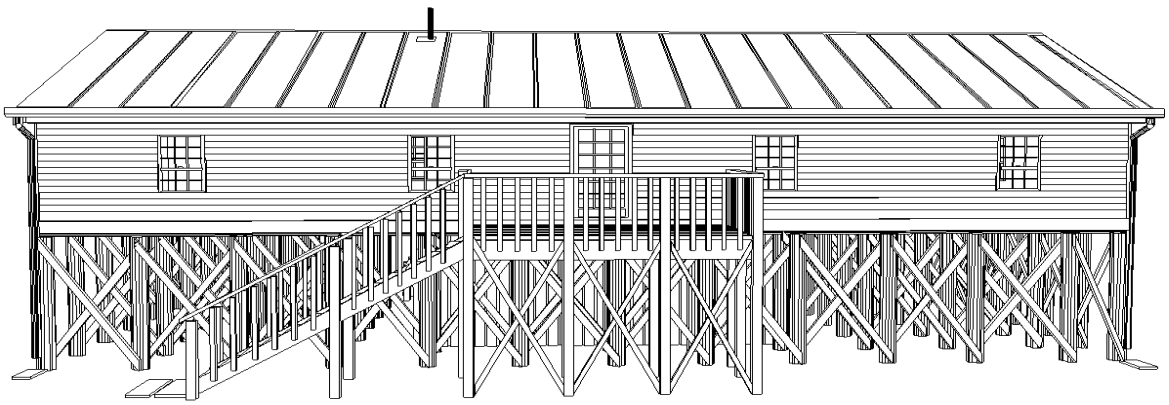
4.5.7.6 Floodproofing Design – Commercial and Public Buildings

4.5.7.6.1 General

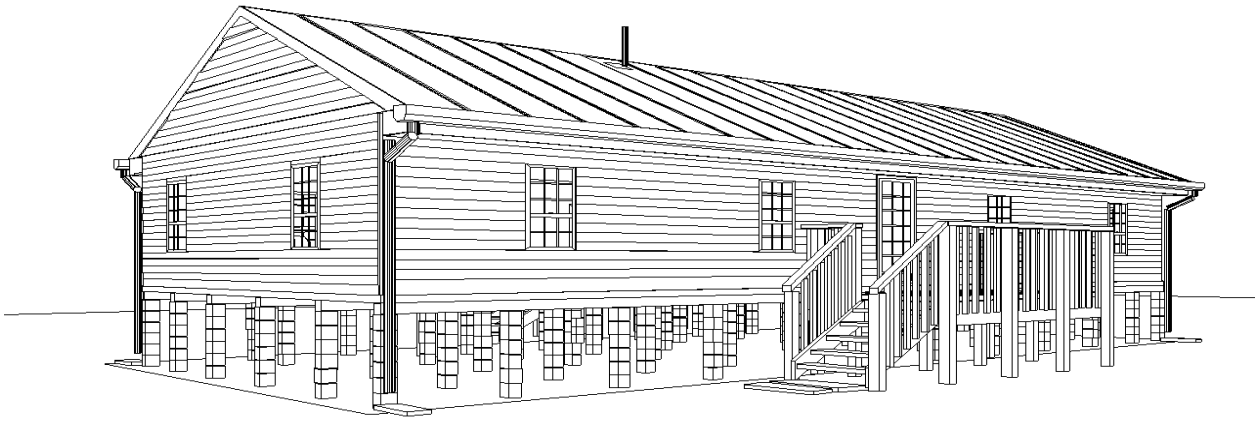
In comparison to floodproofing residential construction through elevation, floodproofing commercial and public buildings is much more complicated due to the need for ground floor access, a much larger footprint size and heavier construction materials (i.e. masonry) in the walls and floors. Commercial and public uses that occupy structures featuring residential-type construction can be elevated according to the techniques, design and costs discussed above. However, commercial sales floors elevated above ground level are not popular with shoppers unless the 2nd floor access is part of a larger raised platform (i.e. elevated mall). For similar reasons, access to most public buildings (significant ADA issues) is preferred at ground level. For this reason floodproofing by elevation for these types/uses of buildings is generally unacceptable to the structure owners and few participate in a voluntary program.

Another major difference is the positioning of the commercial or public building on the lot. Normally residential structures are positioned on the lot with adequate front, side and backyard setbacks (except for the urban residences such as townhouses, etc.) within which construction of various forms of floodproofing can take place. In many cases, commercial retail structures and public buildings are located in more urban settings with minimal setbacks (or no setbacks) from streets, alleys or adjacent buildings. Adequate space for access steps or ramps to an elevated second story is not available on these limited lot sizes.





Figures 42 and 43 – Floodproofing Design – New Structure Wood Piling



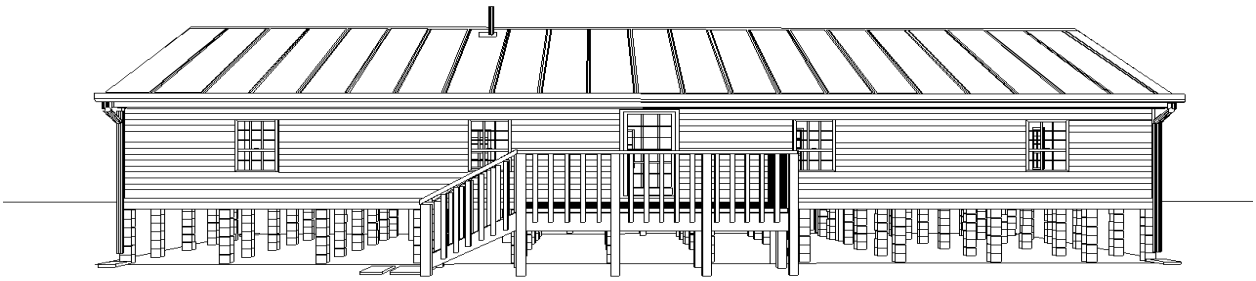
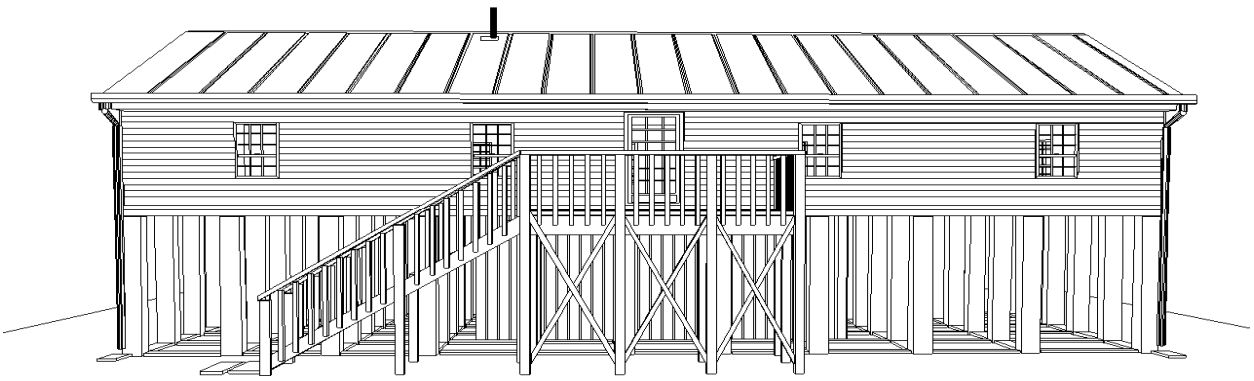


Figure 44 and 45 – Floodproofing Design Segmented Block – Structure Retrofit





Figures 46 and 47 – Floodproofing Design Concrete Column – Structure Retrofit

With these restrictions in mind, other forms of floodproofing such as dry floodproofing must be considered for the commercial and public buildings. Dry floodproofing can take many forms as discussed in Section 4.5.7.2 above. Two of the most popular forms are veneer walls and ringwalls or ring-levees. Veneer walls are constructed as a waterproof layer of dense materials attached directly to the existing structure wall to prevent water-penetration (see more detailed description below). Ringwalls and ring-levees are structural components within nonstructural measures whereby a single structure or complex of allied structures are enclosed with a ringwall or ring-levee structure (see a more detailed description below). In each case, this dry floodproofing technique prevents surge inundation from entering the structure or facility. The primary difference between elevation as a floodproofing technique and this form of protection is the need for closures in the veneer wall or ringwall at structure openings (doors) and the potential need for an interior drainage and pumping system in the ringwall or ring-levee system to remove rainwater due the storm event.

4.5.7.6.2 Design Assumptions

As was the case with residential units, very little specific information has been gathered on the uses, sizes and construction types of the commercial and public buildings within the project area. Generally speaking, they are composed of a mixture of masonry, wood frame and fabricate metal structures. Most of the older public buildings within the urban areas are of masonry construction and are multi-story. Numerous commercial retail and office buildings in Biloxi, Pascagoula and Gulfport are multi-story masonry buildings as well. Newer commercial retail structures located in the sprawl areas and along the major highways (Routes 90 and 29) are generally wood frame construction with masonry surfaces or fabricated metal buildings with various surface finishes. All of the commercial and public buildings appear to be founded on concrete slabs. In view of these observations, the flowing design assumptions were formulated to guide the floodproofing design and cost estimating for these types of structures.

1. The average commercial structure within the project area has a footprint of approximately 8,000 square feet and sits on a concrete slab.

2. Commercial structures can be protected up to 4 feet of water depth by a veneer wall. Costs for that form of protection would be based upon similar installations of veneer walls at commercial structures in LRH.

3. Any flood depths greater than 4 feet at commercial structures would require the use of a ringwall or ring-levee. The costs of that protection method would be capped at the average cost of commercial acquisitions (approximately $2.5 million).

4. Floodproofing of public buildings (schools, fire stations, police stations, city halls, etc.) would be by ringwalls only. Building sizes would be estimated based upon aerial photographs, number of students (square footage) and ground observations. Costs for this form of protection would be estimated based upon indexed values for similar installations at public buildings in LRH. Costs for closures and interior drainage are included in the per linear foot cost.

5. Floodproofing for both commercial structures and public buildings that are of a residential construction type (wood frame on a slab) would be by elevation or ringwall only (wood frame construction cannot support veneer walls).

4.5.7.7 Veneer Walls

One of several methods of dry floodproofing consists of applying a waterproof veneer material immediately against the existing structure wall. In order for landowners to realize the benefits of premium reductions on flood insurance policies, any veneer wall installation must provide at least I foot of protection above the established BFE. The applicability of this method of dry floodproofing depends largely on the structural stability and lateral strength of the receiving wall of the building.

Most residential construction, even masonry brick on concrete block does not have sufficient strength to withstand water pressures above 2 or 3 feet deep. In some cases, heavy industrial or commercial wall construction can withstand greater lateral pressures, but protection above 4 foot depths of water becomes problematic. Un-equalized pressures on un-reinforced masonry walls will soon lead to leaks and possibly catastrophic failures. The waterproof material can range from various sheet polymers, rubber and plastics to concrete. In some cases, constructed veneer walls of high-density, waterproof concrete can be applied directly to the structural walls to provide protection to interior contents. Appropriately sized footers and wall ties provide stability and reliability to the veneer wall structure. Visually pleasing surface treatments can be applied in-situ to poured veneer walls or other surfaces such as brick or stone can be applied to the waterproof concrete structure. Figure 48 shows an example of a veneer wall installation (brick facing) around a restaurant.

In addition to the stability of the structure's walls and waterproofing capability of the material, treatment of closures at existing entrances (doorways, garage doors, windows) into the structure is critical to a successful watertight solution. In veneer wall applications, watertight entrances are affected through casketed, sliding or rolling doors or metal plate inserts in the veneer wall. Although proven designs for these closures are available, none of them are automatic requiring placement by personnel who are on-site immediately prior to or during the flooding event. Annual maintenance of the closure systems is critical to maintaining protection for the structure.



Figure 48. Veneer Wall Installation

Costs for constructing veneer walls on structures varies based upon the perimeter length of the structure, foundation conditions, wall height and number of closures. The NS PDT members have been involved in the design and construction of several veneer walls in nonstructural projects and preliminary costs for this measure can be estimated from those applications. Annual O&M costs for veneer walls relates to inspections of the wall and closures and replacement of gaskets at closures.

Veneer wall costs were based upon information from previous construction of these facilities on LRH nonstructural projects as shown in the above photograph. An average commercial footprint size was determined from aerial photographs and used to estimate approximate costs for commercial floodproofing by this method of protection.

4.5.7.8 Ringwalls/Ring Levees

Another method of dry floodproofing involves the construction of either ringwalls or ring-levees around an individual structure or group of associated structures. Planning and design considerations for ringwalls and ring-levees are similar to any floodwall/levee structure surrounding a community or urban area including risk-based determination of level of protection (wall or levee height), closures at entrances, interior drainage and pumping, geotechnical concerns, foundation design, penetrating utilities, sources of embankment materials and operation and maintenance requirements. Ringwalls can be either of an I-wall design or T-wall design depending upon the soil conditions, footprint restrictions and the height of protection. Normally these ring structures are only applicable to larger commercial, institutional or industrial facilities due to the cost of construction and annual OMRR&R.

Ringwalls can be used to protect schools, medical facilities, and essential emergency facilities. Use of this method of floodproofing is limited on a large scale for residential structures due to restrictions of lot size upon which to align the structure footprint and its cost relative to other options for protection. Generally speaking, these forms of protection are problematic in urban areas where lot sizes are smaller and building setbacks are narrow. Requirements for ongoing OMRR&R and the costs associated with those requirements for these more complex structures also require substantial revenues from the site owner(s).

There would be situations where a ringwall or ring-levee may provide an appropriate level of protection in-place for a critical facility or major employer in the community. On a somewhat larger scale (short of a structural measure), ringwalls and ring-levees may be appropriate for protecting entire neighborhoods of a community or a business or educational complex. In these cases, multiple gate openings in the wall or levee structure require onsite operation just prior to and during a flood emergency and interior drainage and pumping capability can become significant design considerations. Multiple closures and pumping systems require an on-site presence in situations where many surrounding residents may have already evacuated due to the flooding threat. This situation puts operations personnel in great peril should the protection be overtopped.

There are a large number of structures, groups of structures and facilities within the project area that provide critical services to the surrounding neighborhood or community at large. Floodproofing those facilities in-place reduces flood damages and maintains the essential services intact in lieu of relocations to another flood-free site. Opportunities may arise whereby ringwalls or ring-levees protecting neighborhoods could offer protection for valuable infill redevelopment sites allowing at-risk structures located outside the new line of protection to relocate into protected vacant sites. This floodproofing/infill scenario accomplishes the flood damage reduction objectives while minimizing impacts to the socio-economic and environmental justice components of the project area. For these reasons, dry floodproofing through the use of ringwalls and ring-levees will be carried forward into more detailed formulation of nonstructural plans. Figure 49 shows an example of a ringwall protecting a high school and Figure 50 shows an example of a ringwall protecting a commercial structure.



Figure 49. Ringwall Protection for a High School



Figure 50. Ringwall Protection for a Commercial Structure

Capital construction costs for ringwalls and ring-levees can be high depending upon the structure's or complex's perimeter length, soil conditions, height of the wall/levee, material sources, hauling distances, number of closures, interior drainage and pumping requirements, alignment limitations, and wall type (I-wall or T-wall). Among all of the nonstructural measures, ringwalls and ring-levees have the highest potential O&M costs due to the complexity of the structural features and the risks involved in failure of individual components of the protection system. In addition, these protection features require on-site personnel to affect access closures and assure that interior drainage systems (pumping systems) are working prior to the event.

The NS PDT members have been involved in ringwall design and construction for schools and businesses from which preliminary costs have been developed for the plan. Based upon indexed costs for a ringwall (heights ranging between 4 and 8 feet) with closures and interior drainage, linear costs of $3,100.00 per linear foot (included E&D and S&A) of ringwall were used to estimate providing this protection for public buildings.

4.5.7.9. Waveland, MS Pilot Floodproofing Project

In an effort to demonstrate the feasibility and effectiveness of wet floodproofing as a means of reducing flood damages in the project area, a pilot project in Waveland, MS has been formulated as a part of the overall nonstructural program. This pilot project would provide an opportunity to evaluate the technical aspects of the FEMA 550 guidelines as a basis for elevating structures in the program, allow for the public and local officials to see first-hand the application of floodproofing measures by elevating residential structures and affirm Corps cost data and contracting procedures that would support expanded applications of this flood damage reduction method in the MsCIP project area. Given the large number of parcels which would be eligible for floodproofing by elevation and other methods, innovative contracting methods would need to be tested to assure that good quality construction that was both acceptable to the structure owner and that limited the liability of the Corps could be applied in an efficient manner across the project area.

Using available GIS data that displays the ABFE flood levels in the Waveland area and the extent of the high-hazard zones described in this appendix, the NS PDT identified, in cooperation with the Mobile team, a geographic area within Waveland where wet floodproofing would be an effective method of reducing flood damages. This selected pilot area is outside of the identified high-hazard zones where wave action and surge would endanger an elevated residential structure and its occupants. In this initial study phase the ABFE-2 feet was used as the design flood elevation for elevating approximately 25 residential structures. Prior to implementation (if the pilot project is approved), the newest approved local ordinance (City of Waveland local floodplain management ordinance) base flood elevation (or higher) would be used to set the raised elevation of the first habitable floors of the structures. The location of the proposed pilot project is shown in Figure 51.

The 25 residential structures are mainly single-family, wood frame structures on structural slab foundations (two observed crawl-spaces). Many of the residences have a brick veneer exterior. Heights of elevation range between 4 and 6 feet at the ABFE-2 feet inundation level. Using the elevation methods described above, it is anticipated that a combination of the segmented block foundation (0-4 feet high) and the concrete column foundation (> 4 feet elevation) would be used in the pilot project. Project construction would take place over a four year period depending upon the flow of funds. Costs for this method of elevation are dependent upon the footprint size of the structure and the height of elevation. It is estimated that the total, fully-funded cost of the pilot project would be approximately $4.6 M. Upon approval of the pilot project concept a more detailed implementation report would be completed showing detailed cost data, floodproofing procedures, contracting procedures and schedules for completion of the pilot project.

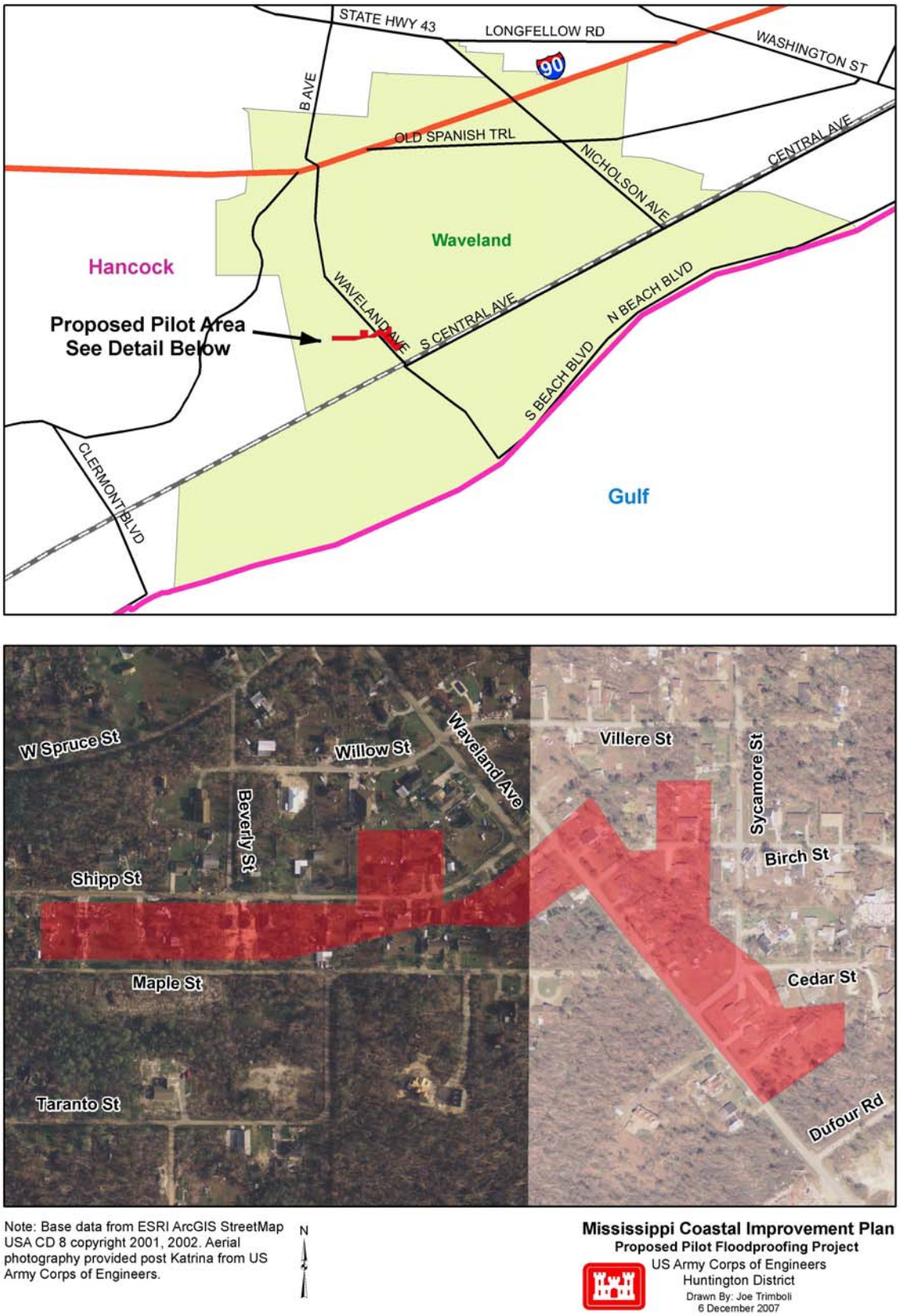


Figure 51. Location of Proposed Waveland, MS Pilot Floodproofing Project

4.5.8. Non-Corps Federal Floodproofing Programs

4.5.8.1. General Program Descriptions.

Following the rescue and recovery operations in the project area, both FEMA and the US Department of Housing and Urban Development (HUD) entered the damaged Gulf areas and began to implement several assistance (grant and loan) programs described in Section 3.5 above. Each of the two agencies has been offering floodproofing (or elevation) grants to eligible landowners so that homes, businesses and public structures (in the public assistance program) could be elevated to reduce future damages. In addition, HUD has been implementing a landowner compensation program that provides up to $150K to eligible landowners within the Katrina surge footprint.

FEMA has been providing elevation grants ($30K) to eligible landowners so that either new construction or retro-fitted surge-affected homes could be elevated in accordance with the NFIP and local floodplain management ordinances. The grant would be in addition to any flood insurance payments that an insured property owner may have received. The elevation requirements specify the base flood elevation (BFE) or the Advisory Base Flood Elevation (ABFE), whichever is the best available data at that time. Since the ABFE was adopted (or the freeboard requirements of the local ordinance modified) by all of the municipalities and counties (see Table 8), landowners had been elevating their new or retro-fitted homes in accordance with those design requirements. Landowners who have been applying for the FEMA elevation grants later in the assistance program would be able to elevate their homes to the revised BFE elevations included in the newly published DFIRM's.

Regardless of the specified BFE elevation used to site the first floor of the structure, there are no restrictions in the FEMA elevation grant program to elevating homes in the newly-mapped V or VE zone. Other than any building code requirements of the municipal or county area or restrictions included in the local floodplain management ordinances, elevating structures in the mapped V or VE zone is allowed under the FEMA assistance program.

Likewise, HUD has an elevation grant program as well that provides $30K to eligible landowners to assist in raising the first floor of either a new home or a retro-fitted home to reduce future flood damages. Similar to the FEMA assistance program, the HUD elevation grants only require elevation of the structure to the most current BFE in force at the time of the permit application. For some landowners that elevation would be the ABFE and for some entering later in the program, the new BFE included in the newly-published DFIRM's. Also similar to the FEMA grants for elevation, the HUD program has no restrictions against elevating homes within the mapped V or VE zones shown on the flood zone mapping.

Both of these programs provide grant funds to landowners that assist the owner in elevating their homes, but in many cases the grant may not provide the total amount necessary to cover the entire costs of elevating the structure according to the full requirements of the NFIP or the local building codes (IRC/IBC). In some cases, when the distance between the ground surface and the BFE is minor (1-3 feet) and the structure is newly constructed, the grant may cover the increased costs of the extended foundation, utility lines and additional steps that support, service and access the higher first floor. Normally, the incremental costs of elevating new construction to meet NFIP requirements is less expensive than retro-fitting an existing structure.

In those cases where an existing structure must be retro-fitted with a new foundation or where a new structure must be raised to a higher level (8-15 feet) above the ground surface, an assistance grant of $30K may not cover the homeowner's full cost. Retro-fitting normally requires much preparatory work beneath the structure (dependent upon the foundation type; slab, crawl space, basement) and then jacking the first floor of the structure to the new design flood height (BFE) using integrated hydraulic systems and installing new piling or masonry columns beneath the structure. This total cost

normally exceeds the elevation grant by a significant amount. Significantly elevating a new structure (10-15 feet) can be quite expensive considering the costs of drilling or driving deep pilings, bracing the pilings, construction of extended utilities and providing access to the higher first floor. Should the household occupants have special accessibility requirements according to the American Disabilities Act (ADA), then the costs of accessing the new elevated first floor would be greater than just steps. This additional cost for access would further reduce the effectiveness of the $30K grant to safely elevate the structure.

In addition to the cost differentials between elevation costs (based upon Corps project cost data) and the grant amounts that may surface during the two programs, the lack of restrictions for elevating residential construction within the mapped V and VE zones in the FEMA and HUD programs is worrisome. Generally, the base flood elevation to which all new construction or retro-fitted construction included within the FEMA and HUD assistance programs must raise the first habitable floor, is significantly lower than the hurricane surge that would be expected (and was experienced during Katrina) from either a Category 4 or 5 hurricane. Hurricane surge depths in Katrina exceeded 25 feet in the V/VE zones of the project area.

For instance, at one property parcel in Waveland, MS, a parcel located within the designated VE zone and included in the MsCIP study database, the Katrina surge was approximately 16 feet deep above the ground surface (ground elevation at that parcel approx. 8.9 feet msl). In the MsCIP nonstructural plan, this structure would only be eligible for permanent acquisition since the structure was located in the VE zone. The pre-Katrina BFE elevation at that parcel was 15 feet msl and the BFE from the new DFIRM is 23 feet msl - an 8 foot increase. A new structure elevated to the new BFE elevation (approximately 23 feet msl or a raise of 14.1 feet above the ground surface) could still be subjected to 2 feet of surge inundation from a Katrina-like storm with storm-driven waves possibly impacting the first floor stud-wall construction. The residual damages to that structure could be significant and any occupants taking refuge in the structure who may have decided to “ride-out” the storm would be in extreme peril. Many other parcels similar to this example exist within the project area in the VE/V zone area.

The result of this lack of restriction in the V and VE zones in both non-Corps programs would be to allow residential structures to be elevated such that the first habitable floor would be subject to the same surge and wave combination that resulted in the loss of thousands of homes and many lives during Katrina. The number of totally destroyed homes in the V and VE zones that had been elevated in compliance with the pre-Katrina BFE is a testament to the potential for significant residual damages and loss of life that could occur as a result of implementing the two elevation grant programs.

In addition to the two elevation programs, HUD’s compensation program (two phases) provides grants of up to $150K to landowners whose structure was damaged by surge inundation in the Phase 1 program and up to $100K to landowners in the Phase 2 program. The Phase 1 program addressed all those eligible owners whose home was located outside of the 100-year flood zone but still suffered inundation damages from surge flooding. The Phase 2 program addresses all of those whose home was damaged by surge inundation and are located within the 100-year flood zone as shown on the FIRM. The compensation is in a lump sum based upon the estimated percentage of damage of the structure up to the $150K – or $100K limitation and requires no certification of work completed to address the structure damages. Any structure that was damaged more than 50% of the structure’s value is required to meet the NFIP requirements for elevating the first floor above the most current BFE and the additional $30K grant in the elevation program may be used to supplement the compensation grant to raise the structure.

Again as in the case of the FEMA and HUD grants to elevate structures, the only restrictions placed upon the use of the compensation grant is conformance to the local building codes and NFIP

regulations and local floodplain management ordinances. Homeowners choosing to rebuild their homes or repairing a damaged home within the V or VE zone can do so long as they meet the NFIP requirements and the local floodplain management ordinances. As shown above for the elevation programs, it would be possible for a homeowner to accept the compensation grant in the phase 2 program and reconstruct a new structure in the VE zone that would be highly susceptible to residual damages in a recurring Katrina-like storm.

In practice both the FEMA and HUD Assistance programs, based upon the NFIP (new DFIRM) and local floodplain management ordinances would result in many more new and rehabilitated/retrofitted homes being located within the V and VE zones where future large hurricanes could wreak havoc. The MsCIP plan in practical application, although using the storm events of 2005 and especially Katrina as its benchmark for protection and reducing flood damages and loss of life would substantially reduce residual damages and threats to public safety.

In their implementation, components of the three programs do not mesh well. Redevelopment within the V and VE zones in both the FEMA and HUD programs directly conflicts with the proposed MsCIP plan to offer only permanent acquisition in those areas. In terms of elevation or floodproofing, both the FEMA and HUD programs have no restrictions to floodproofing within the V or VE zone while the MsCIP avoids any floodproofing actions within the V/VE zones. Residual damages under either the FEMA or HUD programs could be significant (regardless of the participation rate) during a larger hurricane event.

In terms of financial assistance, the MsCIP is founded on the premise of government-directed construction activities with associated design, regulatory and contracting controls to assure good quality, legality and accountability. Both the FEMA and HUD programs are essentially grants to landowners with minimal or no controls for design quality or accountability outside of local government oversight. The MsCIP program costs are founded on the requirements of the Uniform Relocations Act and actual floodproofing/relocations costs while the FEMA and HUD programs have set grant limits regardless of the actual costs of the work required.

4.5.8.2 Coordination with Proposed MsCIP Nonstructural Measures

Other than the restrictions on elevating homes in the V/VE zone, government oversight of design and construction and providing the option of elevating one's home regardless of income status or participation in the NFIP, the technical aspects of MsCIP nonstructural measures are generally the same as those floodproofing options being offered by FEMA and HUD. There is no apparent reason why a MsCIP program featuring elevation of structures and other floodproofing options could not be implemented in cooperation with the other two agency programs described above.

The differences between the programs mentioned above could be addressed in an interagency MOU concurred in by MEMA with local community input. As all three programs are Federally funded, individual homeowners or commercial owners could select the program that suits their needs the best and derives the best benefits to the landowner and residents. Should one or more of the programs appear to be favored by the local residents as implementation proceeds, the agencies can determine an alternate implementation scheme based upon available funding and local support.

4.5.9 Permanent Acquisitions (Evacuation)

4.5.9.1 General

Permanent acquisition, (a.k.a. evacuation or buyout), of coastal properties is an effective way to reduce flood damages and loss of life (due to drowning as a result of hurricane surge). Existing properties (with or without structures) can be purchased at fair market value under the provisions of the Uniform Relocations Assistance and Real Property Acquisition Polices Act of 1970 (P. L. 91-646). For the purposes of this project, all landowners and tenants living on property declared eligible for nonstructural acquisition would be considered to be "displaced persons" under the definition within the Uniform Relocations Act.

Under the Uniform Relocations Act, residential occupants can be assisted in locating suitable DSS (descent, safe and sanitary) replacement housing and commercial landowners are provided the value of their structure and land and provided moving expenses to establish a new location. Institutional structures owned and operated by Federal, state or local units of government (schools, medical facilities, city/county buildings, police and fire stations, emergency services, postal facilities, etc.) can be addressed through the relocations process described in Section 4.6 below. Once the existing structures are demolished (or the structure owner may be permitted to claim salvage rights to the structure and move it at their own cost if they so wish), the vacated land can be turned over to a local project sponsor for future OMRR&R under existing ordinances as may be modified by project agreements. Certain identified lands once purchased can be restored to wetlands from which additional ecosystem benefits can be generated. Post-acquisition use of the land can be dictated through the project partnership agreement (PPA) and could include wetland habitat restoration, recreation or open space uses that would not result in re-establishment of damageable property. Other options can be explored by local communities through local land use zoning for acquired properties.

This nonstructural measure would be applied to a quilt-like, land use pattern of residential, commercial, and institutional uses as well as both occupied and vacant parcels. Some of the current vacant parcels were occupied prior to the arrival of Katrina and others were vacant prior to that event. In the robust coastal development market that existed prior to Katrina, vacant parcels were inhibited from development by ownership/title issues, legal liabilities, high prices, or other site constraints that limited their consumption in the marketplace. The PDT determined that these vacant parcels may not be developed immediately after new regulatory ordinances were adopted and any reinvestment funds were made available to the landowners.

However, parcels now vacant as a result of structure damages from Katrina may be redeveloped within a short period of time when both regulatory and funding issues were resolved. This process is occurring now at an accelerating rate. It was assumed for this report that landowners of parcels currently vacant have found other housing options elsewhere and would not require relocations assistance. For these reasons, parcels with current structures in place and those parcels previously occupied prior to Katrina (both located in the high-hazard areas described below) could be targeted for early acquisition to forestall redevelopment (i.e. the HARP). Other mechanisms for limiting redevelopment of vacant properties are discussed in the section discussing TDR and PDR programs.

4.5.9.2 High-Hazard Zones

The nonstructural PDT identified several zones within the project area, where due to extreme forces generated by storms and hurricanes, other measures such as elevation of an existing or rebuilt structure would not be prudent and may endanger the future occupants. Within these zones,

successful emergency evacuation during the height of a storm event would be highly improbable and dangerous for the responders, elevated structures may be prone to foundation failures due to waves and surge, elevation by placed fill material is prohibited or infeasible, and non-elevated structures may suffer total or significant losses. Each of these zones was graphically identified using GIS mapping and FEMA database information (see Figures 58-62). There are three identified zones where permanent acquisition and evacuation of the property is the preferred nonstructural treatment. Those zones are:

1) The FEMA-identified V/VE Zone displayed on the National Flood Insurance Rate Maps (FIRM) within the project area. This "Velocity" water zone features extreme energy wave action that was responsible for much of the building damages during the Katrina event and makes elevating structures or otherwise floodproofing structures in-place very dangerous.

2) The FEMA-identified "catastrophic damages zone" which was identified in a "post-Katrina" damage assessment of FEMA insured structures within the project area. This zone included a preponderance of structures that had received damages in excess of 50% of the structure's value. Field observations by the nonstructural PDT confirmed that most of those structures in the zone had been totally destroyed or severely damaged (major structural damages). This area includes the V/VE zone within its boundaries.

3) A flood damage zone was delineated extending 800 feet back from the beachfront within portions of Jackson County. The aforementioned "catastrophic damage zone" established by FEMA was based upon the Katrina event only and therefore did not account for the area of damages that could be expected along Jackson County were a Katrina-like storm to strike at that location. The 800 feet zone approximated the spatial extent of observed total structure loss and severe structural damages observed within Hancock and Harrison counties located closer to the Katrina landfall. Modifications of this zone's extent from the waterline could be made to account for intervening topography that would limit the impacts of surge and waves.

4.5.9.3 Non-Floodproofing Zones

The nonstructural PDT also identified one additional zone within the project area where the preferred method of flood damage reduction would be permanent acquisition and evacuation of the property. This zone is located where water depths at the individual structure location occurring during the specified inundation event would exceed the maximum height of elevation prescribed by FEMA's 550 Guidelines for structure elevation. Those guidelines indicate that elevating structures more than 15 feet from the ground surface in hurricane areas would place the elevated structure in high-velocity hurricane force winds resulting in significant damages to the building. Any structure that would be required to be elevated more that 15 feet to place the first habitable or sales floor above the specified inundation level would be acquired. Using GIS software, a zone of inundation deeper than 13 feet (2 feet of freeboard) was identified within the project area where acquisition would be the preferred method of protection.

Additional structure by structure determinations accounting for structurally unsound, dilapidated, non-DSS, or unsafe structures would also result in acquisition of the property and structure. In some cases where the cost to elevate a structure would be greater than the cost to acquire, the owner would be given the option to "buy-up" to the elevation cost or be acquired voluntarily. Another option of rebuilding a new elevated structure on site at a cost less than elevating the old structure would be considered as an alternative to acquisition. As these "switches" from elevation to acquisition are unknown at this time (determined either during more detailed planning or during implementation), they have not been identified on the GIS mapping as were other zones.

4.5.9.4 Real Estate Acquisitions

Any structure identified for acquisition would be processed according to the provisions and requirements of the Uniform Relocations Assistance and Real Property Acquisition Polices Act of 1970 (P.L. 91-646). In view of the enormous number of potential acquisitions in the nonstructural program and the anemic housing market (post Katrina), application of the full range of relocation benefits under the Uniform Relocations Act is warranted. Residential structures, because of the potential for social and economic impacts that could occur to families during relocation, are afforded significantly greater opportunities and financial assistance under P. L. 91-646 than are commercial businesses. Other than payment of the fair market value of the existing property and structure, businesses receive relocations assistance for equipment relocations and business re-establishment. Residences are provided much greater benefits to assist with offsetting the hardships of acquiring a new home, relocating contents, and other moving expenses incurred by households. Additional details of the Uniform Relocations Act and its application to acquisitions in the project area can be found in the Real Estate Appendix.

4.5.9.5 High Hazard Area Risk Reduction Plan (HARP)

As discussed previously, reconstruction within the project area has been delayed due to uncertainty about the anticipated new NFIP regulations for constructing structures and the absence of rebuilding funds due to ongoing insurance claim judicial proceedings. As reconstruction funds and the revised NFIP floodplain mapping become available in 2008, residential and commercial reconstruction may begin at a feverish pace. In view of this anticipated reconstruction boom and the additional costs that would be incurred by the government in purchasing high-hazard zone (HHZ) properties with new, larger, more expensive homes (with greater demolition costs), a proposal for a High Hazard Area Risk Reduction Plan (HARP) that targets parcels made vacant by Katrina (structure was destroyed by Katrina or demolished due to severe damages) has been formulated. Based upon field investigations, as many as 7,400 parcels within the identified high-hazard zone may be included within this vacant parcel category. Of that approximate number of vacant parcels in the HHZ, 2,000 vacant parcels would be included in the initial HARP. That number of parcels could be addressed by Corps real estate resources over approximately a 5 year period, provided that Federal funds would be appropriated.

The initial 2,000 parcels in the HARP would be extricated from the designated high-hazard zone (HHZ) that extends the entire east-west length of the project area. Within that linear zone are several high-quality wetland ecosystem areas that were (prior to Katrina) occupied by various land uses such as residential and commercial structures and facilities. Figures 52 through 54 show those high quality ecosystem areas within the high-hazard zone where acquisition of property through the initial phase of the HARP (2,000 vacant parcels) could provide opportunities for wetland ecosystem restoration following land acquisition and demolition of any remnant facilities (pavements, utilities, foundations, etc.).

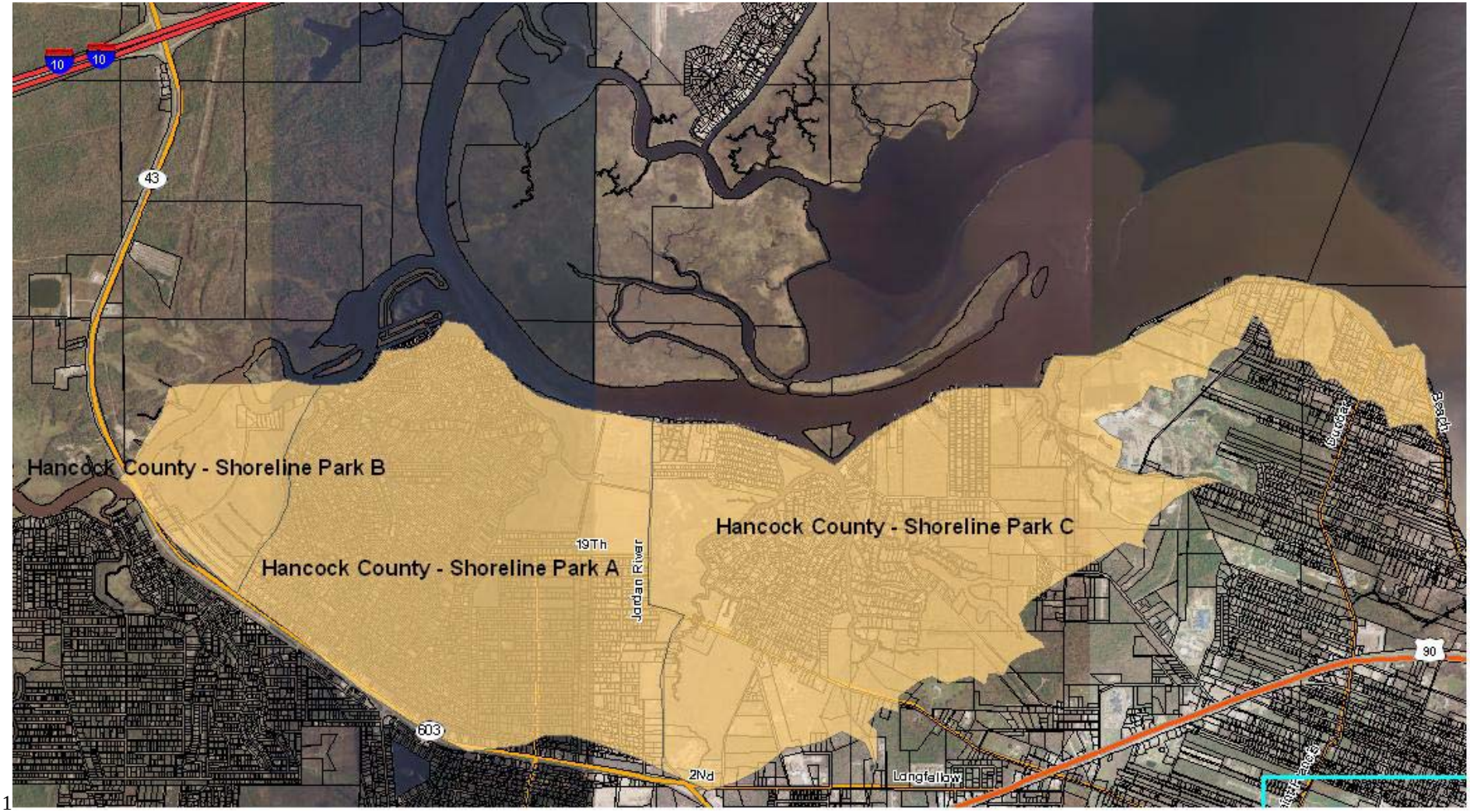


Figure 52 – Project Location – High-Quality Wetland Ecosystem Restoration Areas in the HARP

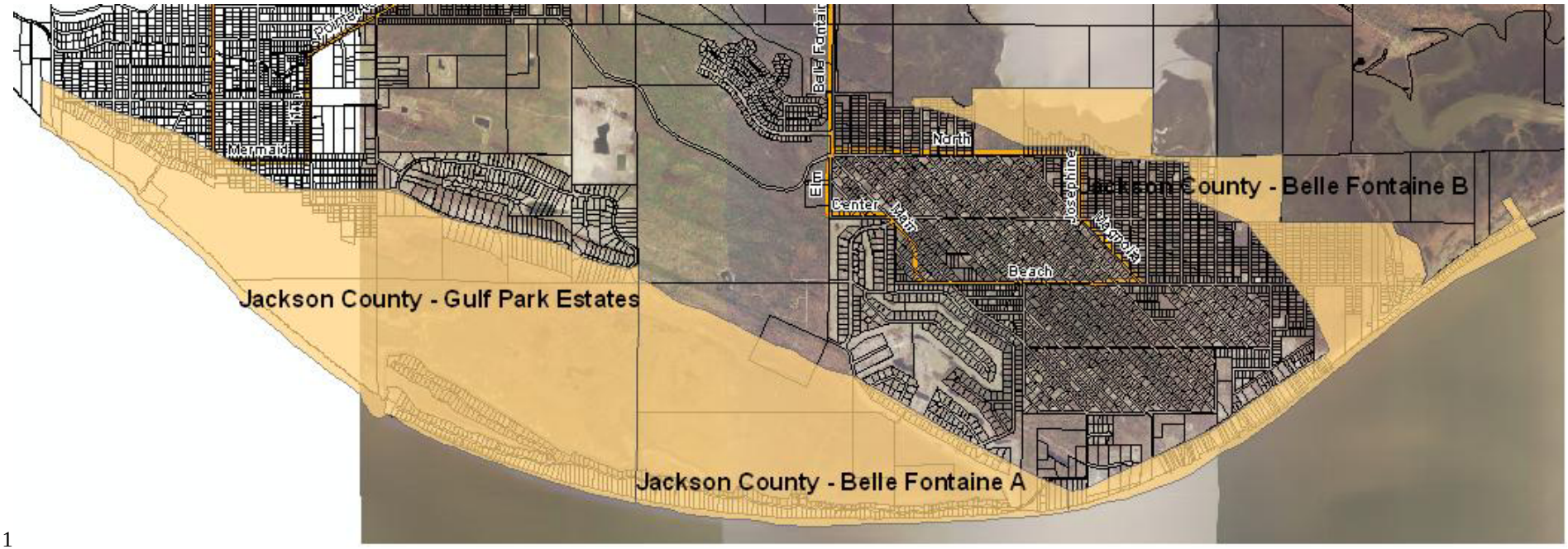


Figure 53 – Project Location – High-Quality Wetland Ecosystem Restoration Areas in the HARP



Figure 54 – Project Location – High-Quality Wetland Ecosystem Restoration Areas in the HARP

4.5.9.7 Permanent Acquisition of At-Risk Properties through Other Federal Programs

Another option for implementing permanent acquisitions within the identified zones would be through the FEMA post or pre-disaster Hazard Mitigation Grant Program (HMGP). Within the overall hazard mitigation program, FEMA has two notable mitigation components that concentrate on acquiring flood-prone properties: the Repetitive Flood Claims Program (RFC) and the Severe Repetitive Loss Program (SRL) that could be used to acquire structures and properties located in these designated high-hazard areas. Generally, all of the FEMA programs target only structures with flood insurance through the NFIP. Annual funds are distributed to participating states through these programs that in turn can provide funds to individual municipal or county jurisdictions to implement their local mitigation plans. Coordination of the proposed acquisitions with the counties' and/or municipalities' All-Hazards Mitigation Plans submitted to FEMA could secure needed real estate acquisition funding and acquisition of the flood-prone properties. Actual implementation of the program would be handled by a local jurisdiction (county or municipal government). Under the provisions of the HMGP program, properties acquired could not be rebuilt upon in the future. Opportunities for merging the FEMA Hazard Mitigation Grant Program and any Corps of Engineers permanent acquisition program within the project area may be problematic given potential differences between the acquisition and relocation assistance components of the two programs.

The HUD Homeowners Assistance Program does not acquire property, but merely provides grant funds up to $100K in its Phase 2 program for homeowners living within the 100-year floodplain to compensate for damages from Katrina surge. The targeting of low and moderate income families with the HUD compensation program does raise the specter of the Corps program with greater financial benefits being applied to a wealthier segment of the population. This may be viewed as a somewhat inequitable scenario when viewed from the public's perspective. Other than financially supporting reconstruction or continued habitation in a highly hazardous coastal zone, the HUD HAP does not conflict in its implementation with the MsCIP plan.

The differences between the agency programs and the MsCIP proposed permanent acquisition program including HARP would not preclude the option of implementing the three programs together. HUD's compensation program does not actually acquire at risk properties, so only differences between the proposed MsCIP and FEMA's acquisition program regarding assistance benefits and replacement housing options would be a concern during implementation. Landowners participating in the proposed MsCIP acquisition program would likely see their assistance benefits reduced by the amount of any compensation received by the other programs.

4.5.9.8 Reuse of Evacuated Floodplain Lands

Since many of the tracts destined for acquisition have existing structures on them, the demolition costs to remove the structures and other site improvements (structural slab, driveways, utilities, building pads, etc.) would be allocated to the nonstructural measures. These demolition costs would only apply to those properties, structures and facilities which the Government acquires as a part of the project. Public streets, utilities and other facilities not within the project measures would not be removed with project funds.

A significant amount of the project land area is either occupied by wetlands or had been wetlands before development encroached upon these sensitive habitat areas. It is widely recognized that wetlands and especially those tied hydraulically to the Gulf and its bays are a significant component of the aquatic and terrestrial health of the Gulf aquatic ecosystems. In addition to reuse for ecosystem restoration, evacuated floodplain areas could be used for recreation uses that would be compatible with the inherent flood risk. The locations of these recreation areas and appropriate facility development would be coordinated with the counties and the municipalities in which the

evacuated parcels are located. Costs for these recreation developments would be cost-shared with local sponsors at the appropriate rate. Operations and maintenance costs for all post-evacuation recreation development would be the sole responsibility of the local sponsors.

In view of the national and regional benefits associated with expanding wetland habitat along the Gulf and within the project area, those parcels subject to evacuation under the nonstructural program, either located within the high-hazard zones or in those areas where floodproofing is not a viable option (inundation depths greater than 13 feet), and that are suitable for wetlands restoration could be set aside for those ecosystem purposes. Using information from ERDC, USFWS and other natural resources agencies, areas suitable for wetlands restoration were mapped in GIS format and prioritized by a joint-agency team. The wetland layers were integrated with tax parcel, structure databases and acquisition layers to determine where permanent acquisitions and wetlands restoration would coincide.

4.5.9.9 Relocation of Acquired Households and Commercial Businesses

4.5.9.9.1 General

The sanctity of the American home and all that it represents to the owner and family are at stake when nonstructural or structural measures are being considered for reducing flood damages. The home represents a unique place full of social interaction, psychological development, self expression and security from the outside world. Our homes may be the largest single investment in our adult lives and the place where families are started and nourished. For those retired, the home may be a place of relaxation and the center for extended family vacations (especially those located on the Gulf). Leaving one's home either by choice, by necessity or by force can be a very traumatic and stressful event. In close association with losing one's home is the loss of one's neighborhood or community due to a relocation project. Numerous studies have shown that although there can be both positive and negative impacts from housing displacement/relocation, the negative impacts can be more long-lasting and mentally stressful. With these considerations in mind, relocation of substantial numbers of households in either structural or nonstructural projects must be accomplished with appreciation for these impacts and stresses on the household members.

Based upon available inundation data for the parcels within the study area and the design limitations on elevating structures (maximum 15 feet in height) there may be a great number of acquisitions and relocated businesses and households in any nonstructural plan featuring floodplain acquisitions for the project area. Needless to say that any major nonstructural program that would feature significant numbers of relocations from the coast would dramatically change the economic and social characteristics of the coastal communities. In addition, the number of public buildings (many regarded as critical facilities) that could be eligible for relocations indicates that some relocation/redevelopment models could produce dire economic and social consequences for the coastal communities. In view of this potential, there are three possible avenues for addressing the relocations of these commercial and residential uses.

In addition to the potentially large numbers of landowners who may be only eligible for the permanent acquisition option due to the hazardous location or ground surface elevation of their property, the personal nature of the nonstructural program further exacerbates the problems of relocating thousands of individual households and commercial establishments within the project area. Left to each landowner's own understanding of the program and expectations of the future, individual decisions to participate in the acquisition program and where to relocate to will be outside the control of the municipality or county governments. An unplanned or uncoordinated dispersion of the coastal population would create many "wicked" problems for municipal managers and public service providers – "wicked" problems being those for which there are no discernable good answers.

In view of this potential "scattering" problem, some in-place market systems and options should be explored and considered in planning for such a large movement of the population.

4.5.9.9.2 Market Housing Resources

Although hurricane Katrina demolished or severely damaged an estimated 65,000 residential structures, there are a number of remaining DSS structures that may become available on the market should a Corps buyout program be implemented. These "latent" market resources could be used to address relocations provided that the annual number of relocations from a Corps-sponsored program would not exceed the capability of the existing housing market to allow existing owners of DSS homes to "buy-up" in the market. Some rebuilding of owner-occupied and rental units is already underway in the project area following Katrina (over 1,600 building permits for single-family units in 2006), but the local housing market may not be capable of producing sufficient numbers of DSS replacements to satisfy the entire program-driven need. Should the Corps-sponsored program provide sufficient financial resources through P. L. 91-646 to allow the acquisition or creation of DSS market housing, this option could result in both successful relocations through the acquisition program and a significant housing construction program that would address the expectations of the existing owners and developers.

Regrettably, relying on existing market housing resources to address all of the relocation needs of program participants has a "down-side". Since these available housing resources are now scattered all over the three counties (or to adjacent counties or in other states), these once "neighborhood or community-centered households" would be dispersed all over the region. Besides the obvious impacts of breaking many long-standing social ties within the older, well-established neighborhoods and communities, social problems arise with displaced children, the elderly, physically handicapped, fixed-income, and other interdependent households within the community from displacement. Car-pooling, babysitting, in-home care and other informal social contracts would be broken within the community. In addition to these "social" impacts, dispersal of acquired households could result in impacts to schools, utility districts, public services, and other organizations (churches) that depend upon a stable population for financial resources.

In turn, those communities where displaced landowners would relocate to would be confronted with accommodating the needs (schools, utilities, public services, etc.) of many new neighbors of varying backgrounds and expectations without sufficient financial resources to mitigate the socio-economic impacts. Similar impacts have been realized in "boom-bust" communities associated with energy development and military projects of the past. There are numerous small communities located just north of the I-10 corridor that could be the recipients of this out-migration of relocatees. Table 10 shows a listing of those communities including their land area (in square miles), population, population density and projected population in 2030. The population projections are based upon information from the Gulf Regional Planning Commission's analysis of future traffic generated by zones within Harrison County. It is possible that one or more of these communities would be impacted by an influx of relocatees and many do not have the infrastructure or resources to handle a large number of new residents.

With respect to the commercial relocations, convenient access to one or more of the major existing highways in the area is of paramount importance. Major arterials such as Route 90, Route 49, Route 63, Route 603/43 and Route 110 have captured the majority of the new commercial growth in strip malls and big-box retail complexes. Relocations of at-risk businesses along the coast could follow a similar path given the availability of adequate land along these access roadways. Some flood-safe infill opportunities may exist within established communities, but they are limited due to zoning

Table 10.
Communities Adjacent to the Project Area

Community Name	Population Estimates	Population Density	Community Area	Projected 2030 Population
Escatawpa	3,566	553/sm	6.45 sm	NA
Latimer	4,288	265/sm	16.2 sm	NA
Van Cleave	4,910	113/sm	43.4 sm	NA
Kiln	2,040	153/sm	13.3 sm	NA
Picayune	10,535	918/sm	11.8 sm	NA
Lyman	1,634	135/sm	8.10 sm	4077
Saucier	1,303	186/sm	7.0 sm	NA
Helena	778	385/sm	2.02 sm	NA
Dedeaux	598	NA	NA	3040
Wool Market	3,050	NA	NA	5161
Orange Grove	1,914	NA	NA	3500
New Hope	601	NA	NA	1396
Wortham	NA	NA	NA	NA
Lizana	1,624	NA	NA	2459

sm = square mile(s); NA = data not available
Data source: US Census 2000

restrictions and lot sizes. Other commercial redevelopment opportunities may exist within planned unit developments established with relocated housing initiatives. Certainly for businesses that depend upon a more local clientele, relocation into an existing community structure would better assure their financial success.

4.5.9.9.3 Existing and Planned Redevelopment Sites

In view of the potential impacts that scattered displacement of acquired households could generate in surrounding communities, at least three other redevelopment scenarios should be considered. The first redevelopment scenario is based in part upon a recommendation of the Mississippi Renewal Commission that consideration be given to managed-infill development within existing municipal areas where vacant property (or property with abandoned buildings that could be demolished) would be available for reconstruction of new housing units. These infill sites should be located at elevations greater than the 500 yr. frequency elevation shown on local FEMA FIRM or where the replacement house could be elevated to avoid first floor damages from a 500 yr. flood event as defined in FEMA mapping or within a line of protection that may be afforded by a Corps structural project (i.e. ring-levee project).

Since existing utilities, streets, public services and other amenities are available at these sites, costs associated with providing these site amenities are significantly reduced. Issues to be resolved in infill projects include land costs, infrastructure capacity, potential HTRW contamination and restrictive zoning regulations. Despite these site issues, infill development helps to increase concentrations of municipal population that can support transit services, recover lost tax revenues, and support social organizations and public services. Any new housing options at infill sites would be subject to local zoning and building codes thus assuring that replacement housing would be DSS and able to withstand hurricane winds.

As was shown in the Mississippi Renewal Design Charrettes, there are many housing and commercial design options available that could provide a visually pleasing urban environment while

addressing the flooding risks. Opportunities for mixed use development (residential and commercial) in the more urban areas of the project would abound and strengthen the communities by reinvestment in those damaged economies. Application of New Urbanism concepts for recreating traditional neighborhood areas within existing urban spaces could significantly change the social and economic structure of the communities and reduce the need for vehicular use and parking. See Figure 55 for an example of infill development within the project area in areas where elevation of the new structures may be necessary to meet the program guidelines.

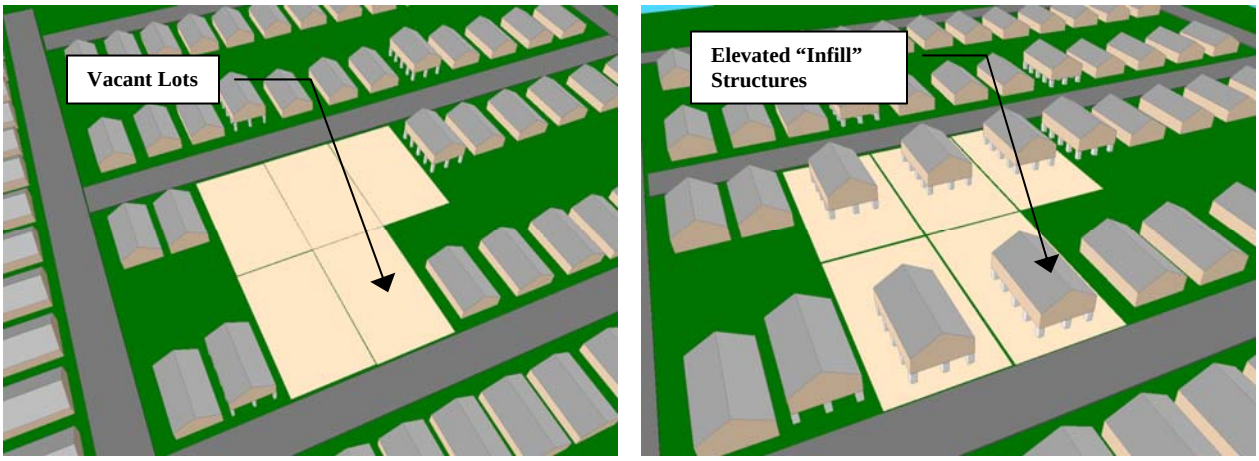


Figure 55. Infill Development

An additional option for redevelopment that could accommodate displaced landowners is the creation of new communities in flood-safe areas. This option can address issues of community cohesion and social impacts that would be raised in circumstances where an existing neighborhood or community has established social or ethnic ties that would resist displacement or where environmental justice issues may arise from acquisition. Sites located above the Probable Maximum Intensity (PMI) hurricane surge inundation elevation (or at a minimum 500 yr. frequency level) or sites that could be physically raised by fill material to be above those elevations, would be platted according to existing subdivision regulations featuring basic residential amenities (utilities, infrastructure, streets, lighting, sidewalks, etc.) and be ready for new housing construction to accommodate displaced landowners. A variety of lot sizes would be platted in the new communities so that a variety of home sizes could be accommodated to meet the replacement housing needs of the displaced owners under the Uniform Relocations Act provisions. These sites could be developed in such a way that many of the urban development concepts recommended by the New Urbanism Congress for Mississippi Renewal could be realized on the ground. These "Housing and Community Development" (a.k.a. H&CD) sites could be located with convenient access to Interstate 10 interchanges and the major arterial roads leading back towards the coastal area. A north-south transit system on those arterials could be initiated to reduce future traffic flows between the relocated communities and the remaining shoreline urban areas.

Should this H&CD option be exercised, relocations of schools and other critical facilities as part of the coastal protection project could be coordinated such that the new communities would be served by those relocated public facilities. Figure 56 shows an example of a new community development with opportunities for residential, commercial and institutional land uses. Development costs for H&CD sites could be as high as $45,000 per lot including land acquisition, site grading and drainage, utilities, streets, lighting and landscaping.



Figure 56. New Housing and Community Development

The third redevelopment scenario is based upon the new community concept but the physical location of the existing community does not change. The best example of this option is the community of Pearlington where the current density of development is relatively low and portions of the existing community exhibit higher elevations above the Gulf. The primary component of this redevelopment scenario would be raising areas of the community with locally excavated fill material. That new site elevation could be adjusted to meet any of the selected levels of protection associated with surge inundation from hurricanes. New residential, institutional and commercial development could be constructed upon the raised site in a more dense development pattern that would be more efficient and safer thus avoiding the social impacts associated with dispersal. New utilities and roadways would complete the community redevelopment.

In the case of Pearlington and the few small residential subdivisions surrounding that community, their current footprint is surrounded by a low-lying landscape that could be converted to wetland habitat as part of the excavation process for fill materials. With careful planning and design the development of a new raised Pearlington community could result in many acres of new wetland habitat adjacent to the Pearl River as a by-product of the borrow operation. Opportunities for a “safe harborage” along the Pearl River could also be explored as a part of the excavation of near-by borrow material to raise the community. Further investigation of this type of on-site redevelopment may indicate other coastal locations for its use and some cost savings above other options for whole community relocations. Certainly the prospect of creating additional high-quality wetland habitat as part of the redevelopment process is noteworthy.

In recognition of current community planning models that emphasize more concentrated development rather than the sprawl pattern of the last four decades, relocations of large numbers of households would need to be better planned and closely coordinated with the municipal and county planning and zoning commissions. New urban development initiatives being promoted by the New Urbanism Congress and “green” neighborhood programs being promoted by LEED (Leadership in Energy and Environmental Design) can be applied to new relocation sites. In an age of higher fuel prices, growing concerns of the effects of greenhouse gases, and conversion of green areas to

urban uses, this anticipated redevelopment needs to emphasize walkable communities and reliance on public transit rather than the vehicle-oriented neighborhoods that have become popular along the coast. The more concentrated urban communities within the project area (Biloxi, Gulfport, and Pascagoula) exhibit these more pedestrian-oriented patterns of development. Any new redevelopment options must consider these emerging societal concerns.

4.5.9.9.4 Replacement Housing Options

As important as the location and quality of the relocations sites will be to local governments, the quality and affordability of relocation housing units will be more important to displaced families. The need for affordable DSS housing resources in the project area is well documented. Much of the new replacement housing that has appeared following Katrina has been larger and more expensive than the destroyed units. This trend in replacement housing does not bode well for those families that may be in need of replacement housing but either had limited financial resources or did not have insurance coverage. Housing unit options that can meet a wide range of financial situations will be more successful in such a massive relocation effort.

Housing options such as manufactured units (not mobile homes), panelized units and modular units can provide reasonably priced, well constructed homes for relocated families. Most amenities found in stick-built homes can be incorporated into manufactured homes at the factory. Built in a controlled environment with quality materials, close tolerances and meeting the latest building codes, these units can be produced in large numbers for reasonable prices. A wide variety of styles, sizes and built-in amenities are available from multiple suppliers. All International Building Code requirements can be met with these manufactured housing units. Transported into redevelopment sites and placed on either a concrete slab or crawl space foundation, installation of these units requires days rather than weeks or months and new communities can be established quickly. Coordination with local zoning and code enforcement offices prior to construction and installation of these housing units can reduce any development permitting problems.

4.5.9.9.5 Cemeteries

Among the many personal items that may be encountered during the purchase of private property and relocations of a household or business is a cemetery on the acquired property. The cemetery could be associated with a family or with a church or another commercial enterprise. Cemeteries will not be purchased or relocated as a part of the nonstructural permanent acquisition measure. Under the nonstructural program, cemeteries remaining on the acquired and evacuated land do not result in residual damages and do not further threaten lives. Cemeteries will be left in place unless the landowner chooses to relocate the cemetery with their own resources. The purchase price of the property will take into account the value of the land occupied by the cemetery. Reasonable access to the cemetery for the family or business (or church) will be provided during the structure demolition process. Any additional security, adornment and all maintenance of the cemetery or the plots in the cemetery will be at the discretion and expense of the cemetery owner(s).

The only cemeteries that may be purchased under the nonstructural program would be those located within property purchased for redevelopment sites and then only in cases where the location and size of the cemetery significantly limits the efficient use of the site. All efforts will be made in the site development process to avoid any new or relocated home construction on land previously occupied by known cemeteries. Cemeteries found within the footprint of the contractor's work limits of a structural project (Levee, floodwall, pump station, etc.) will be relocated in accordance with standard Federal relocation procedures.

4.6 Relocations of Public Buildings and Facilities

4.6.1 General

Public buildings and facilities for which there is an identified compensable public interest and are considered to be essential for continuance of public services can be protected by either some form of acceptable floodproofing (wet or dry floodproofing) or, if they cannot be protected safely in place, a new replacement in-kind facility/building can be constructed in lieu of direct purchase under the permanent acquisition option. The replacement, in-kind structure in effect represents the value of the purchase price of the existing structure. In these instances, a relocations contract would be executed between the Corps and the public jurisdiction (county or municipality) for design and construction of the replacement building/facility. Identification of public facilities eligible for relocation was based in part upon FEMA data and data provided by individual counties and municipalities.

4.6.2 Critical Facilities Database

The database within FEMA's HAZUS (**HAZ**ards **U**nited **S**tates) program identified approximately 75 structures categorized as "critical facilities" within the project area that were damaged by Katrina. Many of those structures and facilities were confirmed by cross-checking municipal and county databases. Of that total number, approximately 66 could be identified (by name or by use such as schools, fire stations, police stations, city halls, emergency management, or medical facilities) as being publicly-owned or otherwise eligible for the relocations program. A number of the critical facilities were identified as being privately-owned (faith-based schools, government offices in private office space) and would be purchased through the permanent acquisition program. Of the 66 structures, 49 could be positively identified with an existing tax parcel in the project database and were determined to be eligible for relocation or floodproofing by some method.

4.6.3 Relocations Planning

Using the GIS hazard zone layers previously developed for commercial and residential structures and the locational data from the tax parcels and HAZUS program, preliminary options for each of the public buildings and facilities were determined. Due to some inaccuracies in the geo-coding of the structures used in the GIS databases, exact determinations of the disposition of each public building cannot be made until each building or facility is field verified in a more detailed study. As with residential and commercial structures, any public buildings/facilities that were located within the three high-hazard zones were determined to be eligible only for relocations to a flood-free site. Public buildings such as schools, city halls, police stations, fire stations, emergency services buildings, and medical facilities located within those hazard zones would be relocated (in-kind replacement structure) through a relocations contract to a suitable flood-free site. Initial analysis of the data indicates that 7 structures/facilities would be subject to relocations to a new flood-free site. Another 43 public structures were determined to be protected by floodproofing by various methods (assumed to be ringwalls for this appendix).

The redevelopment site selection, new facility/building design and construction would be fully coordinated with the facility owner. Relocations planning would determine, in cooperation with the owner and regulating entities whether the existing structure met current regulations regarding size, facilities, and uses. Bona fide upgrades to meet current building/facility standards would be included in new designs for relocated structures. Any upgrades that would exceed current standards for that specific building use would be considered "betterments" and would be subject to financing by the owner of the structure or a non-Federal project sponsor.

4.6.4 Relocations Costs

Costs for relocations were based upon estimated square footages for fire and police stations and city halls. Prices per square foot for standard frame construction were used to estimate new buildings and associated facilities construction. RS Means building construction online calculators (http:www.rsmeans.com/calculator for 2007) were used to determine building costs for each use type based upon a local zip code location (Gulfport, MS) within the project area. Square footage estimates for relocated schools were based upon numbers of students (using current online county school board databases) and square footage recommended per student (based upon 2006/2007 school construction in the four state region including MS). Using school construction information from a 2007 Construction Report published by School Planning and Management for a four state region (including MS), costs per square foot of building construction were determined. Per square foot costs were determined by school type (elementary, middle and high school). Land and parking requirements were based upon national standards for the various levels of schools (elementary, middle and high school) and the appropriate contingencies, E&D and S&A costs, overhead and profit were also added to the relocations estimates. Since all of the schools and fire stations in the project area were not specifically identified in the parcel database, an average cost for relocations was calculated for those structures identified in the database and applied to all listed public structures.

For those public structures located outside of the three high-hazard zones and where depths of flooding did not exceed 13 feet, methods for protection in-place would be explored in greater detail. During more detailed nonstructural planning for protecting individual public structures, options for protection in-place such as veneer walls, ringwalls, or ring levees can be considered with respect to the suitability of the property to support certain protection methods as well as building access requirements, utilities, service entrances, ADA requirements and other building use needs that would determine the appropriate type of in-place protection. A more in-depth field investigation of each structure would be necessary prior to implementation of a nonstructural project in these areas.

Approximately 43 public structures may be eligible for floodproofing in some form (elevation, veneer wall, ringwall, ring-levee, etc.). For the purposes of determining a preliminary cost for this nonstructural appendix, it was assumed that each of the structures within the floodproofing area would be protected by a ringwall. Building footprints and perimeter lengths for ringwall length were determined based upon aerial photographs and student numbers for schools. Recent ringwall costs for a high school in LRH (portions of I-wall and T-wall construction) were indexed and applied to the wall lengths determined by the methods described above. Appropriate contingencies, E&D and S&A, profit and overhead were added to the estimated per linear foot ringwall costs. The cost estimates assumed that all floodproofing construction would occur on property owned by the municipal or county government so no costs were included for land acquisition.

Estimated costs for floodproofing public structures such as fire stations were based upon a standard building size of 5000 square feet for the project area. Ringwall length was predicated on a 20 footwall setback from the building for interior drainage, closures and vehicle access. Construction costs were estimated according to the procedures listed in Section 4.3.7.8 Ringwalls and Ring Levees.

4.6.5 Relocation Sites

For those critical facilities determined to be public facilities, information on the use, service area, floor space size and special requirements will need to be determined so that an appropriately sized, located and equipped relocated structure can be estimated for construction. That detailed information was not available for each facility to be relocated at this level of planning study. Site selection for these relocated buildings is a critical component of the relocations process given the sensitivities to the service area (police and fire) and land area requirements. In accordance with

FEMA guidelines, certain critical facilities should be located above the 500 yr frequency event as defined in the FIRM. Relocations agreements specifying all of the relevant requirements and facilities to be constructed are executed between the governmental unit and the Federal government (USACE) prior to construction.

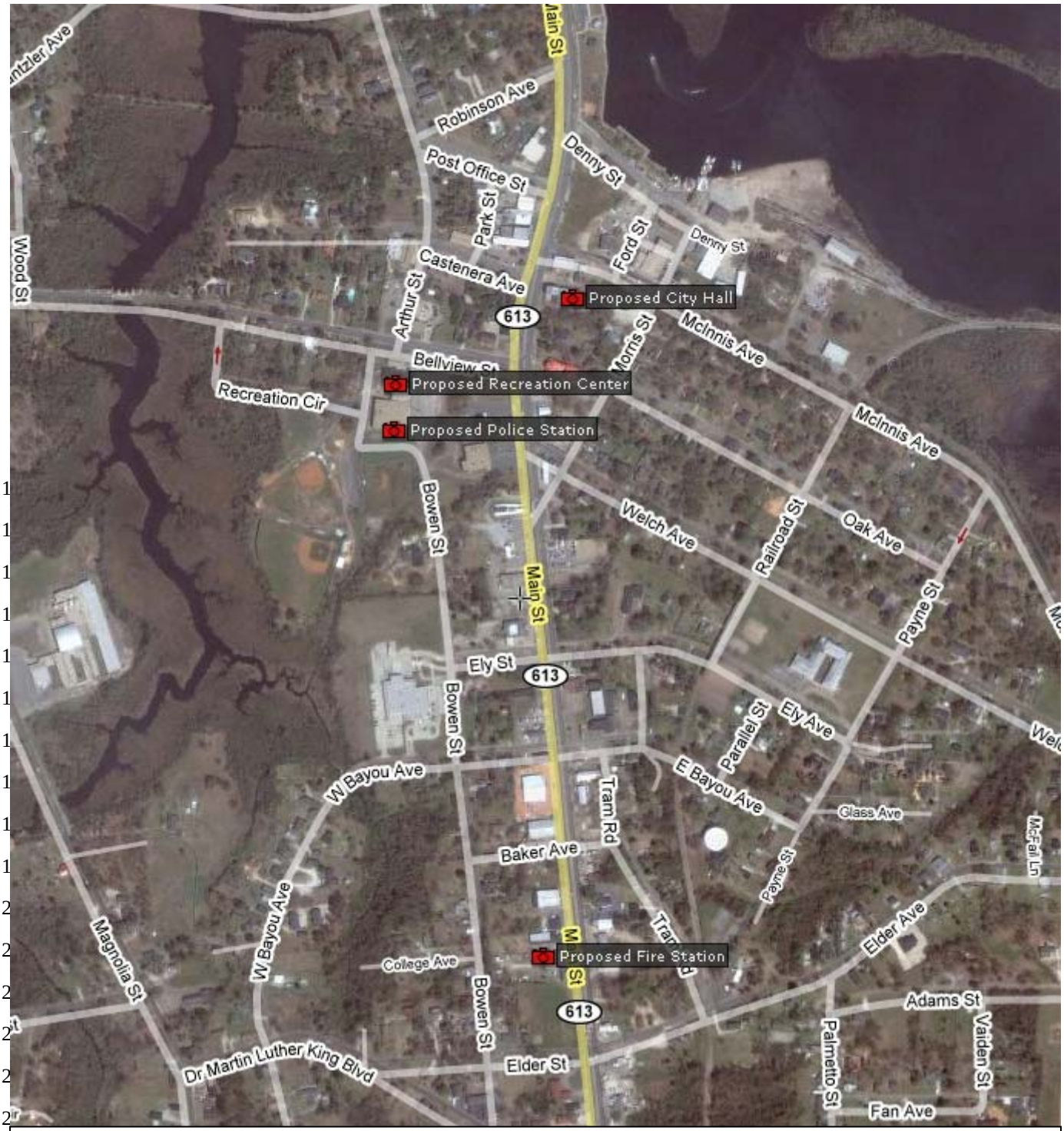
Relocations of these public buildings, some of which are considered to be critical to the safety and economic growth of communities must be carefully accomplished in concert with other potential relocations of residential and commercial structures and facilities. Re-establishing service areas around relocated facilities that conform to state or national legal and funding requirements will be a challenging task. In some cases, regional facilities could be relocated initially while public facilities with a smaller service area would be moved after substantial numbers of residences and commercial uses have been relocated out of hazard zones. Close coordination with local government units and service providers will be critical to the success of the public buildings relocation program.

4.6.6 Pilot Moss Point Public Buildings Relocations Project

During the formulation of the nonstructural measures and alternative plans, the NS PDT became aware of local efforts by the leadership of Moss Point, MS to relocate several public buildings out of the hurricane surge zone to a higher elevation within the municipal area. Members of the NS PDT met with the Mayor of Moss Point and other city officials to develop a plan for relocating those facilities that would be in concert with the relocation concepts described above. As a result of those meetings, the NS PDT developed a Pilot Relocations Project for Moss Point, MS. The purposes of this pilot would be to demonstrate to the other 10 affected municipalities that relocations of critical facilities that are public buildings is an effective way of maintaining services within the community while protecting those structures from flood damages and to affirm the Corps costs of the relocations measure that could be applied to other communities.

The pilot public buildings relocations project would include the Moss Point city hall, police station, fire station and community recreation center. Each of these four facilities was severely damaged during Katrina by surge inundation and waves and prevented local authorities from assisting citizens during the emergency. The City of Moss Point identified several strategic locations within the city where relocated public facilities would be safe from future events. Tentative locations for each of the four facilities to be relocated are shown on Figure 57.

Members of the NS PDT provided a preliminary relocations assessment of the required building square footages, parking requirements and land area needed based upon data from the city officials in Moss Point and field measurements. Using this base data, Corps estimators developed a fully-funded total cost for relocating these four structures of approximately $11.4 M. A more detailed investigation of the existing structures, the proposed relocation sites and formulation of other potential relocation scenarios (single governmental complex or multi-purpose building) would be addressed in a follow-on detailed relocations report.



Note: Moss Point, MS estimated locations of relocated public facilities. Plotted using gpsvisualizer.com maintained by ©2007 Adam Schneider. Arial photography powered by Google provided by Digital Globe 2007

Huntington District US Army Corps of Engineers
Mississippi Coastal Improvement Plan
Moss Point, MS Pilot Relocations Project
Nov 13, 2007
Drawn By: Joe Trimboli

Figure 57 – Moss Point Public Buildings – Pilot Relocations Project Location

CHAPTER 5. SUMMARY OF NONSTRUCTURAL MEASURES

As shown above, there are a number of potential nonstructural measures that could be implemented within the project area and would result in significant reductions in flood damages as well as reducing the threats to occupants of the coastal zone. Some of the measures are generally associated with Federal actions that could be implemented through standing or new project authorities and some are purely within the purview of state and local jurisdictions acting through their police powers. Many of the measures have been proven in other locations to be both effective and reliable and some, although theoretical in their construction, if implemented should have dramatic effects on the existing development patterns along the coast that contributed to the high losses from Katrina.

Given the current conditions within the project area with regard to pending insurance settlements and the uncertainties surrounding the anticipated new flood insurance rate mapping, redevelopment along the coast has been relatively minimal. However, when the regulatory and financial components of redevelopment are finally resolved, new construction along the coast is anticipated to proceed at a feverish pace. Opportunities to assure that new development is located in less hazardous areas than in the past and to reduce the future damages associated with large hurricanes and storms are slipping by each day. Some of the measures described above can forestall unwise development along the coast if they are implemented in the near term. Those measures are discussed in the subsequent formulation and evaluation sections of this Nonstructural Appendix.

Although many of the measures are shown to be effective in reducing damages and threats to life, some of them could result in significant social and economic impacts if administered within a short time period to large areas of the coast. Significant numbers of permanent acquisitions and relocations would result in the movement of thousands of families, hundreds of businesses and many facilities regarded to be critical to the functioning of existing communities. Some of the impacts associated with these activities can be mitigated through available programs, but without careful planning and collaboration between Federal, state and local agencies and jurisdictions, the potential exists for significant impacts to the social fabric and economic viability of the coastal communities.

An important feature of the nonstructural measures is the capability to “tier” or layer the measures in different zones over an extended implementation period. Such “tiering” facilitates a constant stream of flood damage reduction benefits through the application of one or more coordinated measures along the coast. As the following formulation process will demonstrate, multiple measures can be implemented simultaneously on a single parcel or across several reaches, each tier providing ever-increasing layers of protection and damage reduction. The tiering approach also eases the social and economic impacts of significant movements of households, businesses and supporting public facilities from high-hazard zones to more flood-safe areas over time.

Collaborative planning among Federal agencies, the state, counties and municipal jurisdictions will be paramount for successful implementation of the nonstructural plans described in the following chapters. Meaningful and continuous public involvement and consensus building will also be key components of a successful nonstructural program. Few other types of flood damage reduction are as personal as are the nonstructural measures and working with homeowners and landowners can be challenging.

CHAPTER 6. NONSTRUCTURAL PLAN FORMULATION

Formulation or "building" alternatives or plans out of identified management measures is a process of creative thought mixed with planning experience and input from various disciplines. Combining various measures into alternative courses of action that address the planning objectives, work within the constraints and that can be implemented by both the Corps of Engineers and other partners in the project is the foundation of the formulation process. Careful manipulation and combinations of proven and reliable tools that reduce flood damages and threats to life and property can result in imaginative solutions to complex problems.

Formulation of successful plans requires a cooperative effort between team members, stakeholders and project partners. Although implementation of certain identified measures within plans may be beyond the limits of the Corps' authority to implement, that does not restrict their inclusion in the formulated plans. Every opportunity to engage the abilities and authorities of our local partners and cooperating agencies in meeting project objectives should be explored. Since nonstructural measures normally include actions that can only be implemented within the statutory scope of local governments, the opportunities for formulating innovative plans abound.

Formulation of plans must consider the intent and direction of the planning objectives. Although the objectives can be revisited and revised during the planning process, the initial or preliminary objectives of the project, based upon the study or project authorization and a careful examination of the stated problems and opportunities, must be satisfied by the formulation process. Failure to meet or exceed the planning objectives calls into question the entire formulation process.

Plan formulation must also consider the temporal aspects of various measures with respect to the size and complexity of the problems to be solved (extended implementation times) and the sequence of applying nonstructural measures to a large population (cumulative social and economic impacts). Since nonstructural measures tend to impact individual properties (residential and commercial) as well as potentially disrupting community systems (education, security and safety, health, and public services), formulation of plans for this project area will consider tiering of measures over an extended period of time. Attempting to relocate large segments of the coastal population as well as commercial resources and critical facilities away from hazardous areas to less flood-prone areas in a relatively short period of time would be an administrative and social nightmare. On a more practical level, the human and financial resources necessary to complete the full suite of nonstructural measures discussed in this appendix in a relatively short period of time are unavailable at this time.

Formulation must consider the various affects or impacts that alternatives or plans may have on the natural and community resources of the project or program area. Each action or activity will generate some differences in the natural, social or economic conditions of the area. Both beneficial and adverse impacts are anticipated from most nonstructural actions, but formulating plans with those potential affects clearly in view can reduce needed mitigation and plan costs. Since communities by definition and function are composed of a mixture of land uses, people and infrastructure systems, each one contributing valuable benefits to the community as a whole, it was determined by the NS PDT that alternatives that targeted one of the individual land uses or components for protection in such a way to totally remove that component from the community structure (i.e. relocation of all residences or just all commercial uses) would not be presented in the nonstructural plan. In cases where a particular structure type (i.e. mobile homes) would be placed in extreme jeopardy through a nonstructural measure (elevation into hurricane-force winds), acquisition of those structure types in lieu of elevation may be warranted. Although it would be possible to envision the separation of community land uses in some future coastal development plan so as to provide greater levels of

flood protection and more efficient land use, the social and economic impacts of affecting such a community dispersion in a Federally-funded program would be virtually impossible to describe or justify.

Prior to initiating the nonstructural formulation process, three components of nonstructural measures must be considered: 1) program eligibility of structures and properties, 2) level of protection being provided, and 3) nonstructural measure evaluation criteria. Unlike structural projects where a line of protection or an area of reduced inundation gathers hundreds or thousands of properties, many nonstructural measures (i.e. floodproofing) address individual properties and each must be evaluated with specific criteria for their eligibility in the program options. Each of these three components is discussed below.

6.1 Nonstructural Plan Data Use and Analysis

Formulation of nonstructural measures relied heavily upon many sources of data and information provided by the local counties and municipal areas, as well as from other Federal and state agencies. One of the primary data sources was provided by the three counties (Jackson, Harrison and Hancock) tax assessors offices. Tax parcel databases from the three counties that were geospatially constructed for use with standard Geographic Information Systems (GIS) computer models allowed the NS team to account for the many surge-affected parcels, correlate their common site characteristics and display that data graphically for formulation purposes.

As is the case with many county property tax databases, tax parcels may be composed of one or more legally-described tracts of land that are listed under one ownership in the tax system – this is the case for the three county tax parcel databases used in this project formulation. For the purposes of the nonstructural formulation all of those “tracts” were just referred to as “parcels” to avoid confusion. Also, prior to Katrina, a great many parcels were recorded in the tax database as being vacant without any residential or business structure located on the property. Since these vacant parcels could be built upon in the future and suffer damages due to hurricane surge inundation those tax parcels located within the permanent acquisition zones were included within the acquisition category of nonstructural measures. An additional number of parcels that had structures located on them prior to Katrina (as determined in the tax base) had been made vacant due to Katrina. Estimates based upon field observations were made in the project database as to that number of newly vacant parcels that would also be eligible for acquisition. It is out of that estimated number of vacant parcels that the proposed initial phase of the High Hazard Area Risk Reduction Plan (HARP - see Section 4.5.9.5) would purchase parcels prior to landowner reconstruction.

For the purposes of nonstructural formulation and the determination of national economic benefits associated with the nonstructural measures, several future-without-project scenarios were developed (see the Economics Appendix). Those alternative scenarios allow comparison of with-project and without-project conditions with regard to inundation damages, potential loss of life and other factors. Each of those 6 scenarios include the assumption that by the year 2012, all of the parcels of land made vacant as a result of Katrina would be rebuilt upon with either residential uses or a mixed-use of residential and commercial structures. In keeping with those scenarios of the future-without-project condition, the several plans formulated and evaluated in the pages that follow show a full compliment of developed parcels (existing and new structures in place) within the various inundation zones of the project area. For the same reasons, the costs displayed in the various nonstructural plans (those including the land acquisition measure) represent acquisition of land and structures with associated relocations assistance payments and structure demolition for each parcel within the proposed acquisition footprint.

6.2 Nonstructural Plan Eligibility

In contrast to structural projects where the line and level of protection can actually encompass structures, facilities and lands that were not directly affected by the design flood event, nonstructural measures are directly targeted at structures and facilities which had or would have damages to the first floor and contents from specified inundation events. This difference requires that program eligibility criteria be developed to determine whether the owner of a particular structure or facility can participate (either mandatory or voluntarily) in the program. Usually the ability to participate in a nonstructural program is dependent upon the incidence of damages to the first habitable or sales floor of a structure or facility from a specified flood event. Normally nuisance damages to sub-floor utilities in a crawl space or basement (i.e. ductwork, furnace, hot-water heater, pumps, etc.) do not qualify a structure for program eligibility in nonstructural projects.

Of prime importance in determining program eligibility is the water surface elevation of the flood event that was the genesis of the study or project authorization. The study authorization for the MsCIP specifies *".....to expedite studies of flood and storm damage reduction related to the consequences of hurricanes in the Gulf of Mexico and Atlantic Ocean in 2005,.."* Obviously the largest and most damaging of those hurricanes in 2005 was Katrina. Although both structural and nonstructural measures can be formulated that address a wide range of storm and hurricane events including the theoretical Probable Maximum Intensity (PMI) hurricane, the program eligibility for nonstructural measures must settle on one logical event level.

For this study, the extent and water surface elevation of the Katrina surge inundation was determined to be the limits of nonstructural eligibility. Although the most cost effective project may actually provide a lower level of protection than that necessary to protect structures against a recurrence of a Katrina-intensity event, those structures and facilities that experienced first floor damages from Katrina would be eligible for the nonstructural program at some determined level of protection. It would be possible, depending upon the identification of the most cost effective plan, that structures damaged by Katrina would not receive any program benefits should a lower level of protection than the Katrina inundation level be the basis of the most cost effective plan. This declaration of eligibility for properties damaged by Katrina provides the basis for identifying these landowners as "displaced persons" for the purposes of applying the benefits of the Uniform Act.

6.3 Nonstructural Level of Protection

Determining an appropriate level of protection for nonstructural measures is somewhat unique since most measures apply directly to individual parcels and structures or facilities on those parcels rather than a vast area contained within a structural line of protection. Although many nonstructural measures are unaffected by the concept of level of protection (flood preparedness, land use zoning, etc.), measures such as floodproofing and permanent acquisitions are very sensitive to this parameter. Since a maximum height of elevation in place has been established and since the costs of dry floodproofing are also sensitive to water depth, the level of protection selected can significantly affect which of these measures is applied to individual structures. Increasing or decreasing the level of protection has a corresponding affect on the numbers of structures that can be protected in place rather than relocated by acquisition.

Also unique to nonstructural measures such as floodproofing by elevation is the fact that nationally accepted standards for flood protection upon which the nation's entire flood insurance program is based are already in place within the project area. For formulation purposes, a variety of storm events each having a specific level of inundation that would result in flood damages to structures could be modeled and the benefits of specific applied measures calculated. Somewhere in that array of storms, measures and benefit calculations, the most cost-effective combination of measures and

appropriate level of protection could be discerned. Selection of the most cost effective level of protection and array of measures would meet the planning objectives and fulfill the planning process.

However, the National Flood Insurance Program (NFIP) has determined that the Base Flood Elevation (BFE) is the appropriate level of protection with regards to the application of floodproofing (either through wet or dry floodproofing) and other nonstructural measures. The BFE is normally associated with the theoretical 1% annual chance flood event or a level of inundation that corresponds with a storm event of that frequency of occurrence. Since each of the 11 municipal areas and 3 counties continues to be a regular participant in the NFIP, proposing a level of protection less than the BFE in a nonstructural plan for flood damage reduction would not only not be well received by the local population, but would, if implemented, place each of these local units of government potentially in violation of their own ordinances and in jeopardy of being suspended by FEMA from the flood insurance program. For these reasons, the formulation of the nonstructural measures is based upon a minimum level of inundation that approximates the theoretical BFE within the project area. Other higher levels of protection could be formulated for the nonstructural alternatives, but the result of such additional iterations would be merely moving structures from the floodproofing option to the permanent acquisition or relocations (public buildings) option.

For the purposes of this comprehensive plan, the nonstructural formulation appendix bases its development of alternatives and their evaluation on a level of protection approximating the theoretical BFE within the project area. This would be the lowest level of protection that could be provided if floodproofing were a component of the plan. Greater levels of protection would result in fewer structures being protected in place and potentially more structures being acquired and relocated.

6.4 Nonstructural Plan Participation

For the purposes of nonstructural formulation in this appendix, implementation of the identified measures was assumed to be mandatory (thus assuring 100% participation) so that the full range of benefits and costs could be disclosed across the project area and within each reach. Formulation based upon mandatory participation was also necessary so that direct comparisons (costs and benefits) could be made between structural and nonstructural options for protection of particular communities in the project area (i.e. Pearlington, MS). As structural measure protection is in effect mandatory for all those enclosed within or behind a line of protection, nonstructural measures for those same structures and facilities would have to be formulated as a mandatory (100% participation) program for the sake of comparing cost effectiveness of the measures.

Other local, regulatory-based nonstructural measures (i.e. land use zoning, building codes, etc.) can be considered mandatory once legally enacted by the municipal or county government. Such measures, implemented by the local governments, are enabled through state legislation and thus carry the authority of the state's legal standing in land use matters. Landowners could seek relief (code variances) from local mandatory measures should the measures be found to be so restrictive as too diminish property values below limits that constitute a taking.

Under the permanent acquisition measure, mandatory acquisition could be enforced since the Federal government would be obtaining an interest in the property as part of the action. Mandatory acquisitions through the use of condemnation proceedings are common for construction of public projects that are found to be in the public's interest and where the Federal government requires fee title to the property to construct permanent public assets. Using mandatory acquisition for coastal zones determined to be high-hazard areas is an option, but the public acceptability of such a program and the political viability of mandatory acquisitions is questionable. Mandatory acquisitions

on a large scale generate significant social and economic hardships even in the presence of mitigative actions.

The quantification of project benefits and costs and evaluation/comparison of other non-monetary benefits (reducing loss of life) is more problematic when participation is not mandatory. Landowner participation in a nonstructural program is based upon the owner's perception of the costs and benefits to his own self (rather than the nation's) weighed against the owner's perception (or misperception) of the risks of future flood damages to the property. The severity of the damages to the property as a result of Katrina or a similar type storm may weigh heavily on the owner's decision – loss of life during the same event weighs even heavier. Included within the owner's determination may be years of current land ownership and perhaps past generations of ownership that have been handed down to this time. Family values, traditions, cultural biases and other social factors also influence the owner's decision whether to participate in the program. Added to these factors is the uncertainty of the outcome should the owner choose to participate – any changes in lifestyle can be daunting in the current economic environment, changes with great uncertainty can be paralyzing.

The only certain factor in the nonstructural participation process is that it is full of uncertainty. Who and how many landowners would participate at what time during the project's implementation is at best guesswork at this preliminary level of analysis. Feedback from workshops and meetings and from the media about possible public participation in certain measures is not a reliable yardstick – only when the official agency offer to participate is made and landowners are provided with credible information of their options and benefits does the real participation rate become evident. Past nonstructural projects have experienced participation rates as high as 80-90 percent for permanent acquisitions and floodproofing following major flood events. Participation in certain nonstructural measures has also increased measurably following landowners' observation of pilot or prototype projects showing the benefits of participation. Experience has shown that participation rates in nonstructural projects decrease with each ensuing dry year following a disaster.

In an attempt to address the problems of nonstructural participation in plan formulation, the various levels of participation for each of the measures can be shown and the effects on costs and benefits can thus be observed. However, since the participation process is largely random (unless specific geographic zones or land use types are selected for sequential implementation in the program) there is no way to determine which properties will be included in the program at which time. In addition, participation rates will vary between NS program component. Participation in permanent acquisitions for those whose structure was only partially damaged may be relatively low, while those landowners who lost their house and have no flood insurance may have a higher participation rate. A large percentage of those landowners eligible for floodproofing may participate in the program when that component of the project is offered since that form of protection is common in the project area and widely accepted. Participation in the relocations options may vary between each municipal and county area depending upon the extent of damages to their public structures and the local population needs. Therefore the stream of costs and benefits will be erratic with varying levels of both costs and benefits as each property enters the acquisition or floodproofing process.

Acquired properties that have the potential for also generating ecosystem restoration benefits will produce more benefits than properties generating only flood damage reduction benefits and obviously more lavish residences or big-box retail commercial will cost more to acquire than a mobile home. Using total permanent acquisition, floodproofing and relocation units and costs to display the ranges of units protected and cost by participation rate provides a general idea of the effect of varying participation rates. Table 11 shows the total units and costs of permanent acquisition, floodproofing and relocations for Plan NSC-1 (see Section 6.6.2.1. and Table 17) displayed by levels of program participation between 10 percent and 100 percent. Although the ensuing graph from that table would generally display positively-sloped, straight lines showing cumulative units protected and

costs from the various reaches, the random nature of the participation process would actually produce very erratic, sloped lines during implementation.

In affect, the eligible landowners in the project area are consumers of a service or program for protection of their property and lives. Not unlike purchasing flood insurance, landowners can choose to partake or not in a voluntary nonstructural program as well as any of the other Federal assistance programs discussed in Section 3.5 above. Hopefully each eligible landowner would be afforded sufficient information on the benefits and liabilities of each available program so that his or her selection will be well informed. It is improbable that participants would have the option of selecting more than one Federal assistance program for reducing flood damages without some off-setting reduction in program benefits – a "double-dipping" issue.

In an effort to more precisely determine what levels of participation may surface in a nonstructural project or program, delivery of an OMB–approved survey (randomly-selected or targeted sample) to eligible landowners in the project area during preparation of a more detailed implementation report would begin to better clarify an expected level of participation and therefore expected project costs and benefits. This sample survey process has been used successfully in past nonstructural programs to better determine expected project costs and benefits. Such information is also beneficial in addressing project impacts through NEPA documentation and to project sponsors for budgeting cost-sharing contributions. Using a standard deviation around an expected mean participation rate for each nonstructural measure provides a range of possible costs and benefits that can better inform decision-makers.

Table 11
Effect of Participation Rates on Project Structures and Costs – Plan NSC-1

Participation Rate	Permanent Acquisition Structures - Cost	Floodproofing Units - Costs	Relocations Units - Costs	Plan Total Units - Costs
10%	1,714 - $792,841,130	2,542 – $1,080,530,165	1 - $7,316,697	4,252 - $1,878,492,984
20%	3,429 - $1,585,682,260	5,083 - $2,161,060,331	1 - $7,316,697	8,504 - $3,756, 985,968
30%	5,143 - $2,378,523,390	7,625 - $3,241,590,496	2 - $15,365,065	12,756 - $5,635,478,951
40%	6,858 - $3,171,364,520	10,167 - $4,322,120,662	3 - $20,486,753	17,008 - $7,513,971,935
50%	8,572 - $3,964,205,651	12,709 - $5,402,650,827	4 - $30,730,130	21,260 - $9,392,464,919
60%	10,286 - $4,757,046,781	15,251 - $6,483,180,992	4 - $30,730,130	25,512 - $11,270,957,903
70%	12,000 - $5,549,887,911	17,793 - $7,563,711,158	5 - $35,851,818	29,764 - $13,149,450,887
80%	13,715 - $6,342,729,041	20,335 - $8,644,241,323	6 - $46,095,195	34,016 - $15,027,943,870
90%	15,430 - $7,135,570,171	22,877 - $9,724,771,489	6 - $46,095,195	38,268 - $16,906,436,854
100%	17,144 - $7,928,411,301	25,419 - $10,805,301.654	7 - $51,216,883	42,520 - $18,784,929,838

For the sake of an example showing the effects of varying participation rates on the plan units and costs, the safe harborages included in Plan NSC-1 were not included in this table illustration (only 3 proposed). The costs by measure are based upon the average for each option times the units under each percentage rate of participation. Actual plan costs could be any number of combinations of participation rates (and costs) between the three components of the plan.

6.5 Nonstructural Criteria/Design Parameters

All structures and facilities located within the eligibility footprint (Katrina surge limits) that can be addressed by the nonstructural flood damage reduction program as defined herein will be subject to on-site evaluation based upon the criteria listed below. Separation into one of the nonstructural measures identified in Section 4.0 above will be based in part upon the results of that on-site evaluation. The nonstructural criteria are listed below:

6.5.1 Location with Respect to High-Hazard, Moderate Hazard and Limited Hazard Zones

High-hazard zones are defined as those comprised of the FEMA-identified V/VE Zone, the FEMA-identified “catastrophic damage zone”, and a 800 feet wide zone bordering the coast within Jackson County identified by the nonstructural PDT as a high-hazard area based upon observed damages. Moderate hazard areas are those areas where the depth of flooding at the structure exceeds 13 feet at the specified inundation level. Limited hazard zones are those areas where the depth of water at the structure was at or less than 13 feet at the specified inundation level.

6.5.2 Depth of Flooding at the Structure

As described above, the determining inundation depth at the structure that separates structures that can be safely elevated from those that can only be voluntarily acquired is 13 feet at the specified inundation level. This depth is measured from the lowest ground elevation along the perimeter of the structure first floor.

6.5.3 Post-Floodproofing Occupancy Requirements and DSS Status

The proposed floodproofing/elevation program would be implemented in accordance with the requirements of the NFIP as a minimum standard. The goal of elevating or otherwise floodproofing a residential structure is to provide a dwelling unit whose first floor elevation has been raised in accordance with the most current local floodplain management ordinance and for which an occupancy permit can be obtained (should one be required). All floodproofing work would be accomplished in accordance with existing building codes for the purposes of obtaining an occupancy permit from the local jurisdiction following elevation. Any existing structure for which an occupancy permit could not be secured (due to structural instability or other reasons) would be subject to acquisition under P. L. 91-646, considered for an on-site elevated rebuild or regarded as a non-participant in the program.

For existing structures that were not considered DSS prior to or as a result of Katrina damages, no project floodproofing funds would be used to bring the structure up to current DSS standards. Either private or other Federal (i.e. FEMA, HUD) or State funds may be used to attain any DSS requirements. Such additional, privately-funded construction could be accomplished during the floodproofing work by the contractor provided that such work would be described in a separate contract and paid for with non-Corps funds.

6.5.4 Structural Stability

Residential, commercial or institutional buildings that are determined by a qualified engineer or architect to be structurally unsound are not eligible to be elevated as a means of protecting the first floor form inundation. Any structures determined to be structurally unsound would only be eligible for either acquisition or an on-site, elevated rebuild.

6.5.5 Structure Use and Type

Feasible nonstructural options for structures are determined in part based upon the use and type of the structure or facility. Access requirements vary between residential, commercial and institutional uses considering ADA codes, service areas, parking needs, utility needs, lot size, zoning issues, and other characteristics of the building type and use. A critical facility may have stringent service area restrictions that severely limit options to move the structure from its local population. The ability

to either protect a structure or facility in place or acquire or relocate the building is partially dependent upon its use or structure type.

6.6 Applicable Nonstructural Measures

6.6.1 General

Section 4.0 of this Appendix identifies and describes in detail the various types of nonstructural measures that could be applied to the project area for the purpose of reducing loss of life and flood damages as a result of storms and hurricanes along the coast. That section also makes a preliminary determination as the applicability of those individual measures to all or portions of the project area based upon the existing conditions, expected effectiveness of the measure itself in reducing damages and protecting lives and potential social, economic and environmental impacts. Based upon that determination, Table 12 provides an overview of the potential nonstructural measures that could be formulated into several plans either as single measures or as combinations of measures.

Table 12.
Applicable Nonstructural Measures

Measure Acronym	Measure Name
FWEE	Hurricane/Storm Flood Warning and Emergency Evacuation
FM&Z	Floodplain Management and Zoning (NFIP)
LLUR&Z	Local Land Use Regulation and Zoning
BC&E	Building Codes and Enforcement
FP	Floodproofing by Elevation and Other Means
PRM ACQ	Permanent Acquisition
DIF	Development Impact Fees
TDR & PDR	Transfer of Development Rights & Purchase of Development Rights
RELO	Relocations of Public Buildings

As this table shows there are a number of nonstructural measures that have been determined to be potentially effective in reducing damages and preventing loss of life in the project area. These nonstructural measures include three measures that could be primarily applied by Federal agencies (i.e. US Army Corps of Engineers (USACE) and Federal Emergency Management Agency (FEMA) using federal funds and locally supplied matching funds. Those measures are floodproofing (FP) by structure elevation or other means, permanent acquisition (ACQ) and relocations (RELO) of public buildings and facilities.

Prior to the process of formulating alternatives or plans using the above discussed measures, at least three steps must be taken to characterize the measures so that formulated plans do not contain conflicting measures or incomplete measures or that formulated plans have not correctly sized the measure. These three characterizations included scaling, dependency and combinability.

6.6.2 Scaling

Scaling addresses the appropriate sizing of each measure with respect to spatial coverage, timing of the measure application over the period of analysis, number and type of component processes, and size of the measure (number of units or parcels affected in nonstructural terms). In short, formulating 5 different acquisition programs consisting of differing numbers of units acquired would not constitute separate plans, just different scales of the same measure. Likewise formulating

4 alternatives/plans for floodproofing structures that would take place sequentially over 10 years would not constitute 4 separate plans, but one plan implemented over an extended period. Also, raising the level of protection offered by the nonstructural measures from a minimum BFE (approximately the 1% annual chance event) that meets local floodplain ordinances to several inundation depths (i.e. 20 ,30, or 40 feet of depth) would also be scaling the basic plan (i.e. Tables 25 through 29 for Plan NSC-6).

Finally, formulating plans composed of modified zoning or building codes for all 11 municipal areas would not constitute 11 separate plans but one plan applied in 11 separate areas – a scaling exercise. The appropriate scales for each of the nonstructural measures being considered will depend upon the wishes of the potential project sponsors (and the extent of their legal boundaries for those measures being implemented by local jurisdictions) and issues of combinability. In actual implementation, nonstructural measures can be applied to a single parcel of land or many thousands of parcels as funds and resources allow. The ability to have an infinite number of plan scales is one of nonstructural measures primary strengths.

6.6.3 Dependency

It is possible to have nonstructural measures that are dependent upon one another for their effectiveness. Obviously building codes are best applied when the structure has not been acquired from the lot and altering property taxes to discourage development works best when the property is in the ownership of a private individual rather than the county or municipal government (post acquisition OMRR&R). Many measures are not effective in the absence or presence of a structure on the particular tract of land. Independent measures should be grouped together as a single measure or at least depicted as working in concert to meet planning objectives.

6.6.4 Combinability

The concept of combinability addresses whether measures may or may not be mutually exclusive of one another. This character trait can be further divided into combinability with respect to location, function or overlap. Obviously in the nonstructural arena, one cannot both purchase and demolish a structure and then elevate that same structure as a floodproofed structure on the same lot. Once acquired and demolished, no structure is left on the site to elevate. In the same way, application of building codes on property where structures are acquired in the program and reserved for ecosystem restoration is impractical. Some nonstructural measures can negate the benefits of others: modification of the flood insurance program to suspend the program cannot co-exist with a measure to apply new structure design guidelines through the same suspended program. These issues of combinability can usually be addressed through a “pair-wise” matrix evaluation in which the measures are evaluated against one another to determine where conflicts or compatible measures may exist. The pair-wise comparison matrix for the above described measures is shown in Table 13.

Most notable in the table is the combinability and potential juxtaposition of improved components of the storm warning and emergency evacuation system, local land use controls, floodplain management, permanent acquisition, and various types of floodproofing across the project area. Since some of the measures require direct action to be taken on a property (acquisition and demolition, floodproofing or relocations) and others are primarily regulatory or administrative in nature, some of the measures are very combinable and reinforce each other in their application. Combining the flood warning system and emergency evacuation system improvements, upgraded building codes and floodplain management and zoning modifications with floodproofing by elevation on a single parcel (with an existing structure) accomplishes several of the planning objectives at minimal construction and annual O&M costs.

Being more than 80 miles in extent and addressing more than 70,000 individual parcels, the project area provides many opportunities for application of a variety of nonstructural measures that are usually applied on a lot-by-lot basis. In practice, adjacent structures can have different nonstructural measures applied to accomplish project objectives. These measures can be applied as a suite of components that would most effectively reduce damages and threats to loss of life. In some areas of the coast, careful application of these measures could approximate the “100%” solution to flood damages and loss of life with minimal OMRR&R costs while providing ecosystem restoration benefits as well.

Of particular note in the table is the combinability of some of the measures that work in a symbiotic relationship. Such a relationship exists between the flood warning and emergency evacuation measures and floodproofing by elevation or other means. Considering the uncertainty and risks associated with habitation of an elevated structure during a hurricane surge/wave event that may surround the structure, the NS PDT would not recommend that anyone seek shelter within an elevated structure. Therefore, the flood warning and emergency evacuation system is a necessity for a nonstructural program featuring so many potentially elevated structures. Likewise having a reliable and timely warning system enables the safe use of structure elevation to maintain community structure. Likewise, although many structures may be relocated from their present high-hazard location, upgraded building codes can be applied to reconstruction of new housing to resist hurricane force winds.

Nonstructural measures can be divided into two groups for the purposes of combinability. Those measures that concern modification of private and public structures and associated facilities or the ownership of the land upon which they are located and those measures that concern regulation, taxation, fees and assessments and enforcement of regulations and codes that apply to the land. By Congressional action the Corps can be authorized to implement certain nonstructural measures that result in modification of buildings and facilities through contractual arrangements with the landowners to reduce damages and loss of life. However, as certain private and public rights and responsibilities have been conferred to the states by the Federal government and then subsequently passed down to local governments as police powers, the Corps is unable to implement or administer certain nonstructural measures described in Section 4.0. These ‘local measures” can be just as effective in reducing damages although the benefit stream may be more difficult to identify for formulation processes. It is possible to combine both measures implemented by the Corps and measures implemented by local jurisdictions on one parcel of land and realize the full benefit potential of their combination.

Table 13.
Pair-wise Comparison of Nonstructural Measures

Measures	FWEE	FM&Z	LLUR&Z	BC&E	FP	PRM ACQ	DIF	TDR or PDR	RELO
FWEE		Compatible	Compatible	Compatible	Compatible and required	Compatible for new housing wind damages	Compatible	Not Compatible	Not Compatible
FM&Z	Compatible		Compatible	Compatible	Compatible	Not Compatible	Compatible	Not Compatible	Not Compatible
LLUR&Z	Compatible	Compatible		Compatible	Compatible	Not Compatible	Compatible	Compatible	Compatible
BC&E	Compatible	Compatible	Compatible		Compatible	Not Compatible	Compatible	Not Compatible	Compatible
FP	Compatible and required	Compatible	Compatible	Compatible		Not Compatible	Compatible	Not Compatible	Not compatible unless relocated structure is FP
PRM ACQ	Compatible for new housing (wind damages)	Not Compatible	Not Compatible	Not Compatible	Not Compatible		Not Compatible	Not compatible, but vacant land may be in PDR/TDR	Not Compatible
DIF	Compatible	Compatible	Compatible	Compatible	Compatible	Not Compatible		Not Compatible	Not Compatible
TDR or PDR	Compatible, wind related	Not Compatible	Not Compatible	Not Compatible	Not Compatible	Not compatible, but vacant land may be in TDR/PDR	Not Compatible		Not Compatible
RELO	Compatible, wind related	Not Compatible	Compatible	Compatible	Not compatible unless relocated structure is FP	Not Compatible	Not Compatible	Not Compatible	

FWEE = Hurricane/Storm Flood Warning and Emergency Evacuation
FM&Z = Floodplain Management and Zoning (NFIP)
RELO = Relocations of Public Buildings
LLUR&Z = Land Use Regulation and Zoning
BC&E = Building Codes and Enforcement
FP = Floodproofing by Elevation and other Means
PRM ACQ = Permanent Acquisition (a.k.a. HARP)
DIF = Development Impact Fees
TDR & PDR = Transfer and Purchase of Development Rights

Table 14 shows a listing of the various nonstructural measures identified above and whether the Corps of Engineers or another Federal agency (FEMA) or State or local governments would be the appropriate entity to implement the measure. This table also indicates by this division of responsibility the various combinations of measures that could be instituted as a joint effort by the Federal government and the State and local governments in the project area. Of particular interest is the measure "Hurricane Warning and Emergency Evacuation" which has components that can be implemented by both the Federal and non-Federal partners. In addition, although permanent acquisition and floodproofing would normally be Federal roles, local entities could implement these components either through FEMA's HMGP or as local initiatives financed through state resources.

Table 14.
Nonstructural Measures by Responsible Entity.

Responsible Entity	Federal Government	State and Local Governments
Measures		
Hurricane Warning and Emergency Evacuation	X	X
Floodplain Management and Zoning (NFIP)		X
Local Land Use Regulation and Zoning		X
Building Codes and Enforcement		X
Floodproofing	X	
Permanent Acquisition	X	X
Development Impact Fees		X
Transfer or Purchase of Development Rights		X
Relocation of Public Buildings	X	

As these tables show, there are numerous individual measures that could be applied across the project area that would be effective to a certain degree in reducing damages and saving lives. As effective as some single nonstructural measures can be (i.e. just permanent acquisition or just floodproofing or just zoning) in reducing damages and loss of life, they would be applied on the notion of "one size fits all" and could fail to address longer term problems or result in unintended impacts. On the other hand, combinations of these measures have the potential for addressing not only damages that could be expected to occur in the short term (existing development) but long term potential damages that would occur due to different levels and types of future development. Combinations of measures can also be more "tailored" to the specific conditions at each neighborhood or community thus reducing anticipated socio-economic impacts.

The formulation process will address both single-measure plans and combined measures plans to determine the full range of possible nonstructural protection scenarios. As is the case with structural measures, differing levels of protection can be addressed by nonstructural measures by adjusting the measure's response to inundation depths (i.e. floodproofing versus acquisition) or modifying the spatial coverage by each measure.

Since this appendix is accompanying a "Comprehensive Plan" that addresses the entire project area, nonstructural plans that could be tailored to a single community (i.e. Pascagoula) or a single planning unit (i.e. Harrison County) are not included in this formulation as they are scaled-down, more detailed plans of the more comprehensive alternatives described below. More detailed planning documents or implementation plans, formulated in collaboration with local jurisdictions would be needed address specific communities should construction authorization be provided.

6.7 Nonstructural Plans

6.7.1 Single-Measure Nonstructural Plans

Of the identified measures, eight measures could be applied singularly to meet one or a number of the planning objectives. The principals among those singular measures are:

- Permanent acquisition – High Hazard Area Risk Reduction Plan (HARP)
- Floodproofing by elevation or other methods (dry and wet)
- Relocations of Public Buildings
- Floodplain zoning and ordinance enforcement
- Upgrading and enforcement of existing building codes
- Land use regulations and zoning
- Flood Preparedness and Public Education
- PDR and TDR

Each of these measures implemented as a singular measure across the project area is able to reduce the incidence of flood damages and reduce the threats to life from storms and hurricanes. However, many of them, implemented as a single measure are unable to reduce all of the potential for future flood damages or loss of life along the coast. The closest single solution would be permanent acquisition of all structures damaged by Katrina or a specific subset of that population, but without significant changes to State laws and the economic base of the area, permanent acquisition cannot address all of the damages or threats to life either as described below. In addition, the social and economic impacts of a compete buyout of the project area are unacceptable to the population.

For the purposes of inter-agency and public recognition, the single-measure nonstructural plans have been designated with a two-letter prefix “NS” and all combined measure plans are designated with the prefix “NSC” (**N**on **S**tructural **C**ombined). The suffixes “HHZ” and “PA100” used for the single measure plans refer to “**H**igh **H**azard **Z**one” and “**P**ermanent **A**cquisition in the **100**-year flood zone” (a delineated zone in the flood insurance rate maps). Both numbers and letters (letters are used to designate scales of surge inundation in plans NSC-1 and NSC-6) are used to further differentiate the plans with the prefix NSC.

6.7.1.1 Permanent Acquisition – Katrina Level of Protection

A single-measure plan, featuring the permanent acquisition of all structures and facilities found to be eligible for the nonstructural program literally removes every structure and facility within the proscribed level of inundation across the entire coast. This measure could be implemented as a flood damage reduction program component. Application of a very high level of protection (i.e. Katrina level) would be very effective in reducing flood damages and threats to life from surge and waves generated by storms and hurricanes. In all, approximately 74,000 parcels of land would be purchased at an approximate cost of $17.0 billion (using an average cost per structure based upon RE estimates of nonstructural acquisitions). Although effective, acquisition of all eligible properties across the project area would be expensive when compared to other effective alternatives and would result in catastrophic consequences for the socio-economic fabric of the three counties and 11 municipal areas. Also, it has been determined that certain structures and facilities closely associated with the Gulf (ship-building, power plants, energy resource exploration and production) or locked to a location by State law (casinos) cannot be moved from their high-hazard location. For these reasons, a singular plan featuring permanent acquisition at a high level of protection (Katrina inundation or higher) should not be carried forward. However, permanent acquisition as a single measure for more

modest levels of protection (1% annual chance event) or for specific high-hazard zones may be acceptable and cost effective (see Plans below).

Obviously, both of the following permanent acquisition plans would have to be closely coordinated with FEMA and HUD disaster-assistance programs currently being administered in the project area. Opportunities for landowners to "double-dip" into Federal funds would be carefully scrutinized by the agencies through sharing of databases on program participants. Initial coordination of the various programs between USACE, FEMA and HUD was undertaken prior to completion of this appendix.

6.7.1.1.1 Plan NS-PAHHZ - Permanent Acquisition of the High-Hazard Zone

Permanent acquisition of structures and property within the high-hazard zones identified in this appendix would significantly reduce damages and potential loss of life in this hazardous area. Approximately 14,900 parcels of land (including approximately 7,500 structures) are located in the high-hazard zones that could be acquired. Field observations indicated a substantial number of properties without structures (vacant parcels) in the high-hazard zones following Katrina. The proposed initial phase of the HARP may be able, if authorized and funded, to acquire a substantial number of the vacant parcels before new structures are rebuilt at an overall cost savings to the program. However, this alternative does not contemplate that many properties would be vacant when this plan is implemented. In view of the future-without-project condition predictions of redevelopment along the coast, this alternative assumes that a substantial number if not all properties would be rebuilt upon by the time the normal project implementation process begins to acquire parcels. The costs of this plan (acquisition, relocations assistance and demolitions) therefore are based upon structures being present on the parcels when the plan is implemented.

Approximately 57,000 acres of land could be acquired in the high-hazard zone. The vacated property could be used for ecosystem restoration of wetland habitat, passive recreation uses that are consistent with the identified flood hazard or just maintained as open space for passive public uses. Of the total acres that could be purchased in this zone, approximately 4,000 acres of land have been determined to be suitable for ecosystem restoration as wetlands.

For eligible residents displaced by the acquisition process, sufficient financial resources would be made available through application of the Uniform Relocations Act so that suitable replacement DSS housing could be secured for eligible households in this area. The estimated cost for real estate acquisition, relocations assistance and structure demolition for this alternative is $5.9B. This plan is identified as Plan NS–PAHHZ. The numbers of parcels to be acquired by reach and the costs are shown in Table 15. The high-hazard acquisition areas are displayed on Figures 58 through 62.

In addition to the cost of the real estate acquisition, relocations assistance and structure demolition associated with this alternative, the large number of displaced households may trigger the need for replacement DSS housing over and above what normal market resources could provide. Based upon current housing construction capacity in the project area, as much as 40 percent of the need may be unmet by the market area (based upon current levels of housing construction permits). In view of this anticipated shortage of suitable DSS housing, the plan would include several redevelopment sites (at least one in each county) that would hold approximately 3,000 residential lots. Lot sizes would vary within the redevelopment sites but would be no less than quarter-acre in size. At an average cost of $45,000 per lot for site acquisition, site development, infrastructure and site amenities, the total cost of these redevelopment sites would be approximately $135.0M

This alternative could be supplemented by the addition of either the TDR or PDR program to address redevelopment of property that was vacant prior to the destruction wrought by Katrina. As this vacant property within the high-hazard zone was probably encumbered in some way so as to hinder development, either the TDR or PDR program could be applied to restrict any future

development that would be subject to inundation damages. Development right values would be established through comparison of tax assessments for the “with” and “without” development scenarios. Either of the two programs would be administered as a joint effort by the counties and municipalities with an estimated start-up cost of $1.5M. Annual costs for the TDR program would be local and minimal administrative expenditures while the PDR annual costs could be supplied by the state and local jurisdictions and would reflect a percentage of the total assessed value of those properties.

The High Hazard Area Risk Reduction Plan (HARP) could be an initial component of this alternative whereby the highest-risk properties that were vacated (structures demolished) by Katrina and not as yet rebuilt upon could be acquired at a fraction of the cost that would be required once a new structure is rebuilt. Avoiding the costs of acquiring a new structure, relocations assistance (for relocating a household to a DSS replacement house) and demolition of the existing home would significantly reduce the overall program cost and assure that families would not be re-entering a high-hazard area. The estimated cost of the initial HARP program is $397.0 M and would affect approximately 2,000 parcels. Those 2,000 initial acquisitions would be extracted from the designated high-hazard zone (approximately 7,400 total vacant parcels in the HHZ) extending the east-west length of the project area. Figures 52, 53 and 54 show areas with potential for restoration of high quality wetland ecosystems that are within that acquisition footprint.

Table 15 – Plan NS-PAHHZ
Permanent Acquisition in the High-Hazard Zones

Economic Reach	County	Parcels for Acquisition	Cost
1	Hancock	0	0
2	Hancock	1056	$459,548,812
3	Hancock	2099	$851,631,850
4	Hancock	823	$202,919,893
5	Hancock	971	$107,653,678
6	Hancock	210	$114,862,969
7	Hancock	125	$9,562,216
8	Harrison	1565	$431,782,512
9	Harrison	5	$6,652,740
10	Harrison	1695	$736,216,496
11	Harrison	0	0
12	Harrison	450	$138,318,777
13	Harrison	595	$821,785,431
14	Harrison	0	0
15	Harrison	66	$88,566,796
16	Harrison	36	$14,594,008
17	Harrison	0	0
18	Harrison	285	$608,152,730
19	Harrison	12	$17,246,403
20	Harrison	1150	$316,031,090
21	Jackson	2082	$695,355,710
22	Jackson	62	$39,368,916
23	Jackson	0	0
24	Jackson	138	$45,373,108
25	Jackson	0	0
26	Jackson	31	$11,221,913
27	Jackson	37	$5,996,209
28	Jackson	583	$10,167,976
29	Jackson	132	$14,287,454
30	Jackson	81	$24,818,841

Economic Reach	County	Parcels for Acquisition	Cost
31	Jackson	37	$9,281,900
32	Jackson	0	0
33	Jackson	0	0
34	Jackson	0	0
35	Jackson	0	0
36	Hancock	0	0
37	Hancock	0	0
38	Hancock	0	0
39	Harrison	0	0
40	Harrison	0	0
41	Jackson	0	0
42	Jackson	0	0
43	Jackson	0	0
44	Jackson	0	0
45	Jackson	0	0
46	Jackson	0	0
47	Harrison	0	0
48	Harrison	0	0
49	Harrison	0	0
50	Harrison	96	$24,190,783
51	Jackson	0	0
52	Jackson	275	$68,789,089
53	Jackson	300	$46,723,811
54	Jackson	0	0
Subtotals		14,997	$5,921,102,106
H&CD sites	Jackson, Harrison, Hancock	3,000 constructed lots	$135,000,000
Total cost			**$6,056,102,106**

1

Based upon the county assessors data and the future without project conditions scenarios, there could be as many as 14,997 structures located on the HHZ parcels by 2012. Costs for acquisition, relocations assistance and structure demolitions are included in the total cost.

Figure 58 – Plan NS- PAHHZ – Permanent Acquisition in HHZ (A1)

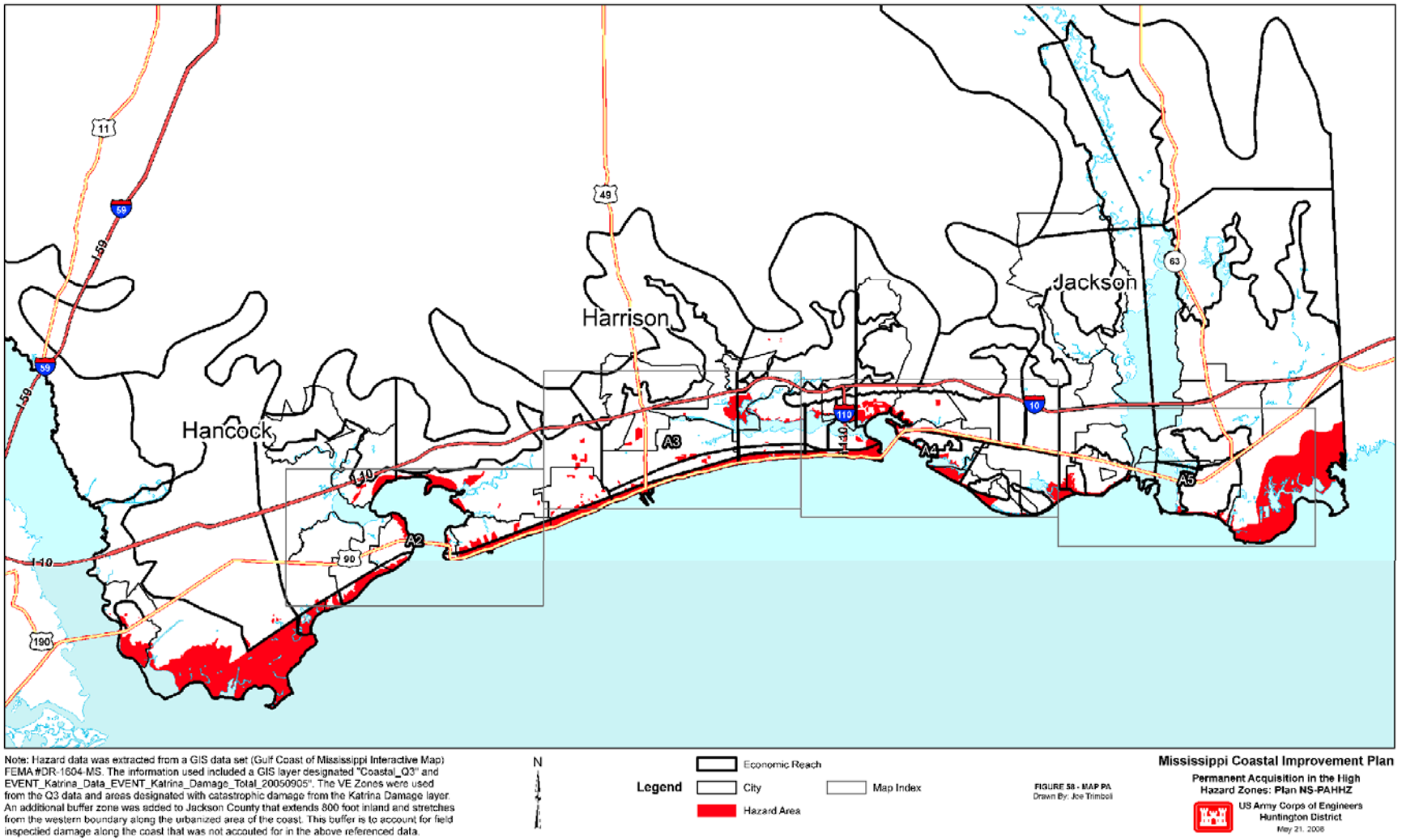


Figure 59 – Plan NS- PAHHZ Permanent Acquisition in HHZ (A2)

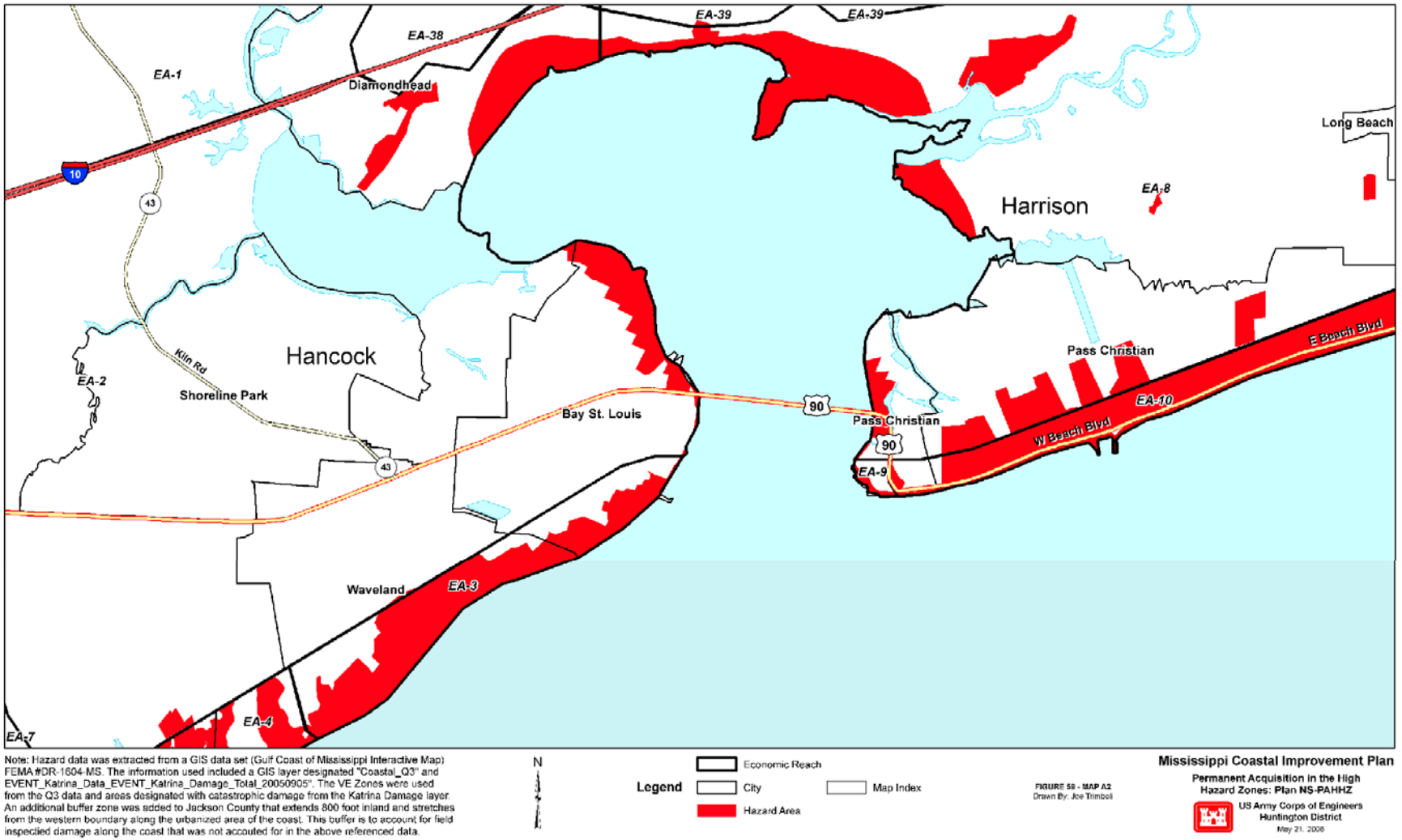


Figure 60 – Plan NS – PAHHZ Permanent Acquisition in HHZ (A3)

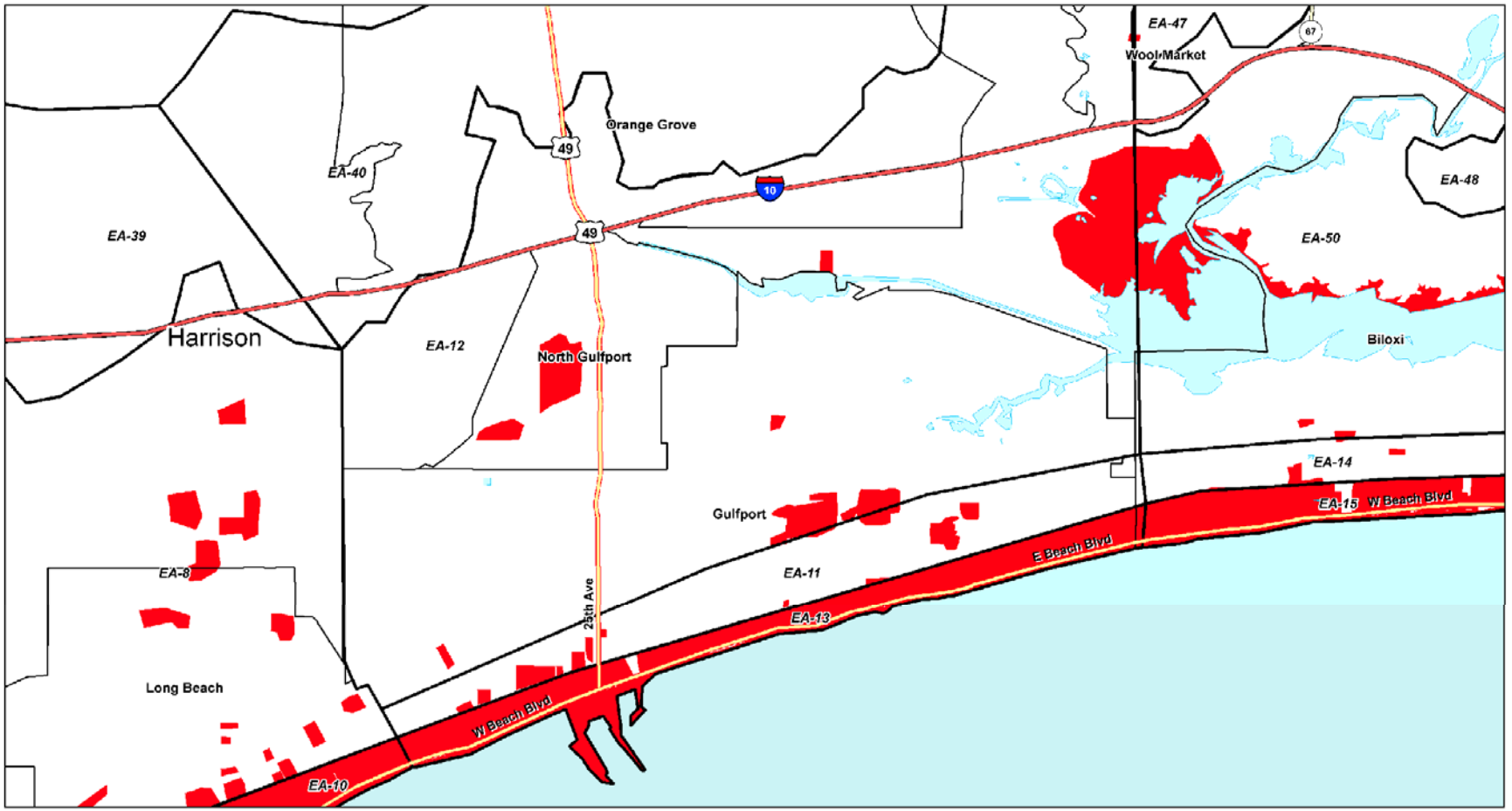


Figure 61 – Plan NS- PAHHZ Permanent Acquisition in HHZ (A4)

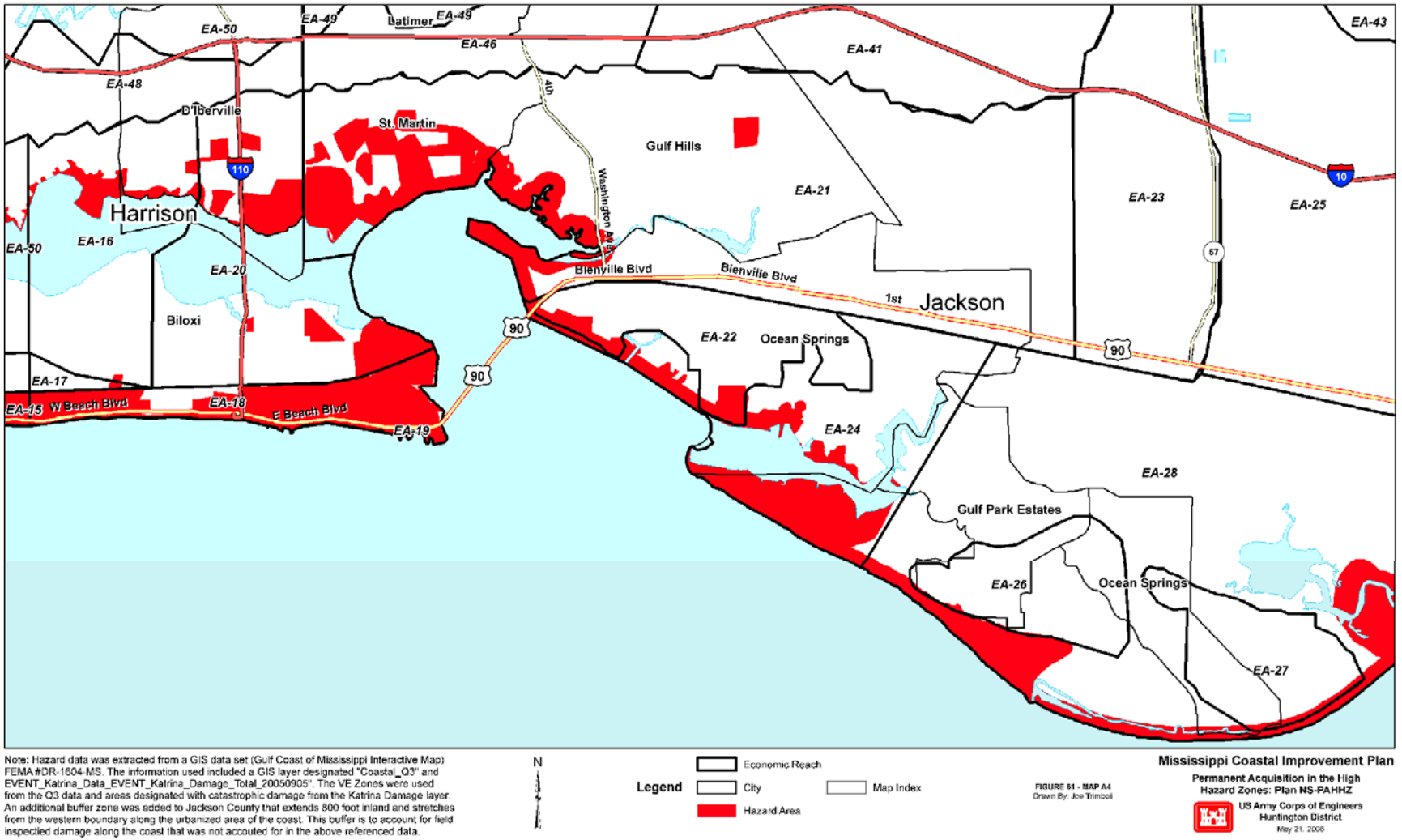
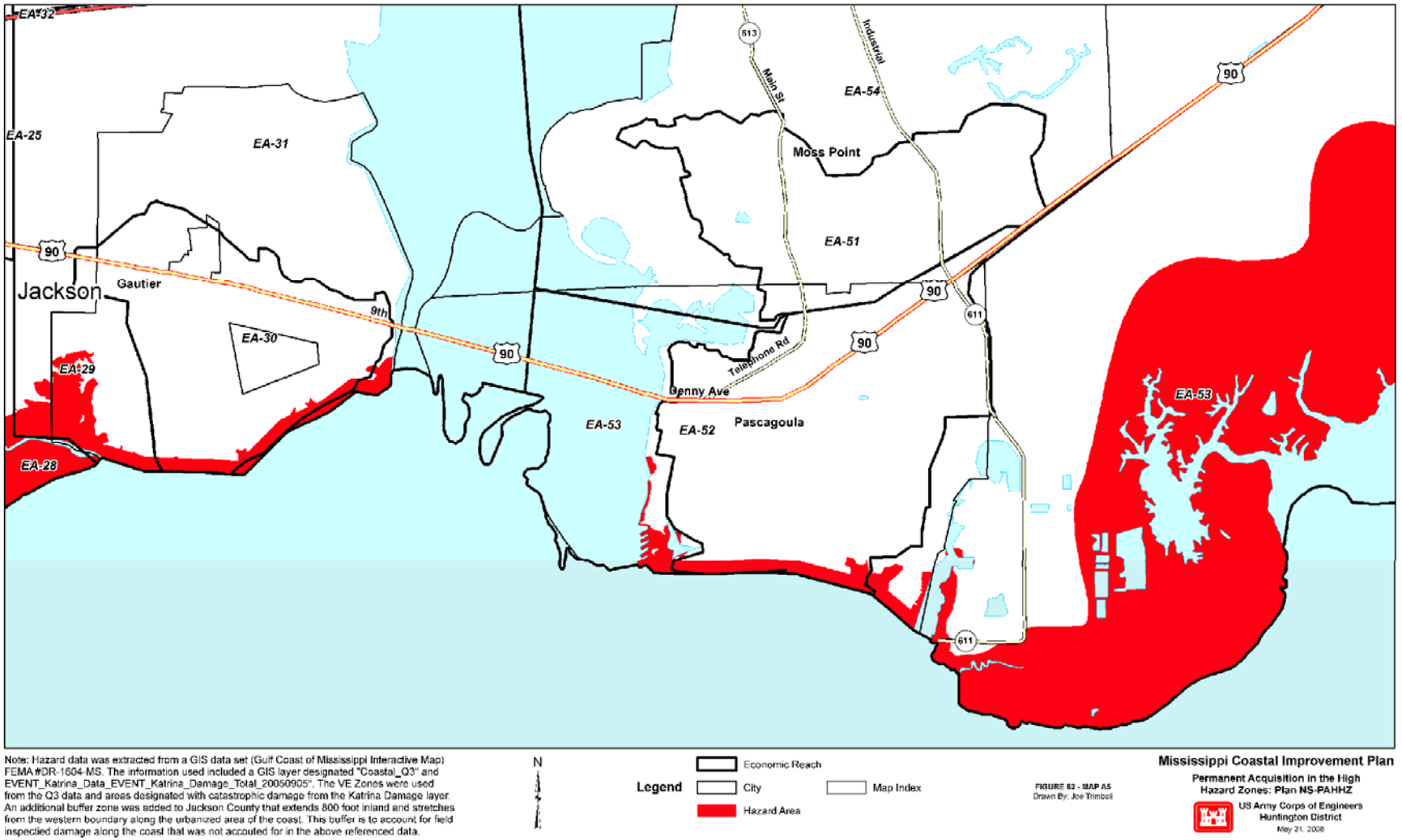


Figure 62 – Plan NS- PAHHZ Permanent Acquisition in HHZ (A5)



6.7.1.1.2 Plan NS-PA100 - Permanent Acquisition within the One Percent Annual Chance Floodplain

Permanent acquisition of structures and property within the FEMA-designated 1% annual chance floodplain (as amended by the adoption of the ABFE's by the communities) that are located within the high-hazard zones and in areas where water depths exceeded 13 feet would significantly reduce future flood damages and threats to life by storms and hurricanes. Approximately 33,200 parcels of land (approximately 17,100 structures) are located within these two areas that could be purchased. Field observations indicated a large number of vacant parcels within the high-hazard zone. This plan contemplates that most of not all of the parcels originally made vacant by Katrina would be redeveloped by the time this acquisition option was implemented as described in the future without-project condition. Therefore the cost of the plan (acquisition, relocations assistance and demolitions) reflects structures and families in place when the plan would be implemented.

Approximately 57,000 acres could be purchased in the high-hazard zones. Of that total, approximately 4,000 acres have been determined to be suitable for ecosystem restoration of wetlands. An additional 37,000 acres of land could be purchased within the area where water depths exceeded 13 feet. Of that total acres approximately 5,200 acres of land has been determined to be suitable for ecosystem restoration as wetlands. In total over 9,000 acres of wetlands could be restored as a result of the purchase and restoration of these hazard zones.

For eligible residents displaced by the acquisition process, application of the Uniform Relocations Act so that suitable replacement DSS housing could be secured for each eligible household in this buyout area. The vacated property could be used for ecosystem restoration of wetland habitat, passive recreation consistent with the flood hazard or just maintained as open space for public uses. The estimated cost of land and structure acquisition for this alternative is $7.9B. This plan is identified as Plan NS-PA100. The numbers of parcels to be acquired by reach and the costs are shown in Table 16. The acquisition areas within the 1% annual chance area (as amended by the adoption of the ABFE by the communities) are shown in Figures 63 through 67.

In addition to the cost of the real estate acquisition, relocations assistance and structure demolition associated with this alternative, the large number of displaced households would probably trigger the need for replacement DSS housing over and above what normal market resources could provide. Based upon current housing construction capacity in the project area, as much as 40 percent of the need may be unmet by the market area. In view of this anticipated shortage of suitable DSS housing, the plan would include several redevelopment sites (at least one in each county) that would hold approximately 6,000 residential lots. Lot sizes would vary within the redevelopment sites but would be no less than quarter-acre in size. At an average cost of $45,000 per lot for site acquisition, site development, infrastructure and site amenities, the total cost of these redevelopment sites would be approximately $270.0M. Added to the total land acquisition figure above, the total plan cost would be $8.2B.

This alternative could be supplemented by the addition of either the TDR or PDR program to address redevelopment of property that was vacant prior to the destruction wrought by Katrina. As this vacant property within the high-hazard zone was probably encumbered in some way so as to hinder development, either the TDR or PDR program could be applied to restrict any future development that would be subject to inundation damages. Development right values would be established through comparison of tax assessments for the "with" and "without" development scenarios. Either of the two programs would be administered as a joint effort by the counties and municipalities with an estimated start-up cost of $1.5M. Annual costs for the TDR program would be local and minimal administrative expenditures while the PDR annual costs could be supplied by the

state and local jurisdictions and would reflect a percentage of the total assessed value of those properties.

The High Hazard Area Risk Reduction Plan (HARP) could be an initial component of this alternative whereby the highest-risk properties that were vacated (structures demolished) by Katrina and not as yet rebuilt upon could be acquired at a fraction of the cost that would be required once a new structure is rebuilt. Avoiding the costs of acquiring a new structure, relocations assistance (for relocating a household to a DSS replacement house) and demolition of the existing home would significantly reduce the overall program cost and assure that families would not be re-entering a high-hazard area. The estimated cost of the initial HARP program is $397.0 M and would affect approximately 2,000 parcels. Those initial 2,000 parcels would be extracted out of the high hazard zone footprint that extends the entire east-west length of the project area. Exhibits 52, 53 and 54 show the potential high-quality wetland ecosystem restoration areas where the HARP acquisitions may occur.

Table 16 – Plan NA-PA100
Permanent Acquisition within the 1% Annual Chance Zone (ABFE-2 feet)

Economic Reach	County	Parcels for Acquisition	Cost
1	Hancock	997	$194,118,218
2	Hancock	9911	$2,990,789,131
3	Hancock	2202	$668,691,437
4	Hancock	922	$120,307,916
5	Hancock	2714	$238,362,794
6	Hancock	567	$107,292,775
7	Hancock	450	$33,210,174
8	Harrison	3623	$476,088,333
9	Harrison	44	$16,132,783
10	Harrison	1945	$432,581,234
11	Harrison	0	$0
12	Harrison	1047	$179,614,825
13	Harrison	650	$583,121,543
14	Harrison	0	$0
15	Harrison	85	$44,354,843
16	Harrison	78	$16,399,728
17	Harrison	0	$0
18	Harrison	1502	$409,411,532
19	Harrison	46	$292,728,063
20	Harrison	1397	$238,433,082
21	Jackson	2108	$301,798,272
22	Jackson	61	$26,330,663
23	Jackson	0	$0
24	Jackson	220	$65,229,820
25	Jackson	0	$0
26	Jackson	37	$9,210,336
27	Jackson	53	$12,880,944
28	Jackson	961	$90,294,697
29	Jackson	147	$23,394,829
30	Jackson	90	$29,459,003
31	Jackson	51	$14,946,829

Economic Reach	County	Parcels for Acquisition	Cost
32	Jackson	1	$216,228
33	Jackson	0	$0
34	Jackson	0	$0
35	Jackson	12	$682,228
36	Hancock	32	$3,834,485
37	Hancock	0	$0
38	Hancock	50	$21,424,866
39	Harrison	0	$0
40	Harrison	0	$0
41	Jackson	0	$0
42	Jackson	0	$0
43	Jackson	0	$0
44	Jackson	0	$0
45	Jackson	0	$0
46	Jackson	0	$0
47	Harrison	0	$0
48	Harrison	0	$0
49	Harrison	0	$0
50	Harrison	495	$89,247,661
51	Jackson	0	$0
52	Harrison	285	$102,951,211
53	Harrison	399	$113,015,335
54	Jackson	9	$1,114,862
Subtotals		33,191*	$7,947,670,680
H&CD Sites	Jackson, Harrison, Hancock	6,000 constructed lots	$270,000,000
Total Cost			**$8,217,670,680**

* This parcel total (33,191) includes 17,144 structures anticipated to be redeveloped by 2012 in the future-without-project condition - this anticipated condition is reflected in the total cost.

Figure 63 – Plan NS - PA100 Permanent Acquisition in 1% Annual Chance Flood Zone (A1)

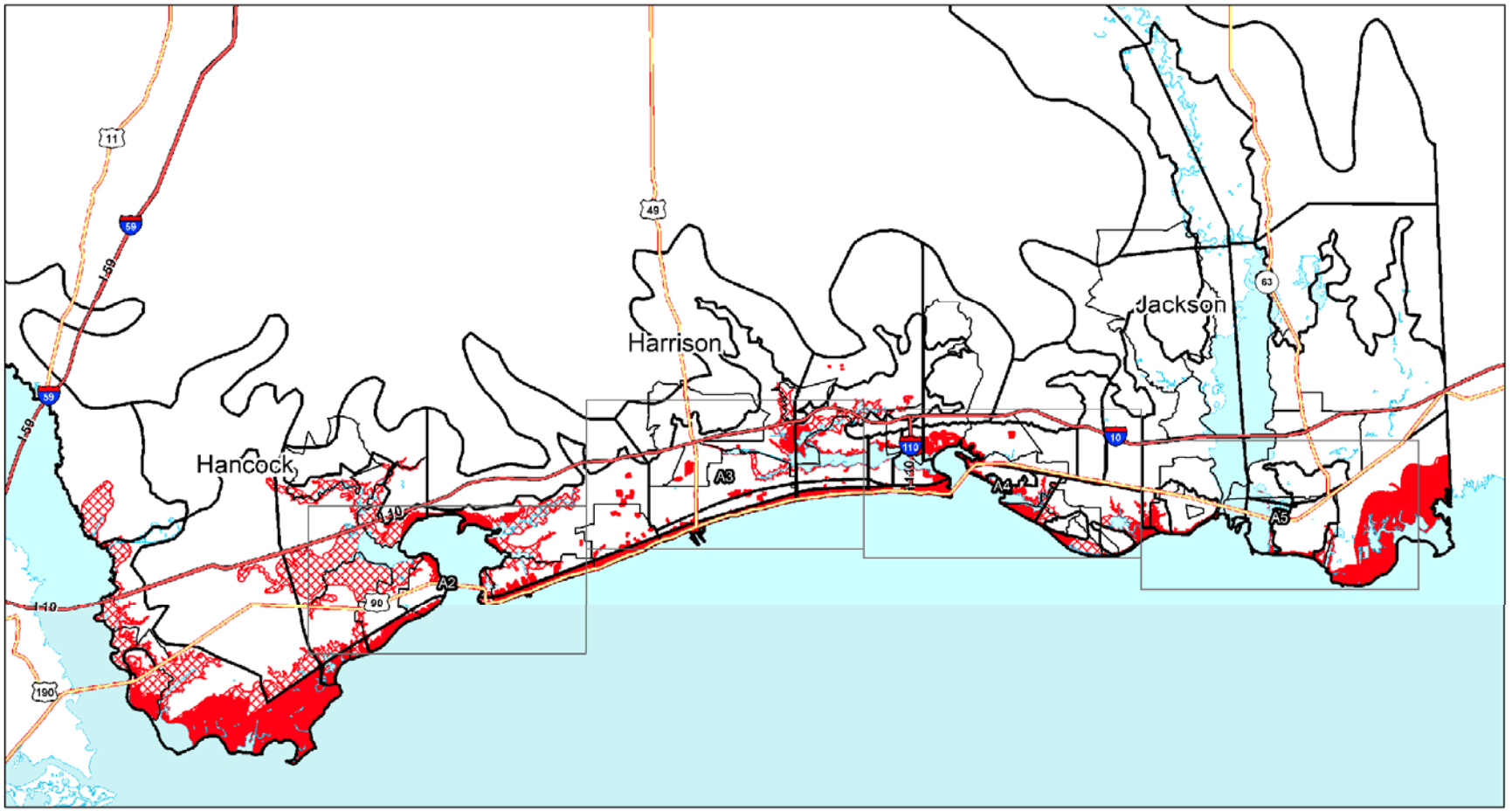


Figure 64 – Plan NS- PA100 Permanent Acquisition in 1% Annual Chance Flood Zone (A2)

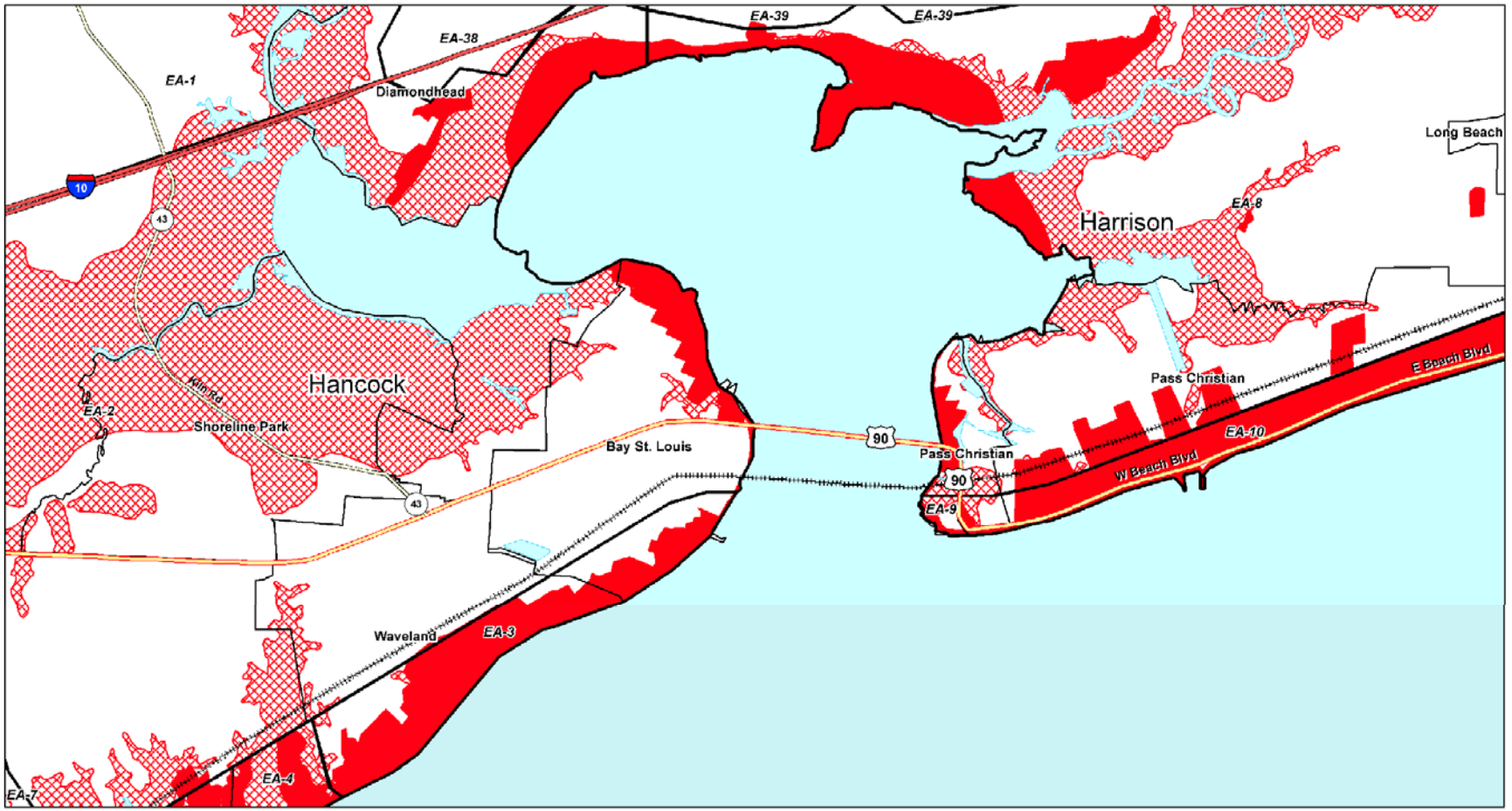


Figure 65 – Plan NS – PA100 Permanent Acquisition in 1% Annual Chance Flood Zone (A3)

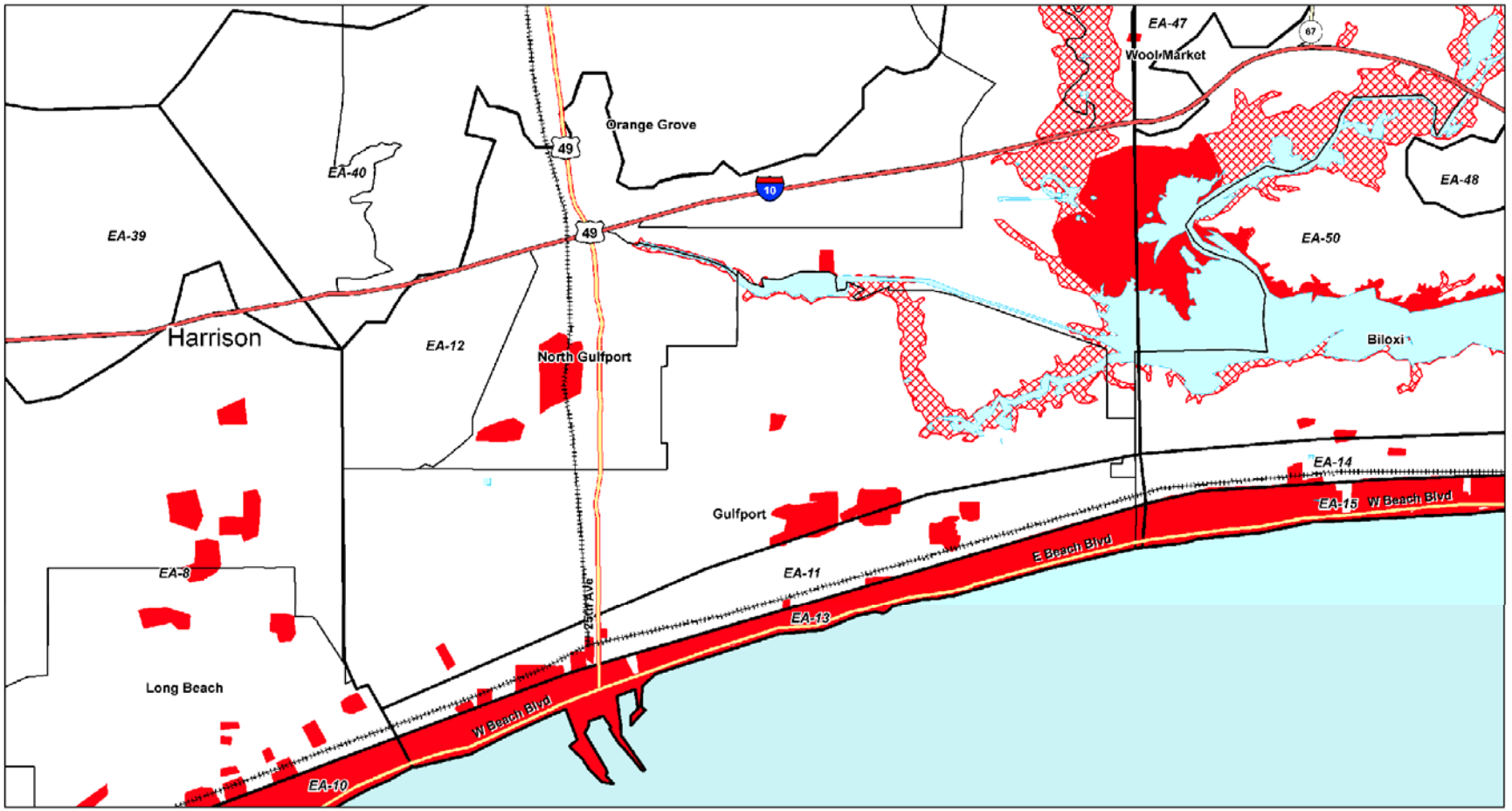
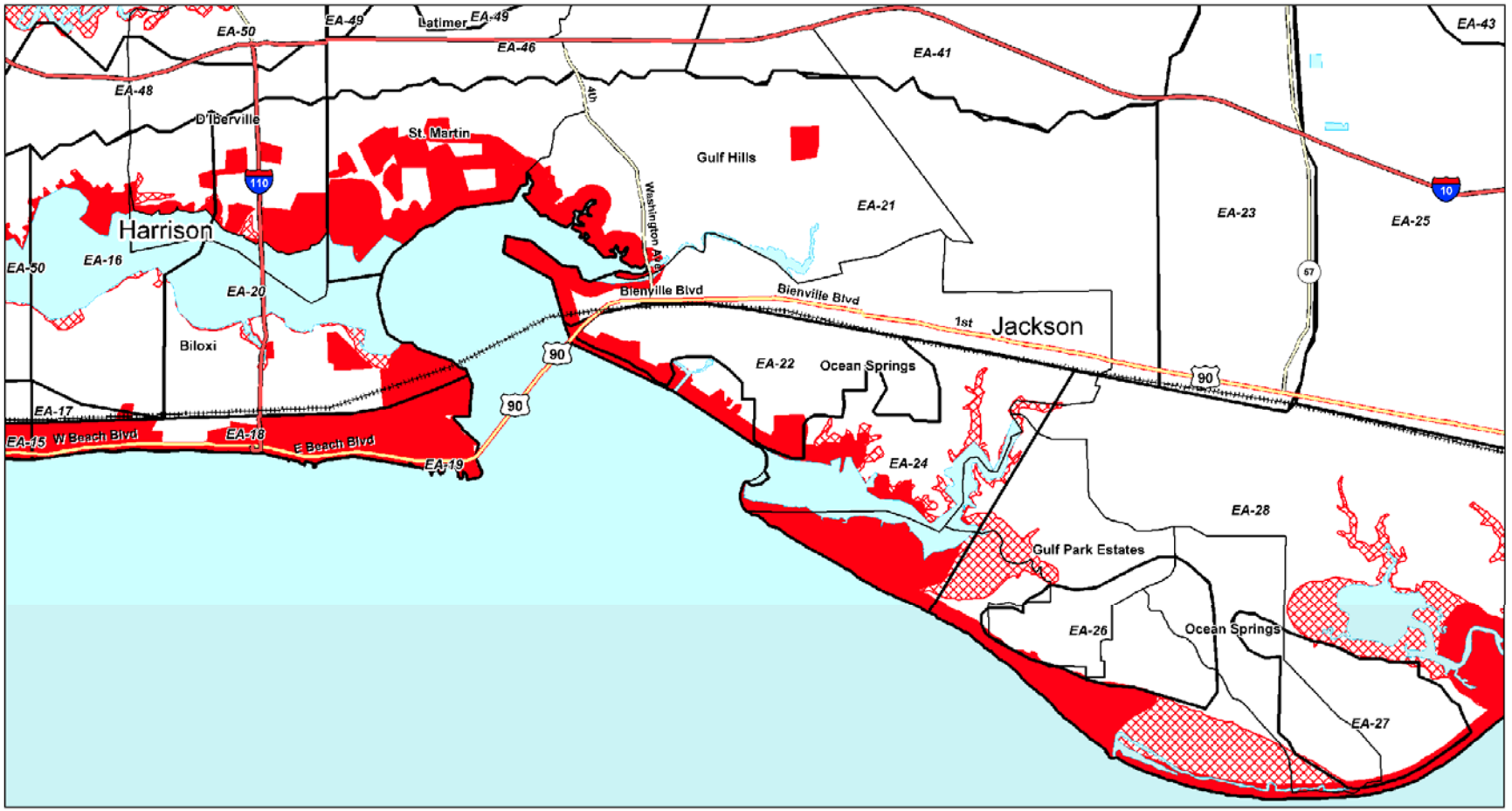
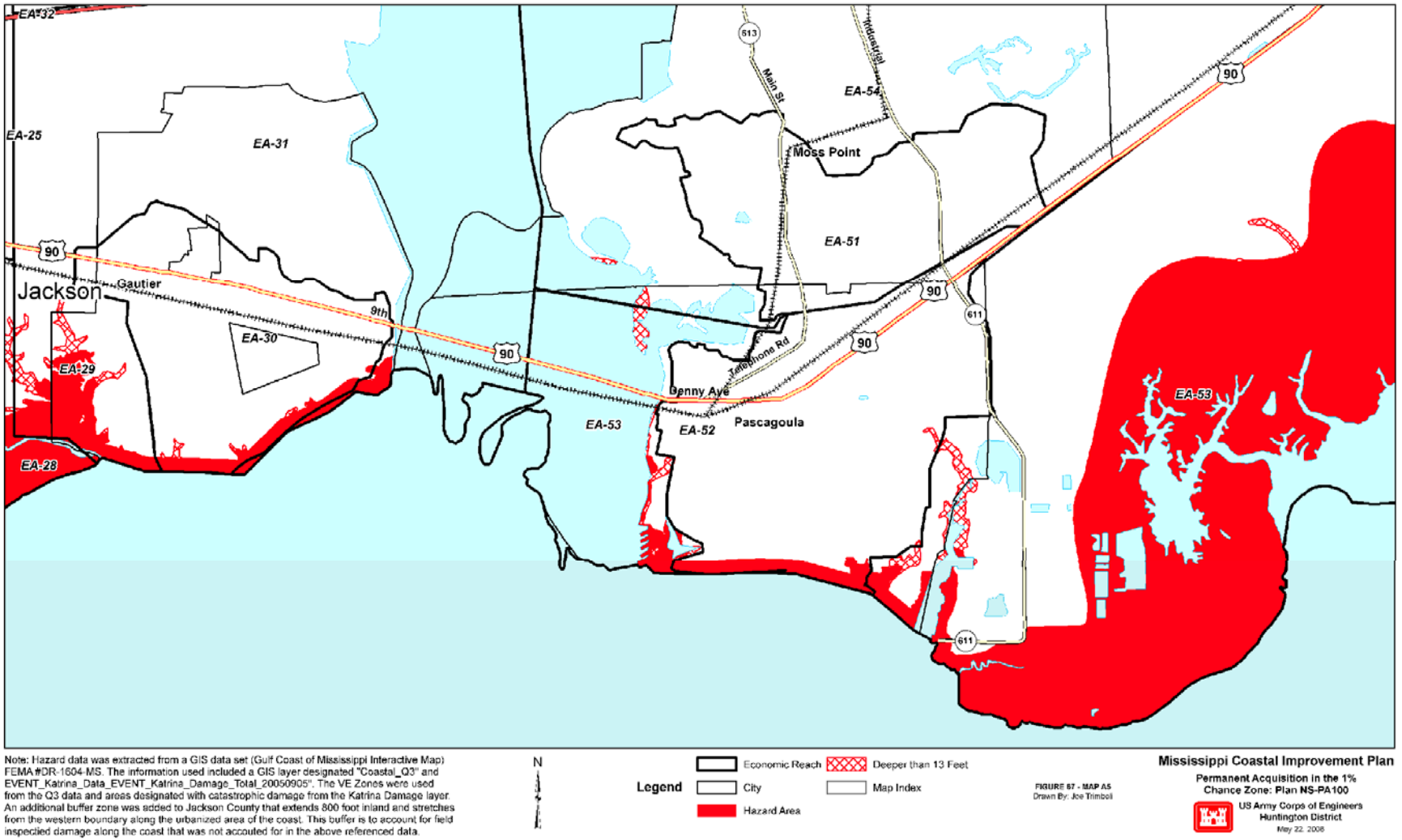


Figure 66 – Plan NS-PA100 Permanent Acquisition in 1% Annual Chance Flood Zone (A4)



Note: Hazard data was extracted from a GIS data set (Gulf Coast of Mississippi Interactive Map) FEMA #DR-1604-MS. The information used included a GIS layer designated "Coastal_Q3" and EVENT_Katrina_Data_EVENT_Katrina_Damage_Total_20050905". The VE Zones were used from the Q3 data and areas designated with catastrophic damage from the Katrina Damage layer. An additional buffer zone was added to Jackson County that extends 800 foot inland and stretches from the western boundary along the urbanized area of the coast. This buffer is to account for field inspected damage along the coast that was not accouted for in the above referenced data.

Figure 67 – Plan NS- PA100 Permanent Acquisition in 1% Annual Chance Flood Zone (A5)



6.7.1.2 Floodproofing

A single-measure plan, featuring floodproofing activities and using both dry and wet floodproofing techniques including ringwalls, ring-levees, elevation and veneer walls would significantly reduce flood damages in the project area. This measure could be implemented by the Federal government as a component of the flood damage reduction program. Unfortunately, because of the restrictions of height for elevation (15 feet maximum height of raise), excessive depths of inundation where veneer walls are impractical and unsafe and limited space for constructing ringwalls and ring-levees on small urban lots, a single measure featuring floodproofing would not address many of the structures and facilities at risk. In addition, although there are many parcels located within the project area where the combination of surge and waves would not be a limiting factor, many thousands of parcels are located in high-hazard surge and wave zones where floodproofing in any manner for certain types of structures would be dangerous.

Also, implementing a single-measure floodproofing plan without adding improvements to the existing flood warning and emergency evacuation system could result in many structure owners deciding to "ride-out" a hurricane that could seriously endanger not only their lives but the lives of rescue personnel. This single measure plan would address approximately 25,400 parcels of land in the project area and would cost approximately $10.8B. Based upon the limitations of floodproofing due to inundation depths, surge and wave dangers, and spatial constraints and the necessity of adding all proposed upgrades to the existing flood warning and emergency evacuation plan, a single measure plan featuring floodproofing should not be carried forward. Floodproofing has been included as an effective measure in some of the combined-measure plans described below.

6.7.1.3 Relocations

A single-measure plan, featuring the relocation of public buildings would be effective in protection of many of the critical facilities located in the project area. Since these structures and the services they provide (i.e. police, fire, city administration, emergency management, education, etc.) are considered critical to the everyday life and security of the communities that they serve, protection of them by either floodproofing in-place (see above) or relocation to a flood-safe site is a significant component of any protection plan. Data from FEMA's HAZUS program and local tax assessments indicates that at least 75 buildings and facilities in the project area are considered to be "critical facilities". Of those, many are publicly-owned and operated. A total of 49 were found to be attached to identified parcels within the project database. Of those, 7 would be eligible for a relocations program and the balance would be eligible for some form of protection (floodproofing) in place. Based upon preliminary information on the types and uses of those structures and their approximate locations, the cost of relocating the 7 structures would be approximately $51.3M. Although this component would be an effective method of addressing damages to these important facilities, relocations accomplished in accordance with Appendix Q of EFARS does not address the other privately-owned facilities considered to be critical (privately owned schools, medical facilities, etc.) or the vast numbers of residential and commercial structures that are also at risk from inundation. Therefore, relocations of public facilities as a single measure plan would not be an effective alternative by itself. Relocations of public structures as a means of reducing damages are included in some of the combined plans described below.

6.7.1.4 Floodplain Zoning/Floodplain Management Ordinances

A single-measure plan, featuring floodplain zoning and floodplain management ordinance enforcement could be very effective in many locations within the project area. Implemented by the 11 municipalities and 3 counties in the project area, these measures would affect approximately 74,000 separate parcels of land (exceptions being military bases and installations). This measure

would be implemented solely by the local governments with technical input from FEMA. Estimated cost for applying this measure across all parcels is approximately $280,000. Although the combination of these two activities seldom is effective in reducing damages to existing structures and reducing threats to life because of the existence of “grandfathered” development, the number of empty lots across the project area that would be subject to more stringent zoning and ordinances that dictate development makes this singular measure palatable and effective. Current floodplain zoning based upon previous ordinances could be replaced with more stringent ordinance requirements and floodplain mapping based upon updated Digital Flood Insurance Rate Maps (DFIRM’s) being prepared by FEMA. As the municipalities and counties adopt and enforce more stringent regulations based upon updated mapping, potential damages and losses of life from future storms and hurricanes to new development would be lessened significantly.

Ironically, a significant number of structures and facilities did survive Katrina’s onslaught with rather minor damages; damages that would not trigger all of the new requirements for elevating structures above the modified BFE or result in any significant improvements in the structure to resist storm damages. However, of the many modifications to the NFIP that could be instituted, instituting cumulative storm-related damages over a period of years (that period to be determined locally) as the trigger for requiring compliance with NFIP regulations and local floodplain management ordinances is worthy of consideration. In fact the City of Pascagoula already has instituted this procedure as a part of their local floodplain ordinance administration. Outside of the ordinance requirements under the NFIP there are few incentives to retrofit existing structures or adhere to upgraded building codes if new requirements are not strictly enforced locally. For this reason, floodplain zoning and floodplain management ordinance enforcement as a single measure plan should not be carried forward. However, both of these measures (upgraded zoning and ordinance enforcement) are used in combined plans described below.

6.7.1.5 Building Codes

A single-measure plan, featuring updated building codes based upon new versions of the IBC and the FEMA 550 guidelines could substantially reduce storm damages to new construction in those areas where units were totally destroyed by Katrina. Implemented by the 11 municipalities and 3 counties these codes would affect over 74,000 parcels and existing or new structures. Other buildings (residential. commercial and institutional) damaged less severely by Katrina would be subject to these updated codes for repairs resulting in some reduction of future damages. Costs for upgrading and applying the buildings codes is negligible since the administration and enforcement of the building codes is supported by building construction permit fees.

However, as in the case of floodplain zoning and floodplain management ordinance enforcement, there are many structures and facilities that were only minimally damaged by Katrina and they would be largely unaffected by the new building codes and therefore still susceptible to flood damages. Although the institution of updated building codes and the FEMA 550 guidelines would reduce future damages to new construction and those structures requiring substantial repairs as a result of Katrina, as a single measure building codes do not address a sufficient number of the planning objectives to be carried forward. Instituting upgrades to the existing building codes and conducting educational seminars for those people in the design, construction, inspection, real estate and mortgaging professions who would be using the codes are included in some of the combined plans described below.

6.7.1.6 Land Use Regulation and Zoning

A single-measure plan, featuring modification and enforcement of new land use zoning by the local governments on areas inundated by Katrina (or any lesser area of inundation) could significantly

reduce damages and threats to life by inundation from storms and hurricanes. As described in Section 4.3.4, land use zoning applied through the police powers of counties and municipalities can direct the types and densities of development that occur in each regulated area. Owing to that fact that so many structures were totally destroyed by Katrina and that redevelopment of those areas has been largely delayed due to lack of rebuilding capital and updated floodplain mapping, it would be possible to modify existing zoning ordinances such that either redevelopment of high-hazard areas was severely restricted (restrictions that may trigger a taking and therefore be more like the permanent acquisition measure) or that redevelopment of high-hazard areas was permitted for only those uses that could afford to invest sufficient funds to provide the high levels of protection needed in that area.

Implementation of these zoning changes to the approximately 7,500 parcels contained within the high-hazard zones could dramatically reduce future damages during redevelopment. Rezoning all of the project area where the most severe damages occurred (total destruction of buildings and facilities) to open space or recreation park land (devoid of damageable structures) may result in a determination that such a diminution of property value and use by private owners would constitute a taking and require full compensation of its market value. In effect, that result would be much like the single measure of permanent acquisition described above.

On the other hand, rezoning of those same areas that would permit mixed-use development featuring high-density commercial (casinos and malls) and high-density residential (condominiums) in structures elevated above pre-determined inundation levels could provide numerous local benefits and meet several of the planning objectives. Such mixed-use high density zoning along the beachfront area could encourage high-end developers to invest the required resources needed to create multi-story structures perched upon layers of parking garages that would be able to withstand the rigors of future storms and hurricanes. An example of this type of zoning is the present location of the Beau Rivage casino and hotel complex at Biloxi, MS. That sturdily-constructed complex weathered the Katrina storm with relatively minor damages compared to other beachfront structures.

This rezoning concept would confer great value on beachfront property that in a post-Katrina market has far less value in the hands of single-family homeowners, would potentially create additional jobs and tax revenues through construction and operation of the mixed use development, could generate additional tourism along the coast, and could create a wave and wind shadow effect for redevelopment located farther inland from the beach area. Large, well-designed and constructed mixed use buildings with first floors appropriately elevated on parking garages to reduce flood damages would provide many benefits to the local economy as well as addressing the reduction of damages and through improved emergency evacuation procedures reduce loss of life along the coast. In effect, current landowners along the beachfront would have the option to sell their land to potential developers at an inflated price above that now available and with appropriate application of floodplain zoning ordinance requirements and building codes, investors could make the best use of this prime beachfront property.

Careful rezoning of the lands subject to inundation by storms and hurricanes could attain one or more of the planning objectives, but accomplishing the rezoning would fall into the hands of the local municipal and county governments. The Federal government is not able to direct or otherwise coerce local governments to rezone private property as a plan alternative. Similar to the concept of allowing local floodplain zoning and ordinance administration to control new development on vacated property (in lieu of offering federal funds to elevate new structures on vacant land) and thereby accomplish planning objectives with no cost to the project, allowing rezoning of high-hazard areas such that permitted uses would be substantially protected from future damages would lead to the same benefits at no Federal cost. The estimated cost of modifying the existing zoning along the coast is approximately $500,000 including modification of or amendments to local comprehensive plans that support local zoning ordinances. This single measure is not carried forward as a separate

plan into the formulation process since it primarily reduces damages on future development and would have little effect on existing structures, but this measure is included in some of the combined plans described below.

6.7.1.7 Flood Preparedness and Public Education

A single-measure plan, featuring flood preparedness and public education would be effective in meeting portions of the planning objectives. Implementing various components of an improved storm warning system and emergency evacuation plan across the project area could significantly reduce the threats to life from storms and hurricanes and possibly reduce damages to structure contents that could be moved out of the inundation zone prior to the arrival of the storm event. In all, approximately 74,000 parcels of land, the structures on them and the families and individuals living within them would be provided an increased level of protection for structure contents and loss of life.

A sustained program of public education regarding the potential threats posed by storms and hurricanes applied to all sectors of the resident and itinerant population in the project area could significantly increase the population's awareness of the dangers and options for reducing the threat. A good public education program could save lives in the event of another large hurricane. The estimated cost of applying this measure across the project area is $2.9M. Unfortunately, without the application of other nonstructural measures, structures and facilities left behind by fleeing residents or business owners would still be subject to inundation damages. Some improvements to structures and facilities as a part of the flood preparedness measures could be undertaken to reduce building damages, but without other measures (i.e. floodproofing, acquisition, building codes, etc.) structure and facility damages would still occur. Therefore, as a singular measure plan, flood preparedness and public education was not carried forward. Flood preparedness and public education was included in some of the combined plans as described below.

6.7.1.8 Transfer of Development Rights and Purchase of Development Rights

A single-measure plan consisting of transfer of development rights and/or purchase of development rights could be effective in addressing properties within hazard zones that were vacant prior to Katrina or became vacant as a result of Katrina. If these programs were instituted by the three counties in cooperation with the municipal areas, future development of vacant private property in hazard zones that are entered into either of the two programs could be thwarted (mitigated by cash payments from receiving property owners) thus reducing future flood damages. Likewise, receiving areas designated under a TDR program would be given the opportunity to develop flood-free property at higher densities that could provide housing for displaced landowners within the hazard areas. Under the PDR option, owners of vacant hazardous properties would sign over their rights to further develop their property for a lump sum of cash provided by the implementing local entity. According to RE data, over 33,000 vacant parcels exist within the project area, many of which are located within the high-hazard zones.

Purchasing or transferring the development rights of these vacant parcels would limit future development of damageable property. The estimated cost to establish the TDR/PDR programs is approximately $1.5M ($500,000 per planning unit) with annual sums of state and/or local capital with which to purchase the development rights. However, neither of these programs can accomplish flood damage reduction objectives for existing structures that survived Katrina because neither of the programs modify or remove an existing structure from the property to avoid future damages but only thwart future additional development of the site from the day of the agreement or purchase of the rights to further develop the property. Although effective in reducing further damages from new development on vacant property, these programs do little to reduce damages to existing structures and facilities in hazard areas. For this reason, TDR and PDR are not effective as a single measure

plan, but could be combined with other measures (such as permanent acquisition) that would address damages to existing and future development.

6.7.1.9 Development Impact Fees

Development impact fees can be used as a financial disincentive to steer development away from hazardous locations and allow jurisdictions to recover the external development costs for emergency services and post-storm recovery activities. Normally the fees are paid by the developer as a one-time lump sum on a per-lot basis rather than a continuing repetitive payment on developed lots that may be located in a hazardous zone. The estimated cost to enact development impact fees across the project area is $370,000. The total number of undeveloped acreage that may be converted to residential or commercial use in the project area is unknown at this time, but the institution of impact fees may limit development on those acres located in flood-prone areas. Although the use of such fees has proven to be effective in modifying the behaviors of developers in high-growth areas, the fees by themselves do not reduce flood damages to existing development nor do they absolutely prohibit such development from occurring. Since the project objectives emphasize reduction of flood damages to existing development, development impacts fees would not be an effective single-measure plan. However, given their ability to redirect growth away from hazardous or environmentally sensitive areas and to recover external costs, development impact fees would be effective when combined with other measures as described below.

6.7.2 Combined Measures Nonstructural Plans

As shown in Section 6.5.1., none of the nonstructural measures in and of themselves (except for lower levels of protection or single measures concentrated on very specific coastal areas such as permanent acquisition) fully meets the planning objectives of the study. Closest to the mark is permanent acquisition of all property damaged by Katrina and yet within that seemingly complete solution are holes bored by legal restrictions and economic imperatives such that it too is unable to fully address the objectives. Two alternatives featuring permanent acquisition as the only measure (described above as NS-PAHHZ and NS-PA100) are effective in reducing damages, but neither of them fully meets the planning objectives stated in the report.

In view of the inability of single-measure alternatives to address a majority of the planning objectives, combinations of measures, each with its unique ability to address portions of the objectives must be considered. Combining the best attributes of measures that can be implemented by Federal agencies and both state and local governments can provide substantial benefits. Using the results of the pair-wise evaluation in Table 13, combinations of measures were developed that can cost-effectively reduce damages, while providing for ecosystem restoration of wetlands and minimizing long-term social, economic and cultural impacts.

Two of the nonstructural measures already functioning in the study area can be components of any combined plan since they involve administrative and regulatory activities that would remain effective in any nonstructural plan. As shown in the pair-wise analysis, these two measures combine favorably under any future development scenarios. Flood Preparedness composed of Hurricane & Storm Warnings and Emergency Evacuation and Floodplain Management and Zoning both operate at the Federal, State and local levels of government to reduce losses of life and property damages. Only in the permanent acquisition measure, does either of these two measures lose their effectiveness (very limited damageable property would remain in place), but with remnants of development (casinos and associated development) remaining even under that acquisition scenario, these two measures would remain in effect and be necessary for those facilities to safely maintain their location on the coast. For this reason the existing components of both Flood Preparedness and Floodplain Management and Zoning are incorporated into each combined plan although in Plan NS-PAHHZ and

Plan NS-PA100 (described above) they are assumed to function only at their present level of operation without the improvements recommended in Plan NSC-1.

As stated above with respect to the two single-measure plans for permanent acquisition, all of the combined measures plans described below would have to be closely coordinated with current FEMA and HUD disaster-assistance programs before implementation so that opportunities for "double-dipping" could be eliminated and so that eligible landowners would be provided with the optimal solution for their individual structure or facility.

The combined nonstructural plans are described below:

6.7.2.1 Plan NSC-1 Federal Agencies Plan

This plan alternative would consist primarily of four measures that could be implemented by Federal agencies in cooperation with state and local agencies. This plan would provide protection for structures determined to be eligible for the program as a result of suffering inundation damages from Katrina. Although the level of protection for this plan was based upon the ABFE minus 2 feet, if approved and implemented, the Base Flood Elevation established by the anticipated revised DFIRM's from FEMA would be the minimum level of protection afforded by this plan in accordance with the local ordinances. Those four plan measures include 1) permanent acquisition of approximately 33,200 parcels (approximately 17,100 structures) located in the three high-hazard zones and areas where water depths exceed 13 feet, 2) floodproofing by elevation and other means for approximately 25,419 parcels, 3) construction of three safe harborages within three separate inlets, and 4) relocation of 7 public buildings. Figures 68 through 72 show the coverage of the different nonstructural measures applied to the project area. Table 17 shows the costs of these various components. The estimated total cost of this plan would be $19.1B.

A variance in this permanent acquisition plan component would be for FEMA through their Hazard Mitigation Grant Program (HMGP) to acquire all insured (insured through the National Flood Insurance Program – NFIP) structures (with the exceptions listed in 3.3.2) within the identified V-Zone. All uninsured structures would be purchased, through the provisions of P. L. 91-646, that are located within the V-Zone, the "catastrophic damages zone" and within the 800 foot buffer in Jackson County as well as structures where water depths at the structure exceed 13 feet. Land acquisition costs would be similar to the all-Corps plan for acquisitions in these identified zones ($7.9 billion in Plan NS-PAHHZ), but relocations assistance payments may be less through the FEMA HMGP program.

Implementation of the HARP would enable the acquisition of many parcels made vacant by Katrina before landowners could re-establish their residence. This early action would reduce acquisition costs and demolition costs and make the program more palatable to landowners. Once a new residence was constructed, landowners would be less willing to accept an offer to purchase the property and new home even with relocations assistance.

All structures and pavements on acquired property will be either demolished or salvaged by the owner or disposed of by auction and removed from the site. Demolished construction materials will be disposed of in approved landfills or accumulated in designated staging areas for submerged habitat purposes. Utilities that are no longer necessary for service could be removed by the utility companies and unnecessary roadways could be demolished and abandoned by MDOT.

It is estimated that approximately 57,000 acres of land could be acquired in the high-hazard zones. Of that total acreage, approximately 4,000 acres have been identified as suitable for ecosystem restoration as wetland areas. Those acres could be restored by numerous methods as described in the Environmental Appendix. In addition, there are approximately 37,000 acres of land that could be acquired in those areas where water depths at the AFBE-2 feet exceeded 13 feet (no floodproofing

by elevation). Of that total acreage, approximately 5,200 acres have been identified as suitable for ecosystem restoration as wetland areas. Those acres as well could be restored by numerous methods as described in the Environmental Appendix. Additional acquisitions could occur in the areas designated for floodproofing by elevation or other means should specific structures be determined unsuitable for floodproofing during more detailed investigations or where elevation costs exceed acquisition costs. Lands acquired within the designated floodproofing areas that could be restored for ecosystem benefits would be investigated by the environmental team for their use as future wetlands.

Total estimated costs for all permanent acquisitions would be approximately $7.9B. Table 17 shows the approximate numbers of units and acquisition costs by economic reach. Figures 68 through 72 show the extent of the permanent acquisition area [shown in red and dark green] in the project area.

In an effort to reduce the overall project costs and forestall the re-establishment of many households in the high-hazard zones, implementation of the High Hazard Area Risk Reduction Plan (HARP) would concentrate on properties in the high-hazard zones that were made vacant by Katrina (structures demolished by the storm). This initial acquisition program described in Section 4.3.8.5 of this Appendix could significantly reduce the overall program cost by purchasing vacant property that has a high likelihood of redevelopment. Foregoing the high costs of purchasing new, larger residences, paying household relocation assistance and demolishing buildings and disposing of the debris, the HARP could save more than $270.0M in the permanent acquisition program and significantly reduce the threats to loss of life for those who would be re-establishing residences in high-hazard zone. The initial HARP program cost is estimated to be $397.0M and would affect approximately 2,000 parcels of property. Figures 52, 53 and 54 show those areas of the project where high-quality wetland ecosystem restoration opportunities correlate with the proposed acquisition in the HARP. Acquisition of vacant property (no structures) would require relatively minimal restoration to achieve ecosystem benefits.

Depending upon the type of redevelopment/resettlement options that are agreed upon by the local communities and the availability of existing DSS market housing for displaced landowners, one or more redevelopment sites may be developed in association with the permanent acquisition component of this nonstructural plan. These redevelopment sites would be constructed on lands acquired by the non-Federal sponsor (or the Federal Government by sub-agreement). All site improvements and community amenities would be installed prior to new housing or commercial building construction. To handle the anticipated number of displaced households a total of at least three redevelopment sites would be needed, one in each county (planning unit). Total estimated costs for three redevelopment sites (total of 6,000 lots) based upon an average developed cost per lot of $45,000 would be $270.0M.

Floodproofing of selected residential, commercial and institutional structures by elevation or other means would be implemented by Federal agencies with cooperation from state and local agencies. The floodproofing component would be on a voluntary basis only. During implementation of the floodproofing component of the plan each structure would be carefully evaluated to determine the appropriate method of protection. The most cost effective solution would be offered to the landowner. The existing structure could be either elevated in-place, purchased and demolished or demolished and a new structure rebuilt on-site in an elevated condition. Guide plans and specifications based upon the engineering standards proscribed in the FEMA 550 guidelines would be prepared for each structure to be elevated. Specific plans and specifications for floodproofing measures at larger commercial or institutional buildings would be completed for each structure. The estimated cost for floodproofing 25,419 structures is $10.8B. Table 17 shows the floodproofing costs by economic reach. A total of 43 public buildings are included in the total number of structures eligible to be floodproofed. Figures 68 through 72 show the extent of the area where floodproofing by elevation would be practical and safe (shown in green).

In order to demonstrate the effectiveness of floodproofing by elevation to the general populace within the project area, this plan would request authorization to proceed with floodproofing construction by elevation in selected communities where elevation could be accomplished safely and at a much lower cost than any other measure (structural or nonstructural) heretofore identified. A neighborhood within Waveland, MS has been identified where elevation of residential structures using the FEMA 550 guidelines for floodproofing in the Gulf Coast would be within the program guidelines. An early-action pilot floodproofing program would provide an opportunity to evaluate the FEMA 550 guidelines, demonstrate to potential program participants the appearance of structure elevation according to the guidelines and provide valuable information to the Mobile District on anticipated floodproofing and administrative costs for the remainder of the project area. Approximately 25 residential structures would be included in this pilot project. The total, fully-funded project cost is estimated to be $4.6 M with a project duration of four years depending upon the flow of project funds. A Detailed Project Report (DPR) or Project Implementation Report (PIR) would be prepared for approval by Corps Division offices prior to implementation of this pilot program.

To address the emergency evacuation requirements of the many fishing and pleasure vessels in the project area, three safe harborages would be constructed within the three major inlets in the project area. Safe harborages would be constructed on the Bay St. Louis embayment, Biloxi embayment and Pascagoula River embayment. An alternate harborage location would be at the Pearlington site on the Pearl River should the Pearlington redevelopment site be constructed. Material from the excavated safe harborage could be used as a portion of the fill for raising the Pearlington community. Construction at these sites would entail excavation of the harbor areas, dredging (if deemed necessary) of channels between the Gulf and the safe harbor area, a berthing area(s) of sufficient size to accommodate fishing vessels, security fencing, lighting and a gravel parking area. The total estimated cost for these three safe harborages is approximately $23.1M. This amount reflects the cost-shared (non-Federal 10%) project cost with a maximum Federal cost per project of $7.0M (Federal project limit revised in WRDA 2007).

Public buildings that cannot be safely protected in place by floodproofing would be relocated to a flood-safe location through a relocations contract. A detailed engineering assessment of each public structure or facility would be made by USACE personnel to determine what a suitable replacement structure would require in terms of floor space, facilities, access, equipment, and maintenance. Building design would be based upon current-day standards for the particular facility (school, police station, fire station, city hall, etc.) being relocated. Relocations costs would account for land acquisition of a new flood-free site, building/facility design costs, construction costs and demolition costs of the old building. The existing flood-prone public property would be turned over to a non-Federal local sponsor for future OMRR&R. The 7 identified public buildings for relocations include schools and fire stations. Based upon available information for the affected public buildings, the estimated relocations costs would be approximately $51.2M. Table17 shows the numbers of public structures that would be subject to relocations or a floodproofing option and associated costs by economic reach. Figures 68 through 72 show the approximate locations of these existing structures within their economic reach.

The aforementioned Moss Point public buildings relocations pilot project could be implemented to demonstrate the effectiveness of relocations in reducing flood damages. The four public structures within the municipality that compose the city administrative offices and community recreation facility could be relocated to less flood-prone locations within Moss Point to demonstrate to other communities in the project area the usefulness of this nonstructural technique. The total, fully-funded estimated cost of this relocation project is $11.4 M with a project duration of four years.

As stated above, flood preparedness and floodplain management zoning and ordinance enforcement as well as building code enforcement would continue as well as the NFIP program in the project area. There wouldn't be any significant improvements to these three local systems

beyond what is currently in-place following Katrina. Costs for these in-place, ongoing local processes are purely non-federal costs and are not captured in this alternative plan.

Other scales of Plan NSC-1 include providing the same suite of protection measures for several levels of inundation (each greater in magnitude than the minimum ABFE) including 20 foot, 30 foot and 40 foot storm surge inundation levels within the project area. The primary differences in this sub-set of Plan NSC-1 are the total number of parcels being protected and the division of the parcels between the floodproofing and either permanent acquisition or relocation (public buildings) measures within the plan. As the level of storm surge increases (ABFE-2 to 20 feet, 30 feet, and 40 feet), the total parcels treated by the measures would be steadily increased and more parcels (and attendant structures if not vacant) would be acquired (water depths greater than 13 feet) than floodproofed.

The only category of parcels whose total number would remain constant across the scaled versions of NCS-1 would be those in the high-hazard zones that are not affected by water depth, but by their proximity to the shoreline. In view of study time constraints and the limitations of the databases to accurately capture public buildings at these higher levels of inundation, municipal buildings listed in the tax assessor's database were considered as commercial structures to determine acquisitions and floodproofing costs at the 20, 30 and 40 foot levels of inundation. Total units and costs for each measure for the three, scaled versions of Plan NSC-1 (NSC-1a, NSC-1b, and NSC-1c) are shown in Tables 18, 19 and 20 by economic reach.

As shown in Tables 18, 19 and 20, the numbers of parcels increases dramatically with each increase in inundation depth between the ABFE and the 40 foot depth of inundation. Also evident is the movement of parcels eligible for floodproofing to the permanent acquisition category based upon depth of water at the structure. In addition, because of the dramatic increases in the numbers of parcels eligible for permanent acquisition, the numbers of potential H&CD lots required to handle the anticipated displaced landowners increases dramatically (as well as the costs and acres of land that would be required to accommodate the displaced households). This close relationship between inundation depth and numbers of permanent acquisitions (as well as needed lots for displaced landowners) remains fairly constant throughout the continuum of inundation depths.

From a total plan cost standpoint, greater levels of surge inundation do result in costs actually decreasing slightly because of the slightly lower cost for permanent acquisition as opposed to floodproofing used in this analysis. As more structures are added to the eligible list (deeper surge depth covers greater land area and more parcels), the overall cost of the plan does not rise at the same rate of increase through each increment of surge depth. Although somewhat counterintuitive, the difference in measure cost and the movement of structures from one category to another (floodproofing to permanent acquisition) drives this slight reduction in cost. As discussed in Section 6.3 – Nonstructural Program Participation, participation in the program at higher levels of surge protection may drop as landowners who would have been willing to have their homes elevated (at a lower level of protection) may not favor having their homes purchased at the higher level of protection.

Although not available at this level of planning for inundation depths greater than the ABFE, the increased depths of inundation above the ABFE generate additional acres of vacant land (following permanent acquisition and demolition of structures) that may be suitable for ecosystem restoration as wetlands and other high-quality habitat.

Table 17.
Plan NSC-1 – Federal Agencies Plan (ABFE)

Economic Reaches	Permanent Acquisition Parcels	Cost	Floodproofing Structures	Cost	Public Buildings Relocations	Cost	Safe Harborages	Cost
1	997	$194,118,218	394	$124,162,500	0	0		
2	9911	$2,992,128,131	3294	$1,940,527,762	0	0		
3	2202	$668,691,437	376	$333,327,500	0	0		
4	922	$120,307,917	16	$30,715,000	0	0		
5	2714	$238,388,794	119	$79,272,500	0	0		
6	567	$107,292,775	590	$332,629,236	1	$8,536,147		
7	450	$33,303,080	232	$186,928,125	0	0		
8	3623	$476,153,333	1730	$696,585,161	4	$25,608,442		
9	44	$16,145,783	16	$16,552,500	0	0		
10	1945	$432,607,234	62	$24,201,250	0	0		
11	0	0	8	$2,105,000	0	0		
12	1047	$179,783,825	1136	$443,587,036	0	0		
13	650	$583,121,543	0	0	0	0		
15	85	$44,354,843	9	$28,406,250	0	0		
16	78	$16,399,728	121	$38,542,500	0	0		
18	1502	$409,463,532	5	$1,396,250	0	0		
19	46	$292,728,063	0	0	0	0		
20	1397	$238,563,082	2050	$876,852,680	1	$8,536,147		
21	2108	$301,824,272	419	$193,663,144	0	0		
22	61	$26,330,663	92	$44,933,750	0	0		
23	0	0	44	$24,735,000	0	0		
24	220	$65,229,821	178	$58,153,750	0	0		
26	37	$9,210,336	952	$331,648,993	0	0		
27	53	$12,880,944	1029	$275,385,243	0	0		
28	961	$90,294,697	122	$59,837,500	0	0		
29	147	$23,394,829	168	$63,560,625	0	0		
30	90	$29,459,003	467	$197,030,000	0	0		
31	51	$14,959,829	447	$209,015,000	0	0		
32	0	0	208	$64,368,750	0	0		
35	12	$682,228	1406	$431,113,125	0	0		
36	32	$3,834,485	2	$6,312,500	0	0		
38	50	$21,424,866	78	$19,440,625	0	0		
39	0	0	6	$1,204,375	0	0		
43	0	0	1	$206,250	0	0		
48	0	0	2	$445,000	0	0		
50	495	$89,312,661	848	$263,763,750	0	0		
51	0	0	786	$329,689,637	0	0		
52	285	$103,016,211	6838	$2,412,346,817	1	$8,536,147		
53	399	$113,054,873	360	$256,581,875	0	0		
54	9	$1,114,862	808	$406,074,697	0	0		
Subtotals	**33,191**	**$7,928,411,301**	**419**	**$10,805,301,654**	**7**	**$51,216,883**	**3**	**$23,100,000**
H&CD Sites		Hancock, Harrison and Jackson Counties			3 Sites – 3,000 total lots			$135,000,000
Total Cost								$18,943,029,838

Table 18
Plan NSC-1a – 20 Feet of Inundation

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
1	795	$242,760,352.63	1068	$111,644,220	$354,404,572.63
2	6119	$1,982,505,118.75	12206	$2,270,306,077	$4,252,811,195.75
3	2029	$869,599,919.38	502	$261,603,614	$1,131,203,533.38
4	769	$137,140,841.63	55	$41,048,722	$178,189,563.63
5	1907	$221,978,091.88	680	$93,803,252	$315,781,343.88
6	753	$84,228,949.38	167	$67,872,872	$152,101,821.38
7	343	$28,183,289.75	1092	$123,833,026	$152,016,315.75
8	6585	$721,036,617.25	2761	$268,481,369	$989,517,986.25
9	23	$10,006,258.75	15	$4,155,724	$14,161,982.75
10	3052	$687,523,634.50	36	$9,985,596	$697,509,230.50
11	45	$13,955,967.50	882	$131,996,005	$145,951,972.50
12	1617	$398,388,336.75	2184	$925,803,107	$1,324,191,443.75
13	2284	$1,059,037,972.50	1	$275,000	$1,059,312,972.50
14	10	$3,531,145.00	3	$0	$3,531,145.00
15	407	$321,467,398.75	5	$195,994	$321,663,392.75
16	178	$45,986,843.00	420	$89,816,180	$135,803,023.00
17	0	$0.00	0	$0	$0.00
18	1650	$531,842,684.50	29	$7,968,172	$539,810,856.50
19	15	$238,143,653.50	0	$0	$238,143,653.50
20	1046	$197,002,707.50	1756	$491,997,409	$689,000,116.50
21	2142	$698,779,207.38	1688	$518,126,016	$1,216,905,223.38
22	314	$142,425,847.38	1921	$475,539,586	$617,965,433.38
23	59	$18,831,864.50	104	$23,208,676	$42,040,540.50
24	301	$134,113,558.00	854	$131,106,828	$265,220,386.00
25	0	$0.00	27	$3,700,964	$3,700,964.00
26	1117	$143,629,375.25	1094	$150,558,498	$294,187,873.25
27	203	$21,004,404.13	2725	$269,721,562	$290,725,966.13
28	1318	$162,484,163.75	444	$40,032,082	$202,516,245.75
29	491	$115,704,667.88	1081	$180,905,804	$296,610,471.88
30	612	$183,628,802.88	2158	$599,471,114	$783,099,916.88
31	472	$150,421,617.50	810	$206,865,030	$357,286,647.50
32	236	$44,686,667.38	461	$71,960,724	$116,647,391.38
33	0	$0.00	0	$0	$0.00
34	0	$0.00	0	$0	$0.00
35	630	$92,739,948.25	1277	$453,335,528	$546,075,476.25
36	0	$0.00	29	$0	$0.00
37	0	$0.00	5	$0	$0.00
38	33	$23,256,254.25	304	$16,587,864	$39,844,118.25
39	8	$1,627,170.00	287	$16,374,482	$18,001,652.00
40	1	$100,211.25	4	$0	$100,211.25
41	0	$0.00	0	$0	$0.00
42	0	$0.00	0	$0	$0.00
43	0	$0.00	4	$366,298	$366,298.00
44	0	$0.00	0	$0	$0.00
45	0	$0.00	0	$0	$0.00
46	0	$0.00	3	$114,092	$114,092.00
47	0	$0.00	5	$587,982	$587,982.00
48	1	$1,457,777.50	5	$587,982	$2,045,759.50

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
49	0	$0.00	63	$2,318,648	$2,318,648.00
50	574	$204,376,584.50	1915	$363,408,582	$567,785,166.50
51	1005	$220,389,345.63	883	$241,849,268	$462,238,613.63
52	1840	$535,059,176.25	7305	$4,108,479,076	$4,643,538,252.25
53	646	$134,435,107.63	613	$207,158,892	$341,593,999.63
54	1100	$276,596,580.13	655	$219,619,572	$496,216,152.13
Subtotal	**42730**	**$11,100,068,114**	**50586**	**$13,202,771,489**	**$24,302,839,603**
H&CD Sites	Hancock, Harrison & Jackson		Approx. 15,000 lots at $45,000/lot		$ 675,000,000
Total Cost					**$ 24,977,839,603**

Table 19
Plan NSC-1b – 30 Feet of Inundation

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
1	1591	$470,268,503.50	511	$80,353,606	$550,622,109.50
2	15864	$3,364,937,903.75	6331	$2,006,692,184	$5,371,630,087.75
3	2565	$1,036,199,788.88	557	$239,155,950	$1,275,355,738.88
4	823	$143,859,191.50	1	$195,994	$144,055,185.50
5	2545	$514,085,341.38	42	$8,818,078	$522,903,419.38
6	920	$108,477,101.25	0	$0	$108,477,101.25
7	1222	$127,404,692.38	267	$18,389,310	$145,794,002.38
8	8591	$913,966,937.50	755	$201,679,104	$1,115,646,041.50
9	38	$12,583,953.75	0	$0	$12,583,953.75
10	3088	$696,444,472.00	0	$0	$696,444,472.00
11	79	$17,236,421.25	848	$315,371,358	$332,607,779.25
12	3801	$1,250,095,756.75	0	$0	$1,250,095,756.75
13	2284	$1,059,037,972.50	1	$2,525,000	$1,061,562,972.50
14	10	$3,531,145.00	3	$0	$3,531,145.00
15	412	$326,617,775.00	0	$0	$326,617,775.00
16	598	$173,917,626.75	0	$0	$173,917,626.75
17	0	$0.00	0	$0	$0.00
18	1655	$533,199,240.00	24	$11,739,556	$544,938,796.00
19	15	$238,143,653.50	0	$0	$238,143,653.50
20	2144	$416,967,996.50	1802	$861,061,816	$1,278,029,812.50
21	3830	$1,483,891,217.50	0	$0	$1,483,891,217.50
22	2235	$872,740,336.25	0	$0	$872,740,336.25
23	163	$57,221,763.88	0	$0	$57,221,763.88
24	539	$264,338,265.75	616	$110,725,374	$375,063,639.75
25	27	$11,661,813.00	0	$0	$11,661,813.00
26	2211	$438,492,100.00	0	$0	$438,492,100.00
27	2928	$453,066,871.38	0	$0	$453,066,871.38
28	1687	$241,776,845.63	1742	$249,531,974	$491,308,819.63
29	1572	$359,722,100.25	0	$0	$359,722,100.25
30	2770	$942,794,462.50	0	$0	$942,794,462.50
31	1282	$415,121,092.13	0	40	$415,121,092.13
32	697	$173,934,340.75	0	$0	$173,934,340.75
33	0	$0.00	0	$0	$0.00
34	0	$0.00	0	$0	$0.00
35	1907	$416,542,564.88	0	$0	$416,542,564.88
36	15	$2,306,708.13	36	$0	$2,306,708.13
37	1	$340,434.38	4	$0	$340,434.38
38	198	$59,672,860.88	452	$74,116,316	$133,789,176.88
39	295	$34,977,357.00	0	$0	$34,977,357.00
40	5	$417,288.75	0	$0	$417,288.75
41	0	$0.00	0	$0	$0.00
42	0	$0.00	0	$0	$0.00
43	4	$1,269,975.00	0	$0	$1,269,975.00
44	0	$0.00	0	$0	$0.00
45	0	$0.00	0	$0	$0.00
46	3	$322,862.50	0	$0	$322,862.50
47	5	$1,720,815.00	0	$0	$1,720,815.00
48	6	$5,485,907.50	0	$0	$5,485,907.50

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
49	63	$8,814,550.50	0	$0	$8,814,550.50
50	1652	$665,887,180.75	837	$176,952,378	$842,839,558.75
51	1888	$447,319,912.38	0	$0	$447,319,912.38
52	9145	$3,199,336,671.63	0	$0	$3,199,336,671.63
53	1234	$464,412,757.75	49	$26,056,898	$490,469,655.75
54	1755	$541,259,959.00	0	$0	$541,259,959.00
Subtotal	**86362**	**$22,971,824,488**	**14878**	**4,383,364,896**	**$27,355,189,384**
H&CD Sites	Hancock, Harrison & Jackson		Approx. 30,000 lots at $45,000/lot		$ 1,350,000,000
Total Cost					**$ 28,705,189,384**

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Table 20
Plan NSC-1c – 40 Feet of Inundation

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
1	2102	$632,549,786.38	0	0	$632,549,786.38
2	22195	$5,686,835,321.25	0	0	$5,686,835,321.25
3	3122	$1,266,472,734.00	0	0	$1,266,472,734.00
4	824	$144,644,086.50	0	0	$144,644,086.50
5	2587	$519,349,802.25	0	0	$519,349,802.25
6	920	$108,477,101.25	0	0	$108,477,101.25
7	1489	$159,349,868.63	0	0	$159,349,868.63
8	9346	$1,119,589,307.50	0	0	$1,119,589,307.50
9	38	$12,583,953.75	0	0	$12,583,953.75
10	3088	$696,444,472.00	0	0	$696,444,472.00
11	927	$238,310,263.50	0	0	$238,310,263.50
12	3801	$1,250,095,756.75	0	0	$1,250,095,756.75
13	2285	$1,059,287,941.25	0	0	$1,059,287,941.25
14	13	$5,321,020.00	0	0	$5,321,020.00
15	412	$326,617,775.00	0	0	$326,617,775.00
16	598	$173,917,626.75	0	0	$173,917,626.75
17	0	$0.00	0	0	$0.00
18	1679	$542,567,877.25	0	0	$542,567,877.25
19	15	$238,143,653.50	0	0	$238,143,653.50
20	3946	$829,880,446.50	0	0	$829,880,446.50
21	3830	$1,483,891,217.50	0	0	$1,483,891,217.50
22	2235	$872,740,336.25	0	0	$872,740,336.25
23	163	$57,221,763.88	0	0	$57,221,763.88
24	1155	$598,237,712.00	0	0	$598,237,712.00
25	27	$11,661,813.00	0	0	$11,661,813.00
26	2211	$438,492,100.00	0	0	$438,492,100.00
27	2928	$453,066,871.38	0	0	$453,066,871.38
28	3429	$714,783,499.38	0	0	$714,783,499.38
29	1572	$359,722,100.25	0	0	$359,722,100.25
30	2770	$942,794,462.50	0	0	$942,794,462.50
31	1282	$415,121,092.13	0	0	$415,121,092.13
32	697	$173,934,340.75	0	0	$173,934,340.75
33	0	$0.00	0	0	$0.00
34	0	$0.00	0	0	$0.00
35	1907	$416,542,564.88	0	0	$416,542,564.88
36	51	$6,438,158.75	0	0	$6,438,158.75
37	5	$1,911,196.25	0	0	$1,911,196.25
38	650	$214,970,390.38	0	0	$214,970,390.38
39	295	$34,977,357.00	0	0	$34,977,357.00
40	5	$417,288.75	0	0	$417,288.75
41	0	$0.00	0	0	$0.00
42	0	$0.00	0	0	$0.00
43	4	$1,269,975.00	0	0	$1,269,975.00
44	0	$0.00	0	0	$0.00
45	0	$0.00	0	0	$0.00
46	3	$322,862.50	0	0	$322,862.50
47	5	$1,720,815.00	0	0	$1,720,815.00
48	6	$5,485,907.50	0	0	$5,485,907.50
49	63	$8,814,550.50	0	0	$8,814,550.50

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
50	2489	$1,063,036,000.75	0	0	$1,063,036,000.75
51	1888	$447,319,912.38	0	0	$447,319,912.38
52	9145	$3,199,336,671.63	0	0	$3,199,336,671.63
53	1283	$496,107,037.25	0	0	$496,107,037.25
54	1755	$541,259,959.00	0	0	$541,259,959.00
Subtotal	**101240**	**$27,972,036,750**	**0**	**0**	**$27,972,036,750**
H&CD Sites	Hancock, Harrison & Jackson		Approx. 35,400 lots at $45,000/per		$1,593,000,000
Total Cost					**$29,565,036,750**

Figure 68 – Plan NSC-1 Permanent Acquisitions and Floodproofing (A1)

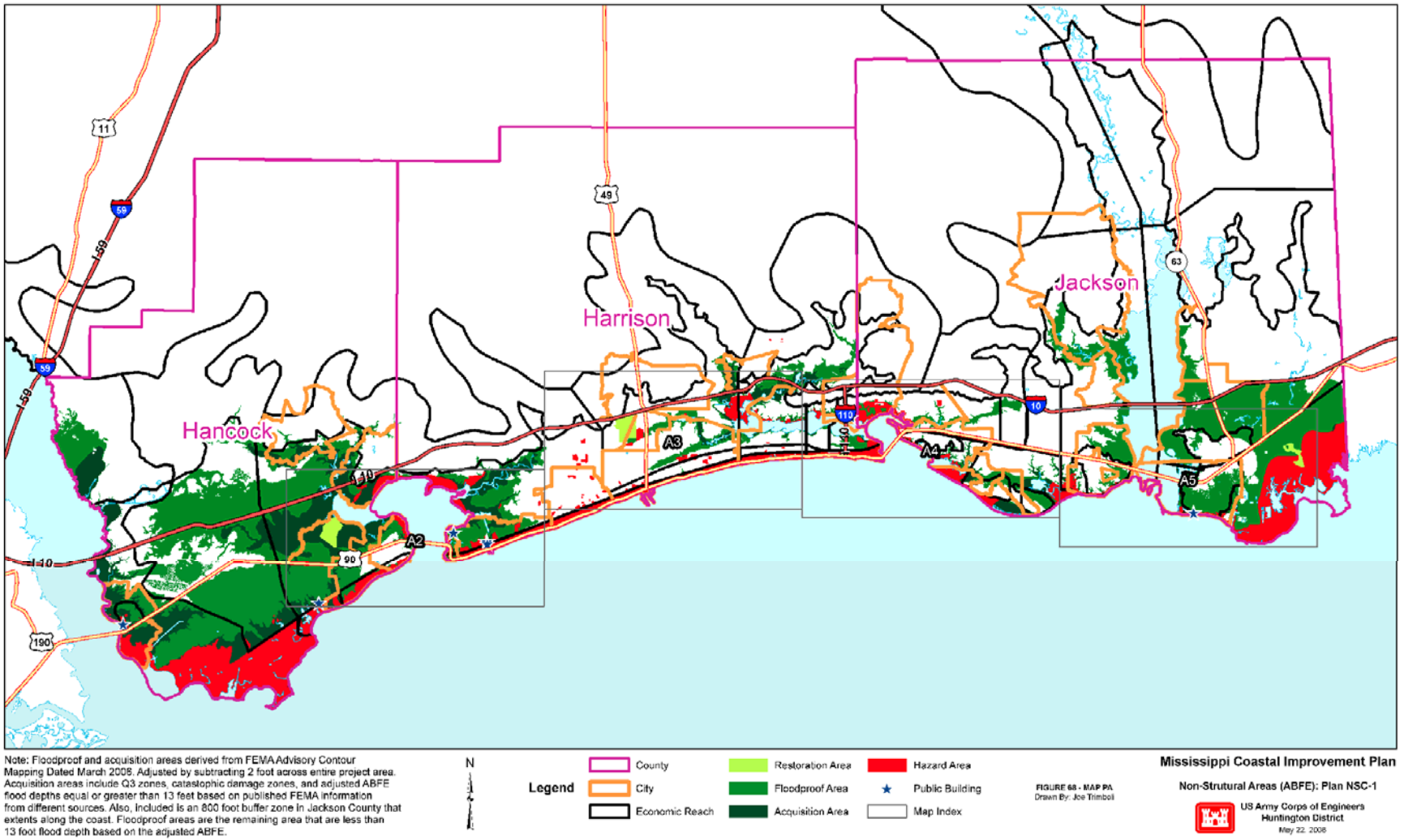


Figure 69 – Plan NSC-1 Permanent Acquisitions and Floodproofing (A2)

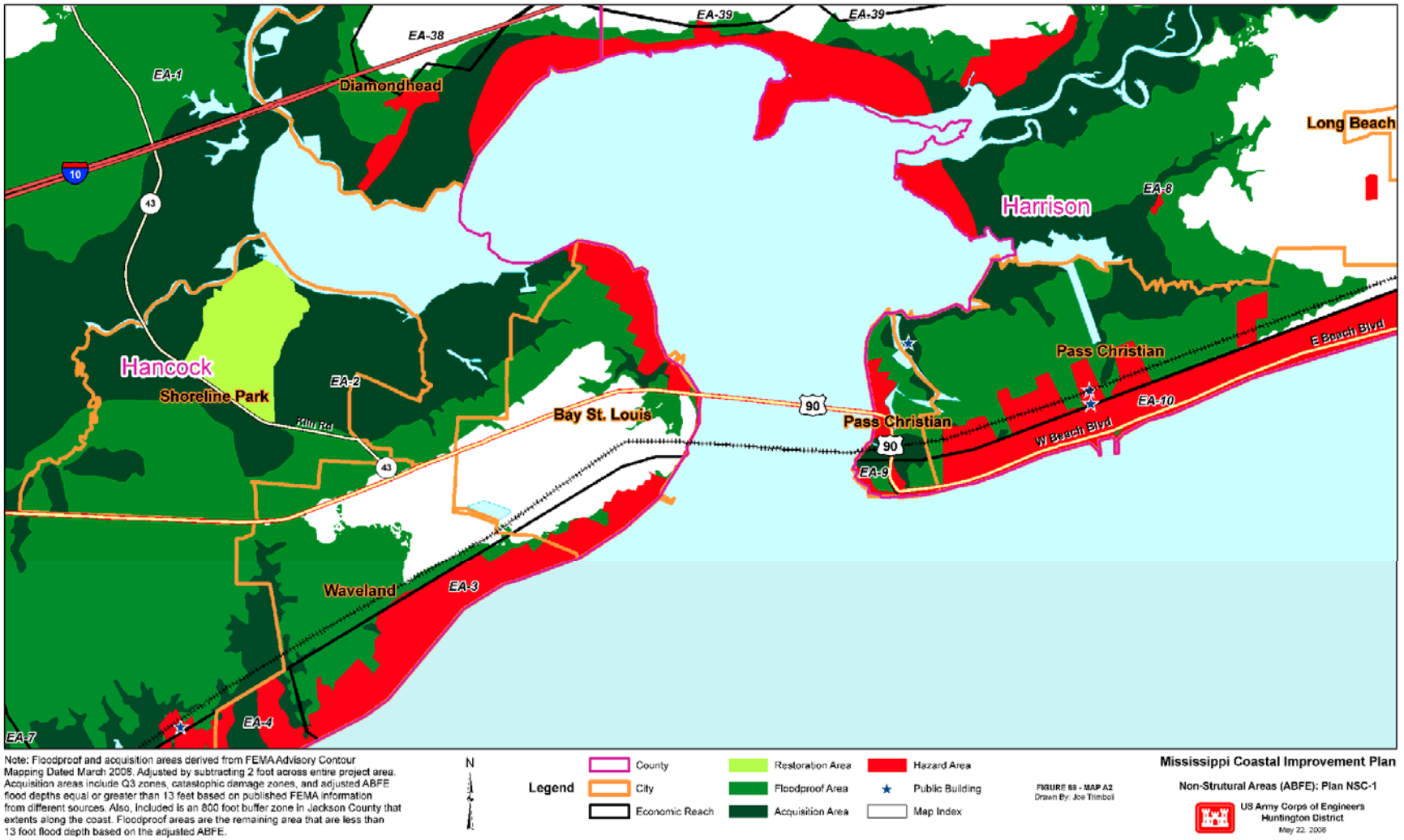


Figure 70 – Plan NSC-1 Permanent Acquisitions and Floodproofing (A3)

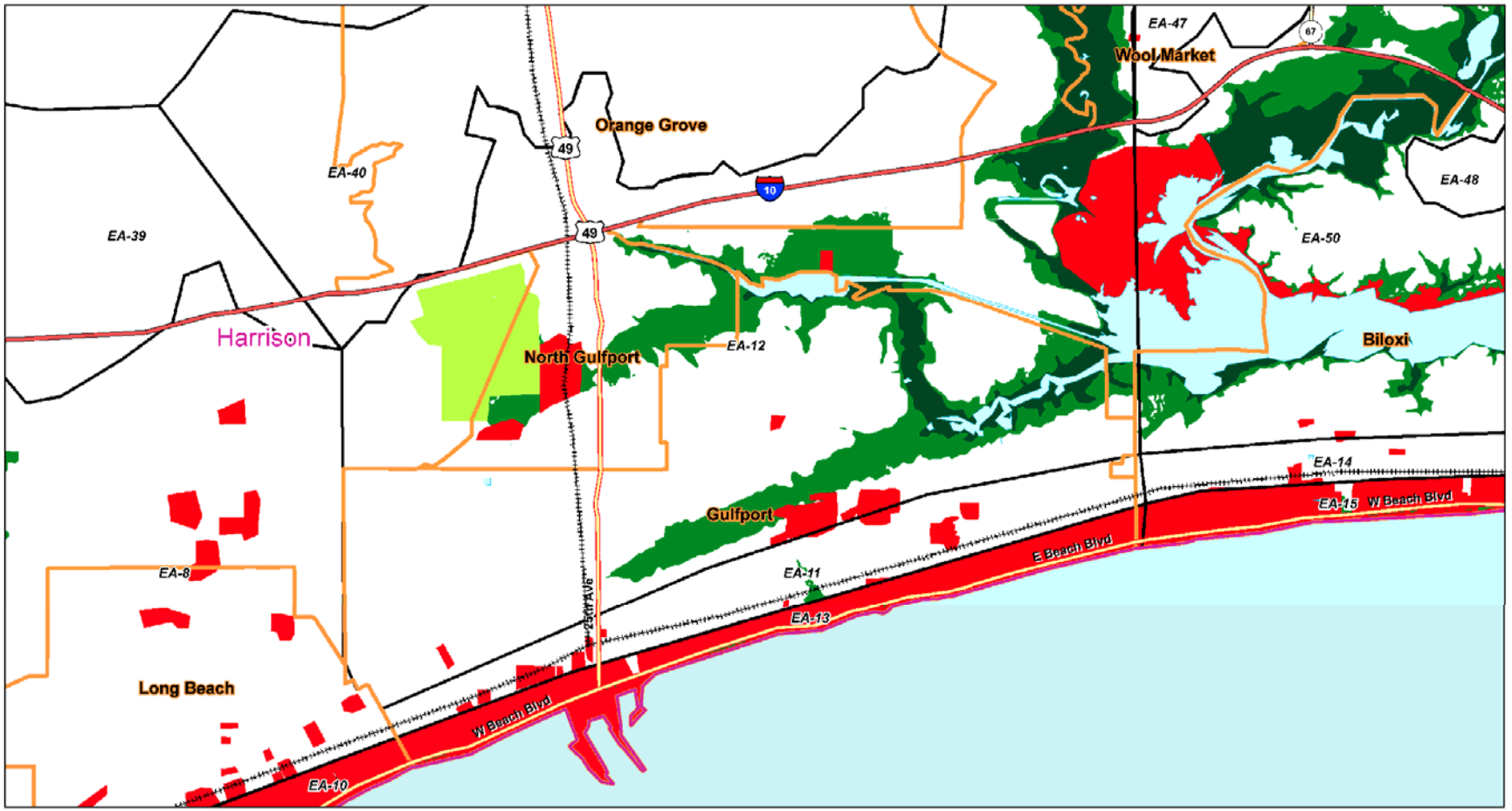


Figure 71 – Plan NSC-1 Permanent Acquisitions and Floodproofing (A4)

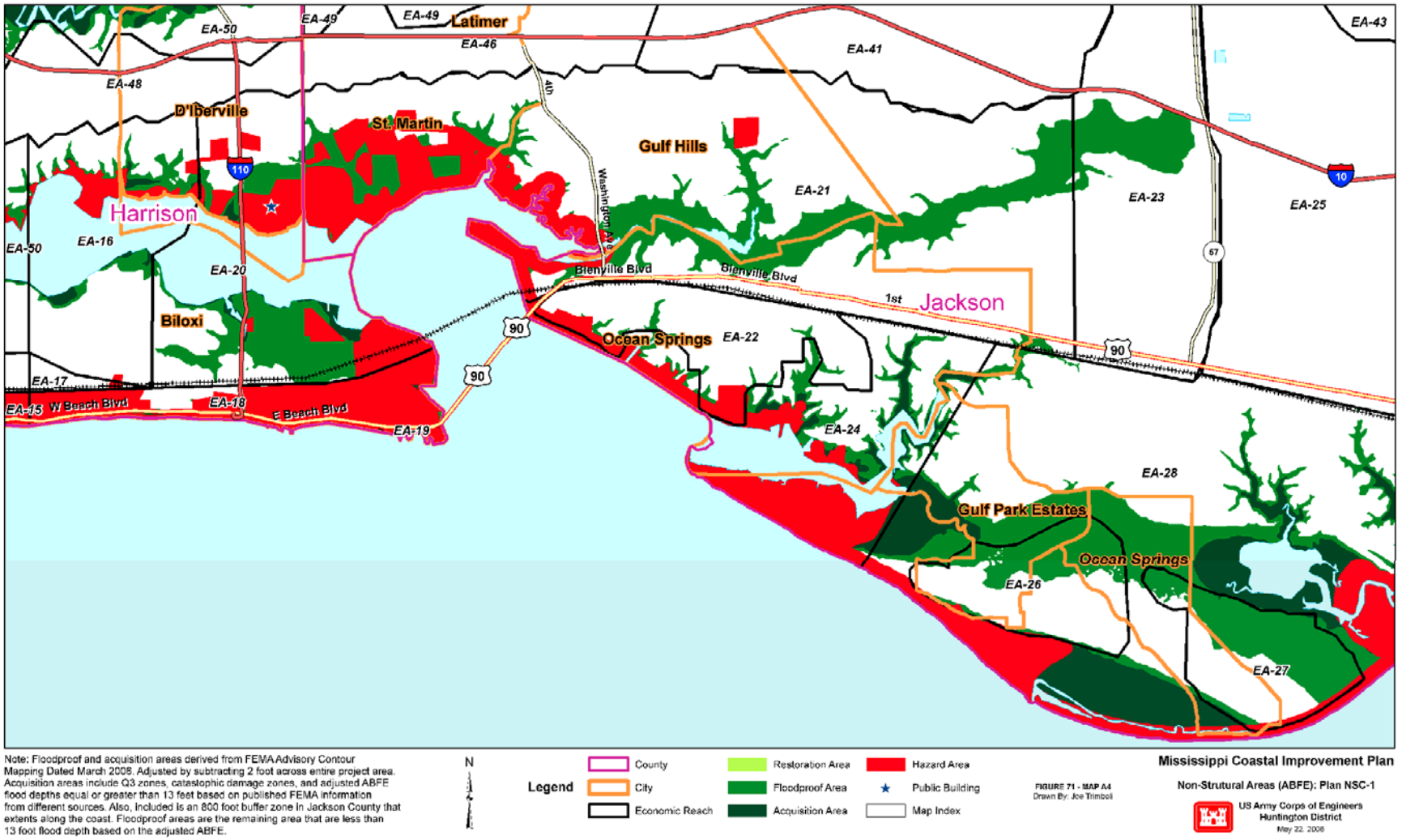
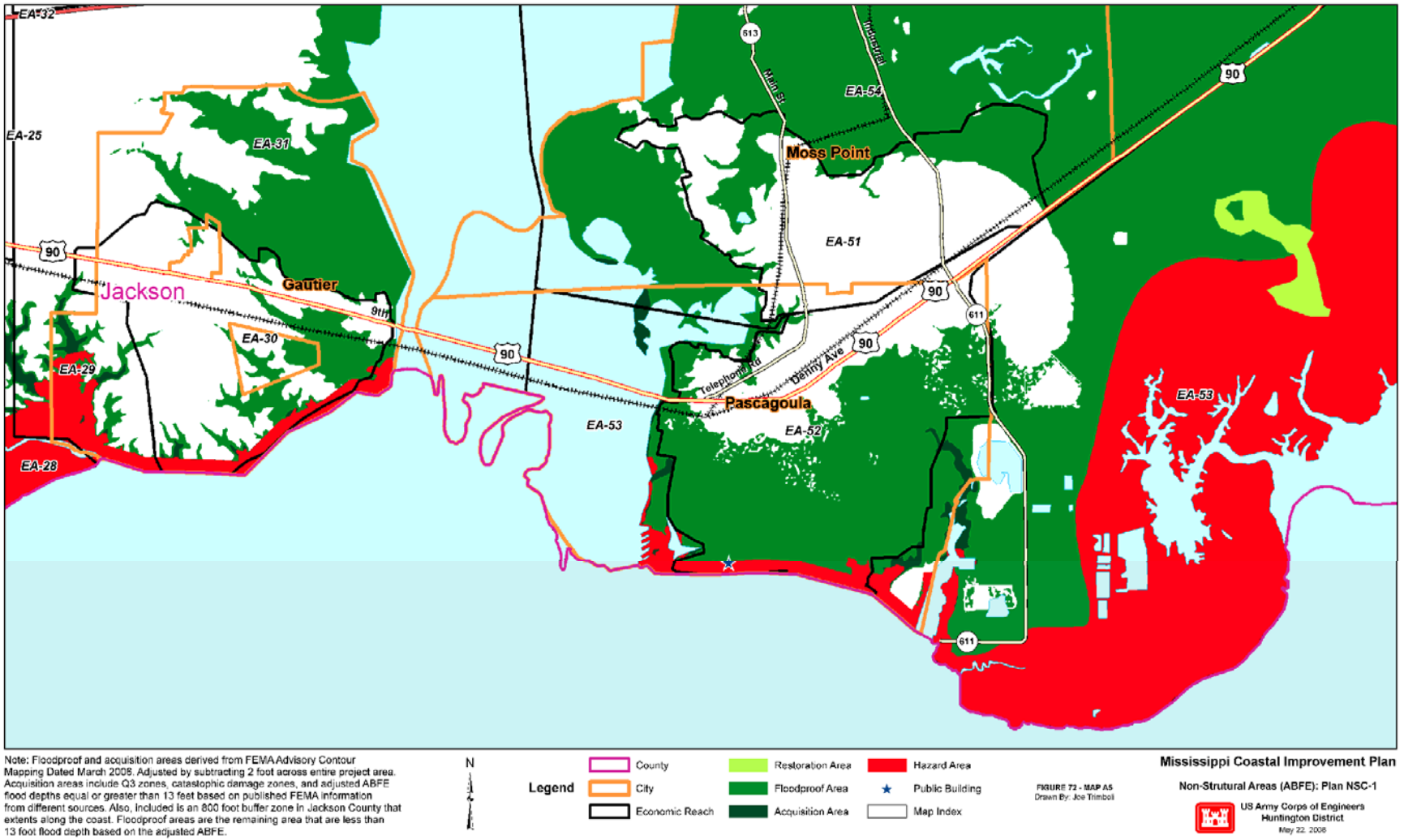


Figure 72 – Plan NSC-1 Permanent Acquisitions and Floodproofing (A5)



6.7.2.2. Plan NSC-2 – Dry and Wet Floodproofing Plan w/FWEE Upgrades

This plan is comprised of two primary measures: 1) dry and wet floodproofing of structures located outside of the high-hazard zones and in locations where water depths would not exceed 13 feet at the ABFE-2 feet flood event, and 2) upgrades to the flood warning and emergency evacuation system. As shown in the pair-wise comparison (Table 13 on page 124), these two measures need to be implemented in concert so that the occupants of elevated or otherwise floodproofed structures would have credible warnings of approaching storms provided in adequate time to prevent their being trapped inside the protected structure. Due to the H&H uncertainties surrounding the determinations of the final elevation of raised first floors and the many risks associated with "riding-out" a hurricane in an elevated structure, all occupants of floodproofed structures would be strongly encouraged (in some areas this could be a mandatory evacuation by local officials) to vacate their homes during hurricane events.

The two methods of floodproofing (dry and wet) would be applied to various structure types and uses including veneer walls, ringwalls and ring-levees (dry floodproofing) for larger commercial or institutional structures or complexes (industry, educational, medical/health facilities, military) and elevation of habitable or sales floors of residential, commercial or institutional structures (wet floodproofing) to protect the structure and its contents. Due to the ADA requirements of most public structures and the confined urban lots on which many of them are located, elevation of institutional structures has limited application. In any case, floodproofing would not be used as a method of protecting occupants of these structures, therefore emergency evacuation of people from floodproofed structures would be the norm.

The flood warning and emergency evacuation (FWEE) system upgrades would include installation of additional reporting buoys in the Gulf (coordinated with NOAA), modifications to existing warning times for category 4 and 5 hurricanes (to assure adequate evacuation time), installation of hurricane evacuation route signs throughout the project area (coordinated with MDOT), installation of messaging boards on primary north/south evacuation routes, installation of warning sirens and dissemination of weather hazard radios, various (but currently undefined) improvements to evacuation routes and intersections (signalization and lanes), and an ongoing public education and emergency evacuation training program. These upgrades to the existing FWEE system would increase public awareness (residents and tourists) of the risks posed by tropical storms and hurricanes, increase the credibility of advanced storm warnings, increase the safety and efficiency of large-scale evacuations in the face of large hurricanes and provide ongoing training and assistance to emergency response teams. In addition, this program would provide technical assistance and appropriate financial assistance to those facilities (casinos, industries, utilities) that are dependent upon their geographic location at the water's edge so that future damages can be reduced and both visitors and employees can be safely evacuated.

The total cost of Plan NSC-2 is estimated to be $10.8B. Of that total, the majority of the funds would be used to floodproof (dry and wet methods) 25,419 structures. Approximately $2.9M would be used for the FWEE upgrades for approximately 95,000 at-risk parcels within the project area. Table 21 shows the numbers of units affected by each component and the estimated costs by reach. Figures 73 through 77 show the extent of the floodproofing areas under this plan.

Table 21
Plan NSC-3 Wet and Dry Floodproofing with FWEE Upgrades

Economic Reaches	Floodproofing	Cost*	Flood Warning and Emergency Evacuations	Cost
1	394	$124,162,500	2062	$62,540
2	3294	$1,910,805,000	19363	$587,280
3	376	$333,327,500	2673	$81,072
4	16	$30,715,000	901	$27,327
5	119	$79,272,500	3109	$94,296
6	590	$311,335,000	1123	$34,061
7	232	$186,928,125	1574	$47,739
8	1730	$691,816,250	8716	$264,356
9	16	$16,552,500	52	$1,577
10	62	$24,201,250	1727	$52,380
11	8	$2,105,000	44	$1,335
12	1136	$438,818,125	2777	$84,226
13	0	0	500	$15,165
14	0	0	788	$23,900
15	9	$28,406,250	76	$2,305
16	121	$38,542,500	209	$6,339
17	0	0	6	$182
18	5	$1,396,250	1223	$3,7094
19	0	0	22	$667
20	2050	$853,008,125	3064	$92,931
21	419	$174,587,500	1867	$56,626
22	92	$44,933,750	157	$4,762
23	44	$24,735,000	65	$1,971
24	178	$58,153,750	524	$15,893
25	0	0	327	$9,918
26	952	$321,001,875	1279	$38,792
27	1029	$264,738,125	2145	$65,058
28	122	$59,837,500	1718	$52,107
29	168	$63,560,625	546	$16,560
30	467	$197,030,000	626	$18,987
31	447	$209,015,000	708	$21,474
32	208	$64,368,750	398	$12,071
33	0	0	77	$2,335
34	0	0	600	$18,198
35	1406	$431,113,125	1599	$48,498
36	2	$6,312,500	62	$1,880
37	0	0	540	$16,378
38	78	$19,440,625	1	$11,040
39	6	$1,204,375	364	$758
40	0	0	7824	$237,302
41	0	0	536	$16,257
42	0	0	667	$20,230

Economic Reaches	Floodproofing	Cost*	Flood Warning and Emergency Evacuations	Cost
43	1	$206,250	25	$61
44	0	0	2587	$78,464
45	0	0	2267	$68,758
46	0	0	3331	$101,029
47	0	0	1303	$39,520
48	2	$445,000	1	$61
49	0	0	338	$10,252
50	848	$263,763,750	1594	$48,346
51	786	$299,966,875	1089	$33,029
52	6838	$2,300,775,000	7628	$231,357
53	360	$256,581,875	1557	$38,125
54	808	$396,536,875	1548	$46,951
Totals	**25,419**	**$10,803,744,154**	**95,931**	**$2,899,820**

* Costs by reach include contingencies.

Figure 73 – Plan NSC-2 Dry and Wet Floodproofing w/FWEE Upgrades (A1)

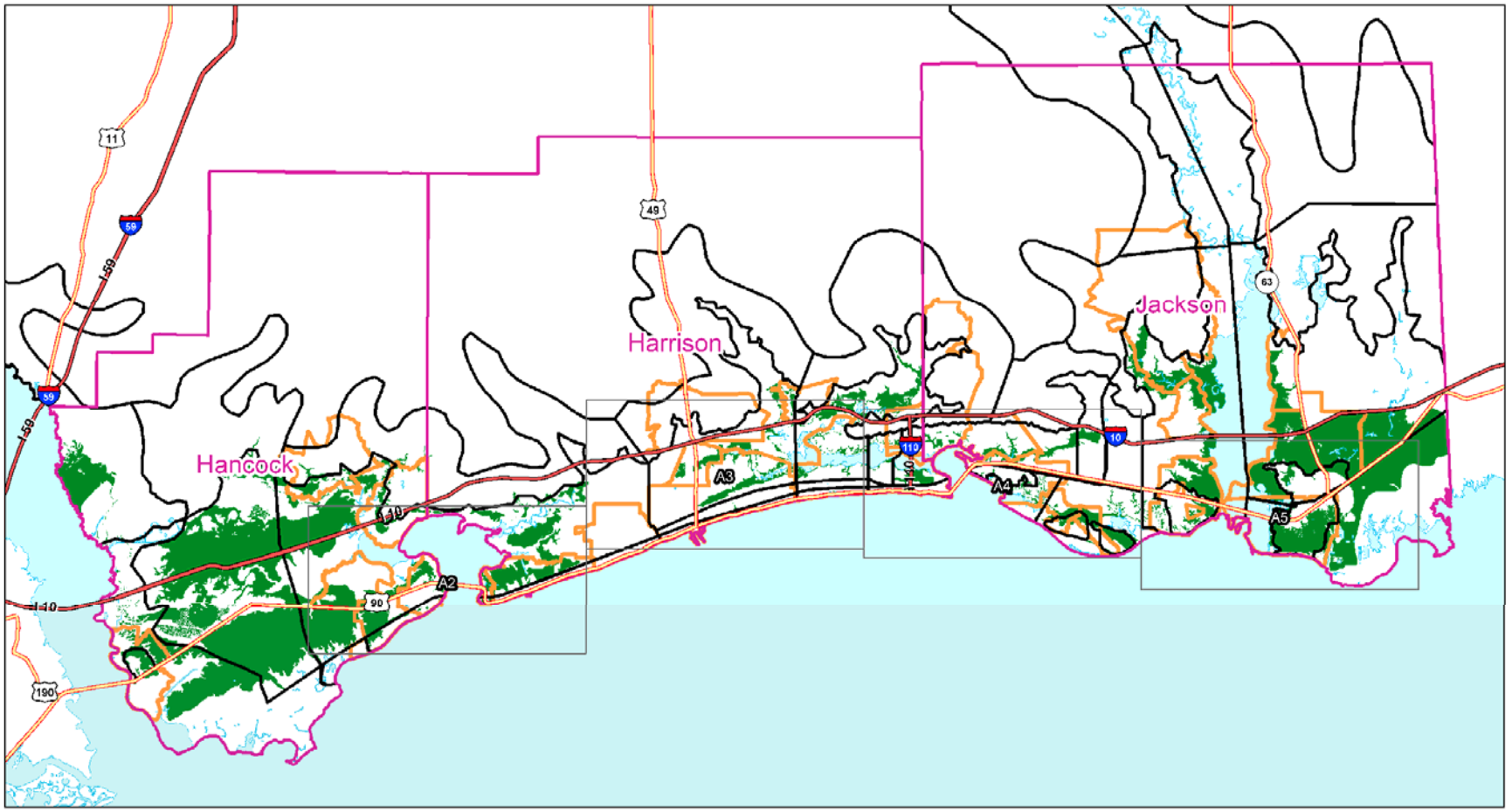


Figure 74 – Plan NSC-2 Dry and Wet Floodproofing w/FWEE Upgrades (A2)

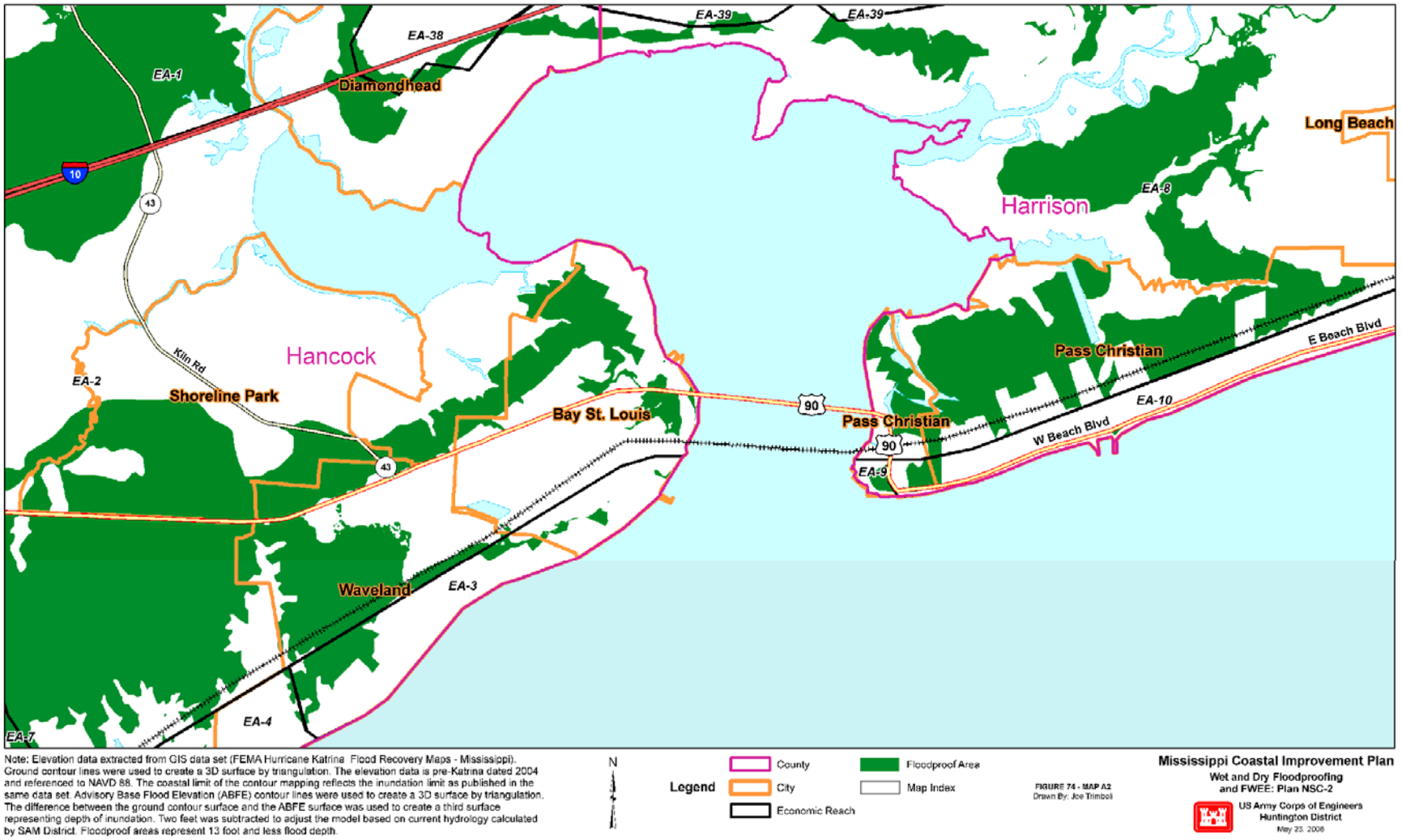


Figure 75 – Plan NSC-2 Dry and Wet Floodproofing w/FWEE Upgrades (A3)

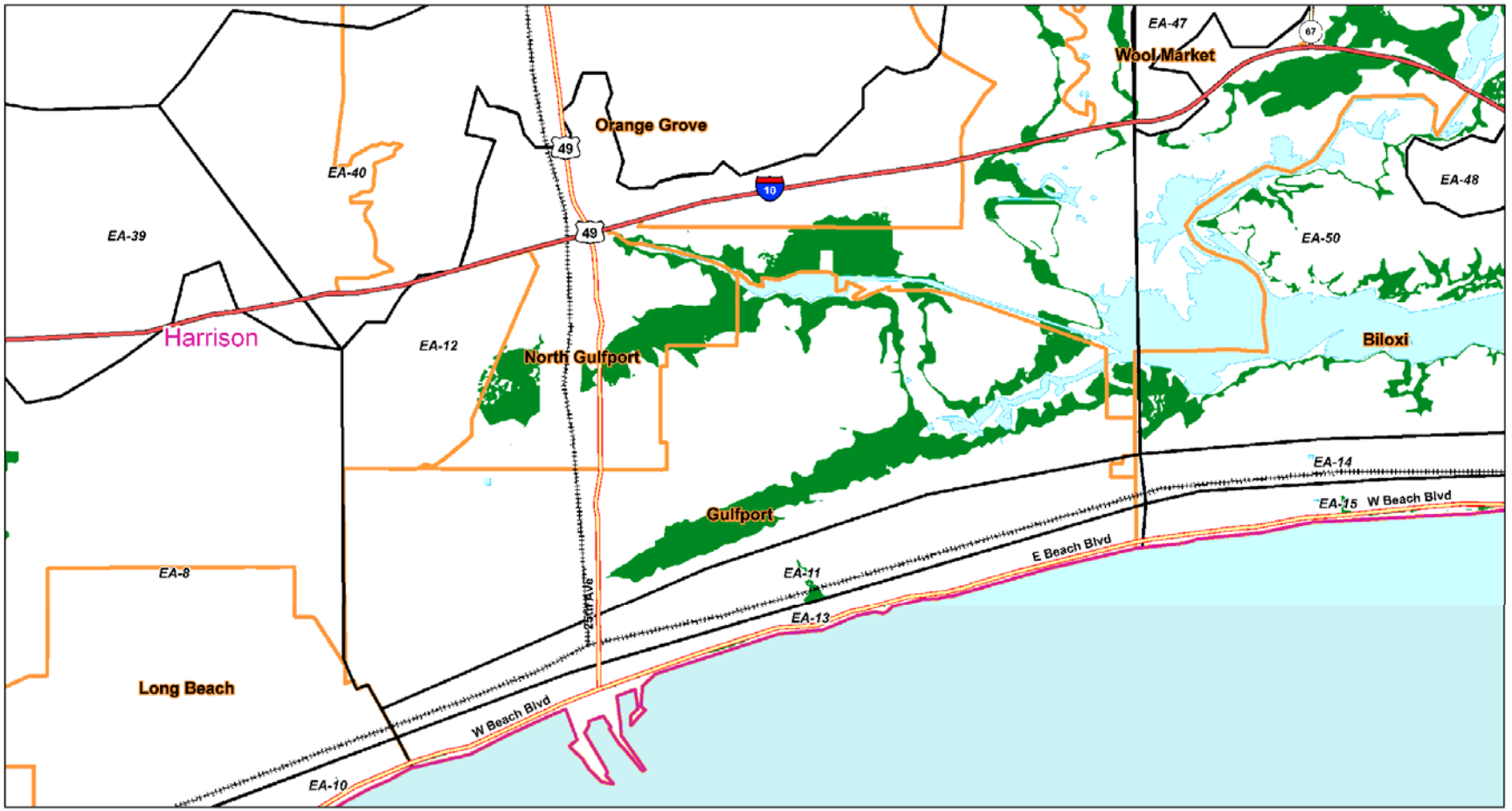


Figure 76 – Plan NSC-2 Dry and Wet Floodproofing w/FWEE Upgrades (A4)

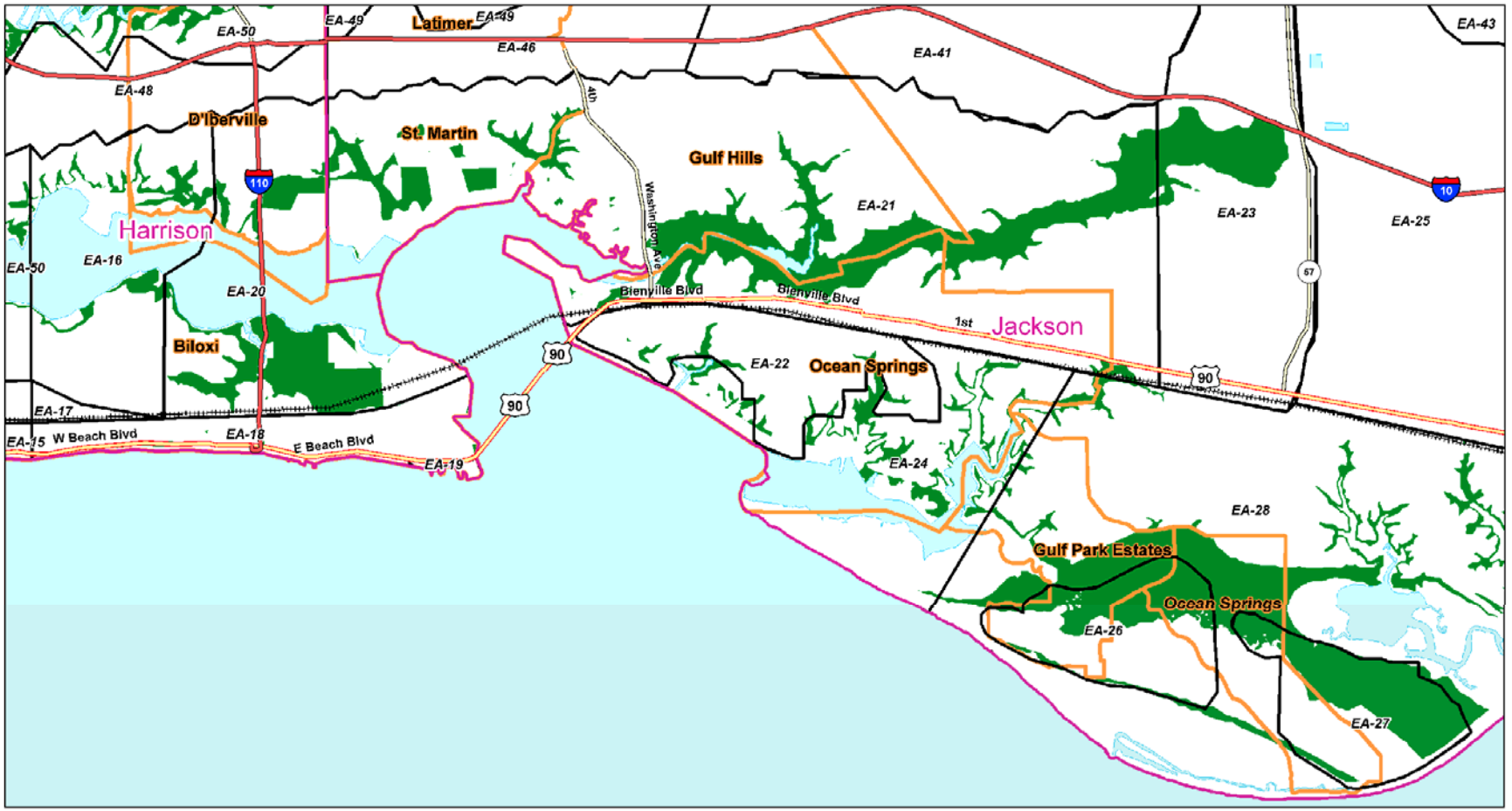
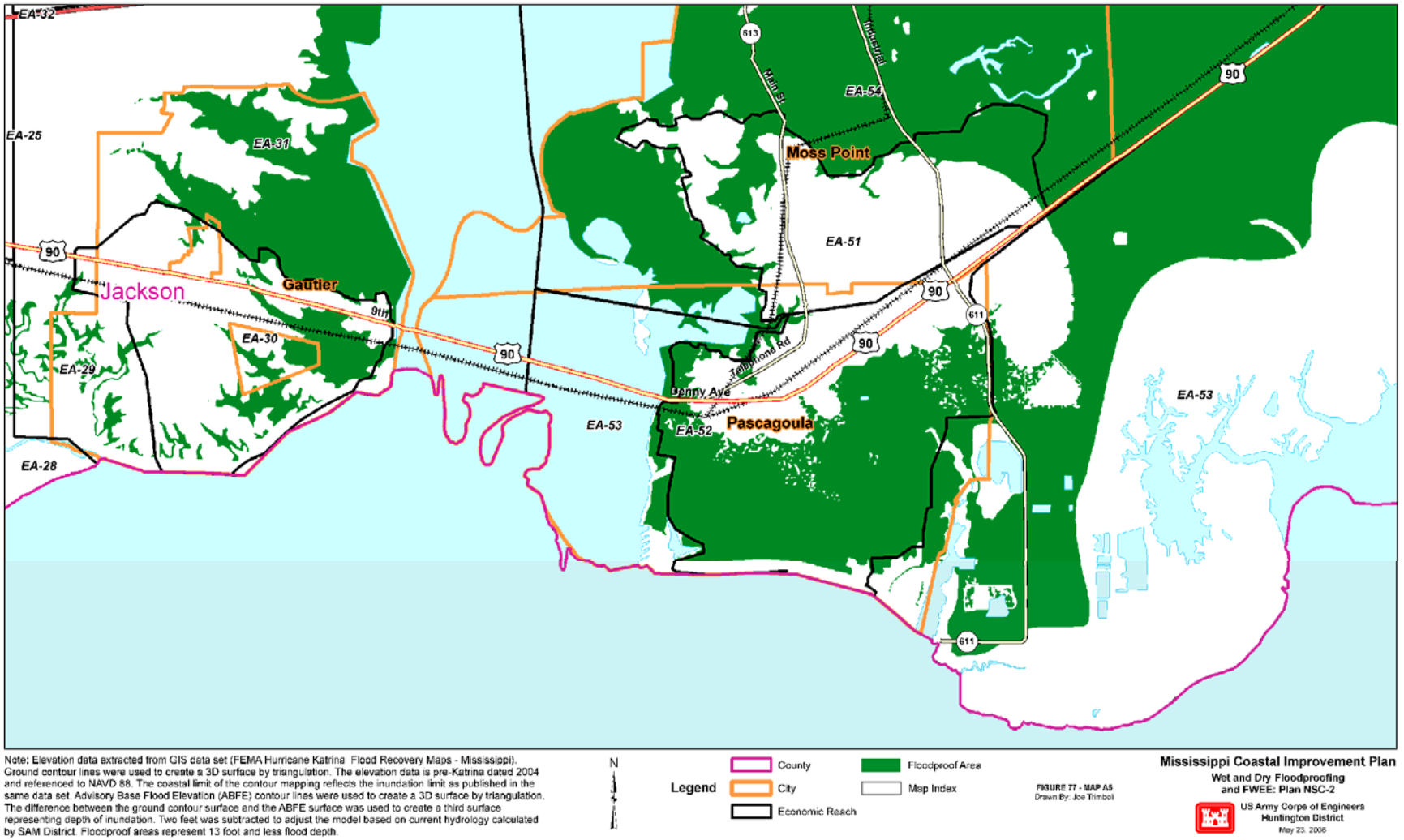


Figure 77 – Plan NSC-2 Dry and Wet Floodproofing w/FWEE Upgrades (A5)



6.7.2.3. Plan NSC-3 – Joint Federal/Non-Federal Jurisdiction Plan

This plan includes an integrated combination of measures that can be accomplished by the Federal government and State and local governments. In effect, this plan is a combination of Plan NSC-1 and Plan NSC-4 integrating all of the components found in both plans. Integration of the measures in each separate plan is complicated by the fact that some of the measures that can effectively reduce flood damages and address losses of life are similar in their effect, but widely different in their application (i.e. Permanent Acquisition and either TDR or PDR) on individual parcels – a combinability issue. Through a collaborative effort, the decisions as where to apply these dissimilar measures would be determined by the USACE, FEMA and State and local agencies and departments. Numbers of structures protected by this plan and the approximate costs are shown in Table 22. Figures 78 through 82 show the application of the various measures described below.

As in Plan NSC-1, this plan would provide protection for structures determined to be eligible for the program as a result of suffering damages from Katrina. The Base Flood Elevation established by the new DFIRM from FEMA would be the minimum level of protection afforded by this plan to be in concert with local floodplain ordinances. Briefly, the plan would consist of permanent acquisitions, floodproofing, relocations of public buildings, flood preparedness and emergency evacuations, floodplain zoning and ordinance enforcement, building codes, land use zoning, development impact fees, redirection of development and either TDR or PDR or both. This suite of nonstructural options applied judiciously across the project area could reduce damages substantially and significantly reduce losses of life due to surge flooding and waves from hurricanes and storms. This plan would require direct expenditures (outside of a normal cost sharing arrangement) of both Federal and non-Federal funds to accomplish the proposed measures – an opportunity for significant in-kind contributions by the non-Federal partner to the overall project cost.

Permanent acquisitions of structures and facilities located in defined high-hazard zones with application of full relocations assistance from the Uniform Relocations Act would reduce the numbers of at-risk structures in these hazardous areas. From a plan formulation standpoint, all acquisitions were considered to be mandatory.

In addition to the structures located in high-hazard zones, other structures located where water depths exceed 13 feet would be acquired as well. Approximately 33,100 parcels (approximately 17,100 structures) would be purchased in this action. Although many of the parcels in the high-hazard zone were found to be vacant immediately after Katrina, it is anticipated (as described in the future without-project condition) that most if not all of the vacant parcels will be rebuilt upon by the time this plan would be implemented. The acquisition costs contain structure and land costs, relocations assistance and structure demolition. The total estimated cost of the permanent acquisition measures (high-hazard zones and areas with water depth greater than 13 feet) is $7.9B.

The acquisition plan could be implemented jointly by the Corps through an authorized project and through FEMA's HMGP program discussed earlier. Since the HMGP funds are administered locally by municipal and county governments in accordance with approved mitigation plans, coordination of those plans with the proposed nonstructural acquisitions in the Corps plan would be paramount in achieving a successful program. In addition, since the HMGP targets primarily insured structures and properties, the Corps' acquisition program could concentrate its resources on uninsured properties in the high-hazard zones. Under any number of possible acquisition scenarios, the high-hazard zones would be cleared of existing structures and facilities (with the exception of certain entertainment, military and industrial uses). Site specific emergency evacuation plans would be prepared for those land uses that could not be removed from high-hazard zones.

In comparison to Plan NCS-1 which relies heavily on direct purchase of properties through the acquisition program, Plan NSC-3 opens the potential for using either TDR or PDR to secure property

development rights indefinitely without owning the property. Using these proven techniques, the counties could secure the development rights of those vacant properties indefinitely while leaving the owner responsible for maintaining the property and paying property taxes (at a somewhat reduced rate). As those programs are funded and administered by state or local governments, costs to the Federal government for reducing flood damages on that vacant property would be zero while accomplishing the same results indefinitely. A beneficial impact of using the TDR program would be the potential for increasing development densities north of the I-10 corridor where redevelopment communities could be established under the program. The TDR and PDR programs would cost approximately $1.5M to establish and would require annual non-Federal sponsor funding to purchase properties.

In consideration of the number of households that could be displaced as a result of a large acquisition program as described above and the slow redevelopment process in the project area, one or more redevelopment sites would be constructed to accommodate these displaced homeowners and renters. Those redevelopment sites would be selected in close coordination with local planning agencies and community leaders. The redevelopment sites would be planned with standard subdivision amenities and designed and constructed according to local subdivision regulations (where present). Site grading, stormwater drainage, streets, access roads, utilities, platted lots, lighting and signage would be provided for each new subdivision. Relocation funds through the application of the Uniform Relocations Act would provide necessary resources for displaced landowners to construct replacement housing at these flood-safe sites. Total costs of the redevelopment sites are estimated to be $270.0M (based upon a per-lot development cost of $45,000 and 6,000 lots).

As described in Plan NSC-1, voluntary floodproofing in all of its forms would be applied across the project area for eligible structures in this plan. First floor elevation up to 15 feet from the ground surface would be used on residential, commercial and institutional structures as determined to be appropriate for the use and available lot space. Those structures that could not be elevated in-place would be either acquired (see acquisitions above) or offered a rebuilt, floodproofed structure on-site. In any case the most cost effective alternative would be offered to the landowner. For those structures that could not be protected by elevation, other techniques such a dry floodproofing (veneer wall, wall sealants, ringwall, ring-levee, etc.) would be considered. Again, the most cost effective option (floodproofing, acquisition, or rebuilt on-site) would be offered to the landowner. Special needs of the household (handicapped occupants or elderly) can be considered in the access design to the elevated first floor. On-site utilities would be modified to service the raised structure and a 300 square foot enclosed area would be constructed beneath the raised first floor for storage and utility chase. Total estimated costs for elevation of eligible structures (25,419) to the BFE are $10.8B. Table 22 shows the numbers and costs of floodproofing by economic reach.

Public buildings that could not be floodproofed in-place because of their location in a high-hazard zone, depth of flooding or other limitations would be relocated through a relocations contract and reconstructed to current day standards. Approximately 7 public buildings, some of which are considered as critical facilities would be eligible for relocations to a flood safe site. The total estimated cost of those relocations would be approximately $51.2M as shown on Table 22.

Modification and updating of current floodplain zoning and floodplain management ordinances would be implemented by the 11 municipalities and three counties to help reduce flood damages to new construction and rehabilitation of damaged structures. Each of the local jurisdictions would adopt the anticipated new DFIRM's and make necessary modifications within their existing floodplain management ordinances to enforce the new floodplain mapping. In addition, all three counties and 10 municipal areas (Pascagoula exempted) would adopt cumulative, storm-related damages (period of accumulation determined by each locality) as the value (along with improvements value) that triggers compliance with NFIP regulations when compared to 50 percent of the structure value. Also,

local jurisdictions would adopt the FEMA 550 guidelines for floodproofing on the Gulf Coast as a part of their floodplain management ordinances so that any new construction in flood-prone areas would be using flood resistant materials and reliable construction techniques. Estimated costs for this measure would be $280,000 in the project area.

Local jurisdictions would adopt the newly revised International Building Code (2006) and provide training for their staff and primary users in the community. Enforcement of the updated codes would help to assure that new construction or any rehabilitation of existing structures would be completed in such a manner as to reduce future flood damages. Adoption of the new codes would take place through appropriate administrative procedures with public involvement and comment. Any training or education seminars concerning use of the new codes would be arranged with the IBC Association at minimal cost since the construction permit process collects fees to offset these costs.

The various municipalities and counties would make modifications to their existing zoning ordinances that would change the types and densities of land uses that could be developed in identified flood-hazard areas. This coastal zoning could take one of two pathways: either very low density development in the higher hazard zones along the coast (just short of a taking) or a mixed use (commercial and high-density residential) that crowds the beachfront with high-rise condominiums and commercial business and entertainment. In addition, counties would revise zoning ordinances to allow higher densities of development (especially residential and commercial) in the flood-free zones. Costs to modify the ordinances as well as the supporting comprehensive plans are estimated to be $500,000 in the project area. To thwart development of new land uses in hazard zones, counties and municipalities would revise their subdivisions regulations such that development in high-hazard zones would be accomplished in such a way to reduce flood damages. Also, development impact fees would be instituted for all new subdivisions with individual lots that are subject to flooding. The costs to initiate this fee structure are estimated to be $370,000 within the project area.

To reduce flood damages and the potential for loss of life, the local jurisdictions would initiate activities identified in flood preparedness, emergency evacuations and public education. Activities such as installation of warning sirens and flashing lights at strategic locations within the communities as well as the purchase and distribution of weather radios to citizens would help to warn at-risk occupants of impending hurricane and storm related flooding. In addition, local jurisdictions would disseminate information brochures on potential hurricane threats and emergency measures to schools, chamber of commerce, hotels and motels and all ports of entry (airports, visitor centers) so that both residents and tourists would be better informed of the threats and evacuation procedures. In cooperation with MDOT the counties could install hurricane evacuation route signage and make minor modifications to intersection signaling that would facilitate the movement of evacuees. In addition, the counties could arrange for the emergency usage of county-owned schools and community centers (located outside of the surge inundation zone) as evacuation centers as well as stockpiling supplies at those centers for emergency use. The estimated cost to implement these improvements to the system is approximately $2.9M.

With all components of the plan combined, the estimated total cost of Plan NSC-3 is $19.1B.

Table 22
NCS-3 – Combined Federal/Non-Federal Jurisdiction Plan

Economic Reaches	Permanent Acquisition Parcels	Cost	Flood proofing	Cost	Relocations	Cost	Flood Warning and Emergency Evacuations	Cost	Floodplain Management	Cost	Land Use Zoning	Cost	TDR & PDR	Cost	Development Impact Fees	Cost
1	997	$194,118,218	394	$124,162,500	0	0	2062	$62,540	2062	$6,042	2062	$10,784	718	$38,715	718	$9,549
2	9911	$2,992,128,131	3294	$1,910,805,000	0	0	19363	$587,280	19363	$56,734	19363	$101,268	6248	$336,892	6248	$83,098
3	2202	$668,691,437	376	$333,327,500	0	0	2673	$81,072	2673	$7,832	2673	$13,980	182	$9,813	182	$2,421
4	922	$120,307,917	16	$30,715,000	0	0	901	$27,327	901	$2,640	901	$4,712	6	$324	6	$80
5	2714	$238,388,794	119	$79,272,500	0	0	3109	$94,296	3109	$9,109	3109	$16,260	346	$18,656	346	$4,602
6	567	$107,292,775	590	$311,335,000	1	$8,536,147	1123	$34,061	1123	$3,290	1123	$5,873	10	$539	10	$133
7	450	$33,303,080	232	$186,928,125	0	0	1574	$47,739	1574	$4,612	1574	$8,232	1012	$54,567	1012	$13,460
8	3623	$476,153,333	1730	$691,816,250	4	$25,608,442	8716	$264,356	8716	$25,538	8716	$45,585	4772	$257,306	4772	$63,468
9	44	$16,145,783	16	$16,552,500	0	0	52	$1,577	52	$152	52	$272	16	$863	16	$213
10	1945	$432,607,234	62	$24,201,250	0	0	1727	$52,380	1727	$5,060	1727	$9,032	32	$1,725	32	$426
11	0	0	8	$2,105,000	0	0	44	$1,335	44	$129	44	$230	36	$1,941	36	$479
12	1047	$179,783,825	1136	$438,818,125	0	0	2777	$84,226	2777	$8,137	2777	$14,524	849	$45,778	849	$11,292
13	650	$583,121,543	0	0	0	0	500	$15,165	500	$1,465	500	$2,615	0	0	0	0
14	0	0	0	0	0	0	788	$23,900	788	$2,309	788	$4,121	221	$11,897	221	$2,935
15	85	$44,354,843	9	$28,406,250	0	0	76	$2,305	76	$223	76	$397	1	$54	1	$13
16	78	$16,399,728	121	$38,542,500	0	0	209	$6,339	209	$612	209	$1,093	35	$1,887	35	$466
17	0	0	0	0	0	0	6	$182	6	$18	6	$31	2	$91	2	$22
18	1502	$409,463,532	5	$1,396,250	0	0	1223	$3,7094	1223	$3,583	1223	$6,396	3	$162	3	$40
19	46	$292,728,063	0	0	0	0	22	$667	22	$64	22	$115	0	0	0	0
20	1397	$238,563,082	2050	$853,008,125	1	$8,536,147	3064	$92,931	3064	$8,978	3064	$16,025	592	$31,921	592	$7,874
21	2108	$301,824,272	419	$174,587,500	0	0	1867	$56,626	1867	$5,470	1867	$9,764	497	$26,798	497	$6,610
22	61	$26,330,663	92	$44,933,750	0	0	157	$4,762	157	$460	157	$821	4	$216	4	$53
23	0	0	44	$24,735,000	0	0	65	$1,971	65	$190	65	$340	42	$2,265	42	$559
24	220	$65,229,821	178	$58,153,750	0	0	524	$15,893	524	$1,535	524	$2,741	119	$6,416	119	$1,583
25	0	0	0	0	0	0	327	$9,918	327	$958	327	$1,710	92	$4,937	92	$1,218
26	37	$9,210,336	952	$321,001,875	0	0	1279	$38,792	1279	$3,747	1279	$6,689	289	$15,583	289	$3,844
27	53	$12,880,944	1029	$264,738,125	0	0	2145	$65,058	2145	$6,285	2145	$11,218	1063	$57,317	1063	$14,138
28	961	$90,294,697	122	$59,837,500	0	0	1718	$52,107	1718	$5,034	1718	$8,985	633	$34,131	633	$8,419
29	147	$23,394,829	168	$63,560,625	0	0	546	$16,560	546	$1,600	546	$2,856	231	$12,456	231	$3,072
30	90	$29,459,003	467	$197,030,000	0	0	626	$18,987	626	$1,834	626	$3,274	64	$3,451	64	$851
31	51	$14,959,829	447	$209,015,000	0	0	708	$21,474	708	$2,074	708	$3,703	307	$16,553	307	$4,083
32	0	0	208	$64,368,750	0	0	398	$12,071	398	$1,166	398	$2,082	269	$14,504	269	$3,578
33	0	0	0	0	0	0	77	$2,335	77	$226	77	$403	22	$1,163	22	$287
34	0	0	0	0	0	0	600	$18,198	600	$1,758	600	$3,138	168	$9,059	168	$2,234
35	12	$682,228	1406	$431,113,125	0	0	1599	$48,498	1599	$4,685	1599	$8,363	758	$40,871	758	$10,081
36	32	$3,834,485	2	$6,312,500	0	0	62	$1,880	62	$182	62	$324	51	$2,750	51	$678
37	0	0	0	0	0	0	540	$16,378	540	$1,582	540	$2,824	151	$8,153	151	$2,011
38	50	$21,424,866	78	$19,440,625	0	0	364	$11,040	364	$1,067	364	$1,904	259	$13,965	259	$3,445
39	0	0	6	$1,204,375	0	0	25	$758	25	$73	25	$131	19	$1,024	19	$253
40	0	0	0	0	0	0	7824	$237,302	7824	$22,924	7824	$40,920	2191	$118,124	2191	$29,137
41	0	0	0	0	0	0	536	$16,257	536	$1,570	536	$2,803	150	$8,092	150	$1,996
42	0	0	0	0	0	0	667	$20,230	667	$1,954	667	$3,488	187	$10,070	187	$2,484
43	0	0	1	$206,250	0	0	25	$61	25	$6	25	$10	1	$54	1	$13
44	0	0	0	0	0	0	2587	$78,464	2587	$7,580	2587	$13,350	724	$39,057	724	$9,634
45	0	0	0	0	0	0	2267	$68,758	2267	$6,642	2267	$11,856	635	$34,226	635	$8,442

Economic Reaches	Permanent Acquisition Parcels	Cost	Flood proofing	Cost	Relocations	Cost	Flood Warning and Emergency Evacuations	Cost	Floodplain Management	Cost	Land Use Zoning	Cost	TDR & PDR	Cost	Development Impact Fees	Cost
46	0	0	0	0	0	0	3331	$101,029	3331	$9,760	3331	$17,421	933	$50,290	933	$12,405
47	0	0	0	0	0	0	1303	$39,520	1303	$3,818	1303	$6,815	365	$19,672	365	$4,852
48	0	0	2	$445,000	0	0	1	$61	1	$6	1	$10	0	0	0	0
49	0	0	0	0	0	0	338	$10,252	338	$990	338	$1,768	95	$5,103	95	$1,259
50	495	$89,312,661	848	$263,763,750	0	0	1594	$48,346	1594	$4,670	1594	$8,337	410	$22,107	410	$5,453
51	0	0	786	$299,966,875	0	0	1089	$33,029	1089	$3,191	1089	$5,695	302	$16,284	302	$4,017
52	285	$103,016,211	6838	$2,300,775,000	1	$8,536,147	7628	$231,357	7628	$22,350	7628	$39,894	485	$26,151	485	$6,451
53	399	$113,054,873	360	$256,581,875	0	0	1557	$38,125	1557	$3,683	1557	$6,574	499	$26,906	499	$6,637
54	9	$1,114,862	808	$396,536,875	0	0	1548	$46,951	1548	$4,536	1548	$8,096	726	$39,146	726	$9,656
Subtotals	**33,191***	**$7,928,411,301**	**25,419**	**$10,803,744,154**	**7**	**$51,216,883**	**95,931**	**$2,899,820**	**95,931**	**$280,133**	**95,931**	**$499,852**	**27,822**	**$1,500,025**	**27,822**	**$370,004**
H&CD Sites		Jackson, Harrison and Hancock Counties				6,000 lots in 3 counties at $45,000 per lot								Total Cost for H&CD sites - **$270,000,000**		
Safe harborages		Jackson, Harrison and Hancock Counties				3 safe harborages – $7.7M each								Total Cost of Safe Harborages - **$23,100,000**		
Total Plan Cost														**$19,082,022,338**		

Notes: 1) The numbers of tracts listed under the TDR/PDR and Development Impact Fees measures are estimated vacant tracts within each reach to which the measures would be applied.

2) Building Codes as a measure were omitted from the table due to space limitations in the table. There are no project costs for upgrading and enforcing building codes since the building construction permitting fee system reimburses the administrative costs for this local measure. The parcels affected by the building codes and the $0 cost is shown in Table 23 for Plan NSC-4.

* The total number of parcels eligible for purchase contain approximately 17,100 structures (residential and commercial)

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Figure 78 – Plan NSC-3 Joint Federal/Non-Federal Jurisdiction Plan (A1)

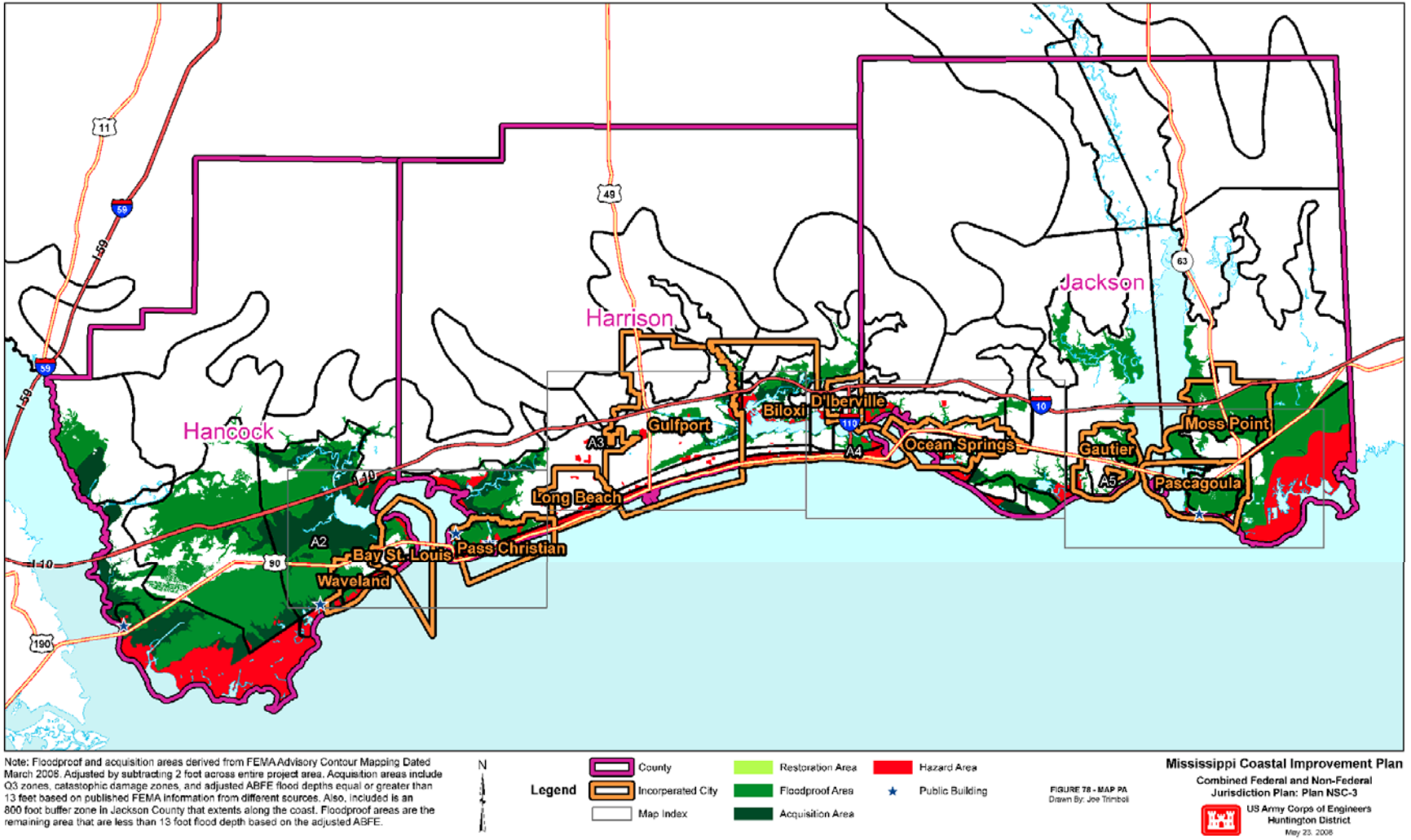


Figure 79 – Plan NSC-3 Joint Federal/Non-Federal Jurisdiction Plan (A2)

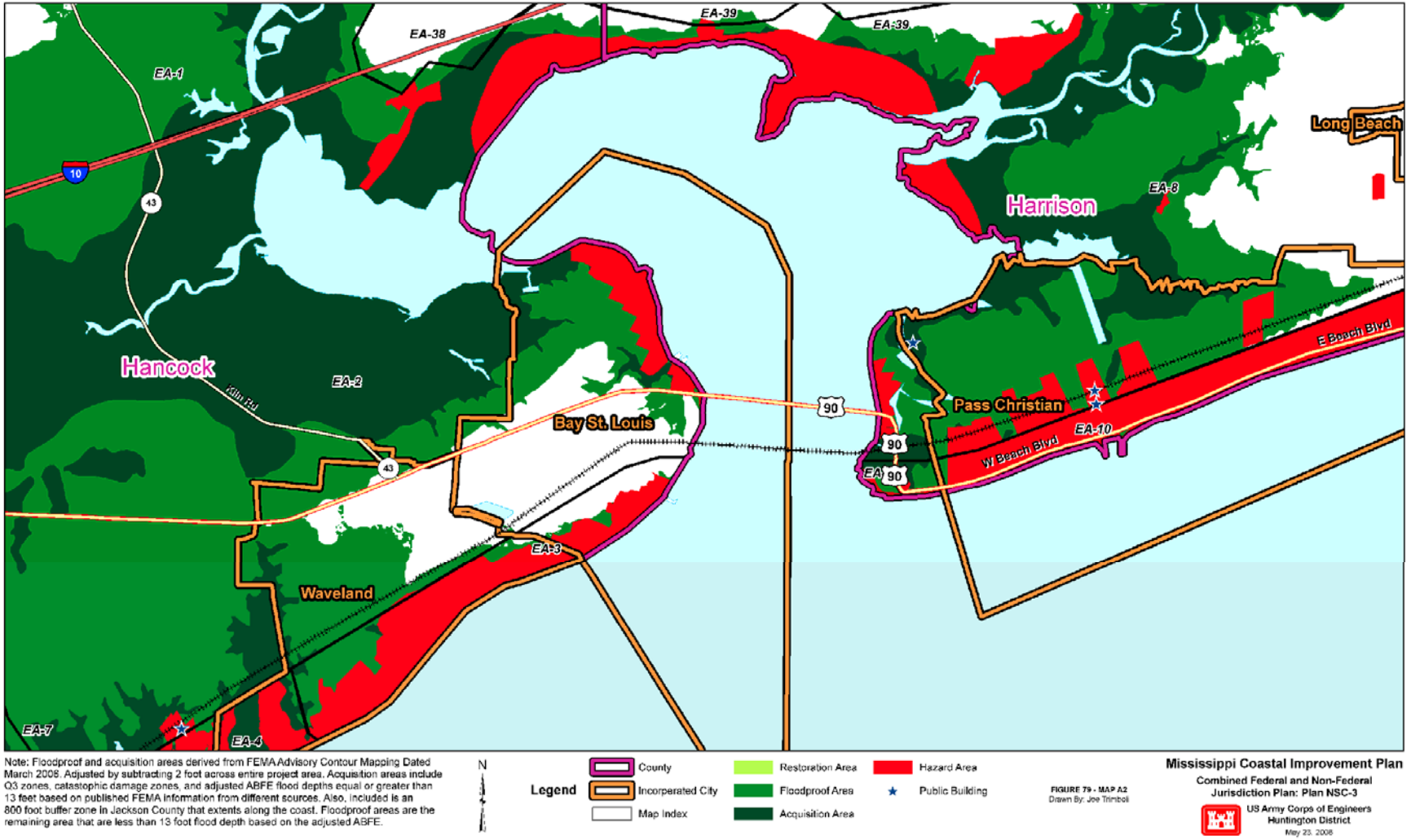


Figure 80 – Plan NSC-3 Joint Federal/Non-Federal Jurisdiction Plan (A3)

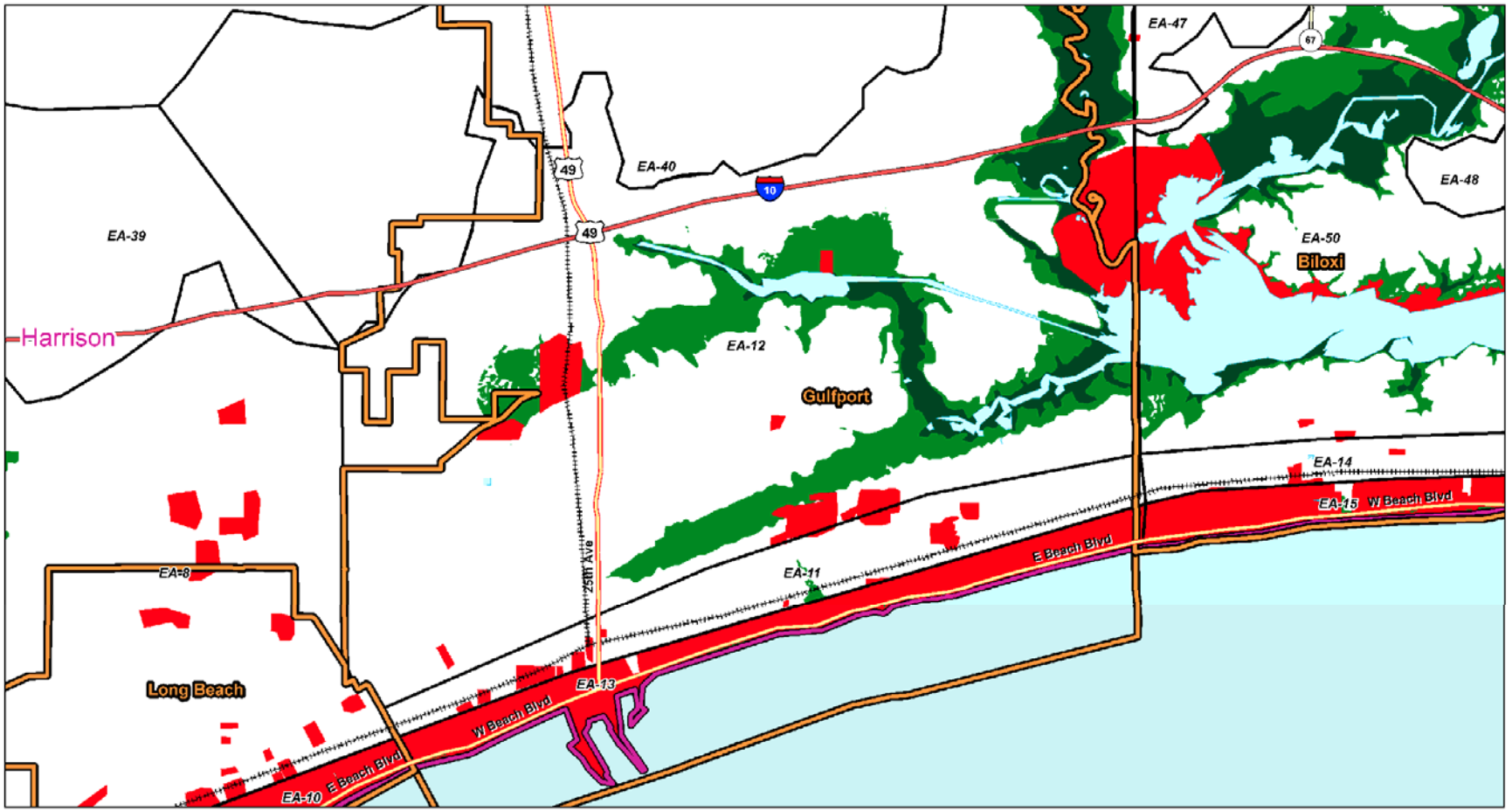


Figure 81 – Plan NSC-3 Joint Federal/Non-Federal Jurisdiction Plan (A4)

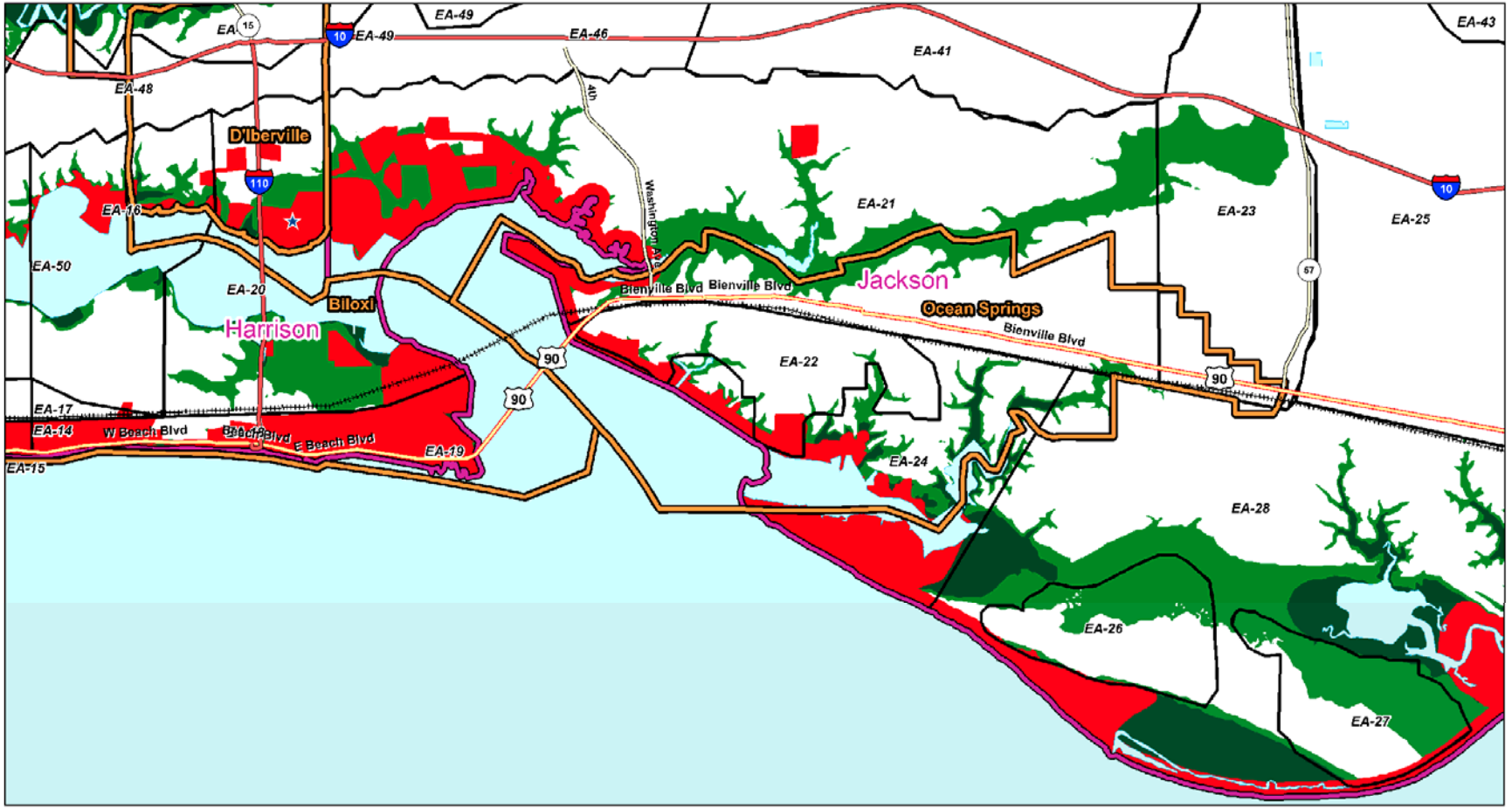
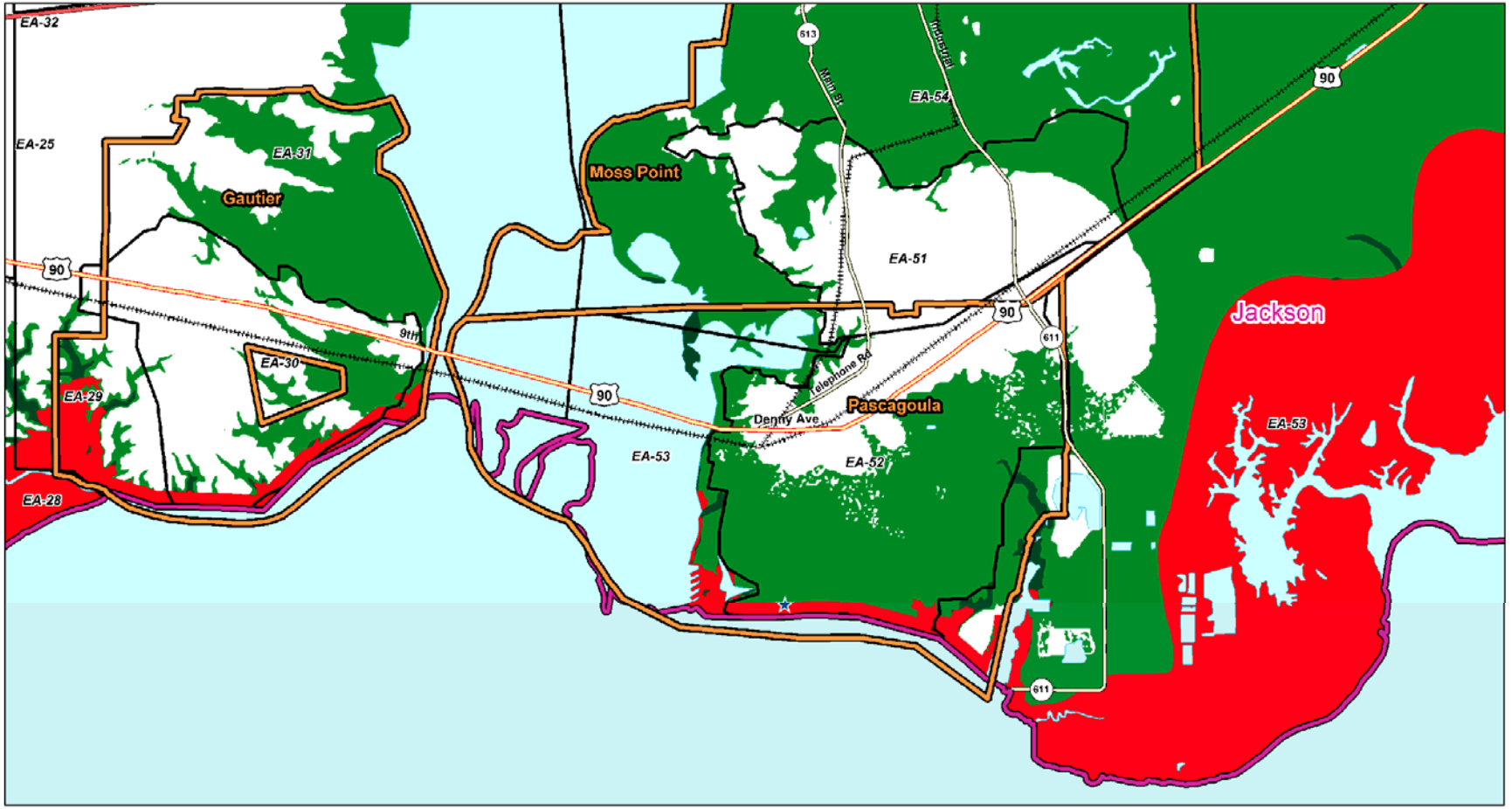


Figure 82 – Plan NSC-3 Joint Federal/Non-Federal Jurisdiction Plan (A5)



In an effort to redirect new development away from high-hazard flooding areas, the local jurisdictions (especially the three counties) would establish either a Transfer of Development Rights or Purchase of Development Rights program within each of the three counties in the project area. Prior to establishing one or more of these programs, the local jurisdictions would have to petition the state legislature through their local representatives to enact enabling legislation that would authorize the three affected counties (and other jurisdictions as may be applicable) within the project area to create the necessary organizations (non-profit) that would administer the TDR and/or PDR programs. Once the enabling legislation is in place, the counties could establish non-profit organizations that would administer the programs and provide start-up funding for administration costs.

Then, in cooperation with the Corps of Engineers, the non-profit organizations would determine the boundaries of the sending (high-hazard zone) and receiving (flood-safe areas) districts for the TDR program or determine only the high-hazard zone from which development rights would be purchased under a PDR program. With property valuation information from the tax assessor's office, the non-profit organization would calculate monetary amounts for the development rights on each property in the sending area. In addition to these programmatic activities, the local jurisdictions would implement a project-wide advertisement and education program informing people of the flood-damage reduction benefits of the TDR/PDR programs and to encourage participation in this voluntary program. In the absence of a Federally-funded permanent acquisition program for the high-hazard zones, the non-profit organization would be unencumbered in their program to either transfer or purchase development rights in those delineated zones. The estimated administrative costs to initiate the TDR and PDR programs are $1.5M ($500,000 for each planning unit). Total acquisition costs for a PDR program may approximate between 60 and 80 percent of the total Federal purchase costs since only the development rights portion of the total land rights package would be acquired. Landowners would retain the land value and continue to operate and maintain the property while assuming a much reduced property tax burden.

6.7.2.4 Plan NSC-4 – Non-Federal Jurisdiction Plan

This plan consists of measures that can be enacted by the local municipalities and counties to reduce flood damages and loss of life. Over 95,000 individual parcels of land in the project area would be affected by these measures enacted by the municipal and county governments. The approximate numbers of parcels that would be affected by these measures and the estimated costs (local and administrative) to implement the measures are shown in Table 23 by economic reach. Figures 83 through 87 show the areas of county and municipal jurisdiction where these measures would be applied.

Implementation of each of these measures is through the police powers granted to individual municipal and county governments by the state and is generally outside the purview of the Federal or state Government. Their implementation would be contingent in part upon the local perception of the flood risks, the political will of the local government leadership and the willingness to invest local funds in the needed changes. The costs of these measures would be largely borne by local jurisdictions (see below for exceptions) and therefore do not generate Federal project costs per se, but there would be flood damage reduction benefits (albeit difficult to quantify) accruing to the project area. The benefits of these locally implemented measures would be found in the incremental inundation damages that would be suffered in the absence of upgrades to the existing control and enforcements systems recommended in this plan.

Some funding for the proposed measures (i.e. Flood Preparedness and Public Education) may be provided by Federal or state agencies (FEMA, MEMA), but generally the administration of the measures would be through local jurisdictions. Although the NFIP is a Federal program administered through FEMA, enforcement of the floodplain ordinances and zoning mapping is clearly the responsibility of local jurisdictions. The ability of the local governments to enact and administer either a TDR or PDR program would be based upon enabling legislation enacted by the state legislature.

Modification and updating of current floodplain zoning and floodplain management ordinances would be implemented by the 11 municipalities and three counties to help reduce flood damages to new construction and rehabilitation of damaged structures. Each of the local jurisdictions would adopt the anticipated new DFIRM's and make necessary modifications within their existing floodplain management ordinances to enforce the new floodplain mapping. In addition, each county and municipality (Pascagoula exempted) would adopt the concept of cumulative storm-related damages as a trigger for determining when a structure must comply with NFIP regulations. Also, local jurisdictions would adopt the FEMA 550 guidelines for floodproofing on the Gulf Coast as a part of their floodplain management ordinances so that any new construction in flood-prone areas would be using flood resistant materials and reliable construction techniques. The estimated administrative and legal costs to update and modify the local ordinances across the project area are $280,000 for the 11 municipalities and 3 counties.

Local jurisdictions would adopt the newly revised International Building Code (circa 2006) and provide training for their staff and primary users in the community. All of the local jurisdictions are using at least the 2003 IBC standards now. Enforcement of the updated codes would help to assure that new construction or any rehabilitation of existing structures would be completed in such a manner as to reduce future flood damages. Adoption of the new codes would take place through appropriate administrative procedures with public involvement and comment. Costs to modify the codes would be offset by building permit fees charged by the municipalities and counties. Any training or education seminars concerning use of the new codes would be arranged with the IBC Association at minimal cost.

The various municipalities and counties would make modifications to their existing zoning ordinances that would change the types and densities of land uses that could be developed in identified flood-hazard areas. This coastal zoning could take one of two pathways: either very low density development in the higher hazard zones along the coast (just short of a taking) or a mixed use (commercial and high-density residential) that crowds the beachfront with high-rise condominiums and commercial business and entertainment. In addition, counties would revise zoning ordinances to allow higher densities of development (especially residential and commercial) in the flood-free zones. To thwart development of new land uses in hazard zones, counties and municipalities would revise their subdivision regulations such that development in high-hazard zones would be accomplished in such a way to reduce flood damages. Also, development impact fees would be instituted for all new subdivisions with individual lots that are subject to flooding at an approximate local cost of $370,000. The estimated cost for modifying the zoning ordinances across the project area is $500,000 and is largely composed of local administrative and legal costs.

To reduce flood damages and the potential for loss of life, the local jurisdictions would initiate activities identified in flood preparedness, emergency evacuations and public education. Activities such as installation of warning sirens and flashing lights at strategic locations within the communities as well as the purchase and distribution of weather radios to citizens would help to warn at-risk occupants of impending hurricane and storm related flooding. In addition, local jurisdictions would disseminate information brochures on potential hurricane threats and emergency measures to schools, chamber of commerce, hotels and motels and all ports of entry (airports, visitor centers) so that both residents and tourists would be better informed of the threats and evacuation procedures. In cooperation with MDOT the counties could install hurricane evacuation route signage and make

minor modifications to intersection signaling that would facilitate the movement of evacuees. In addition, the counties could arrange for the emergency usage of county owned schools and community centers as evacuation centers as well as stockpiling supplies at those centers for emergency use. The estimated cost to implement the upgrades to this system is $2.9M.

In an effort to redirect new development away from high-hazard flooding areas, the local jurisdictions (especially the three counties) would establish either a Transfer of Development Rights or Purchase of Development Rights program within each of the three counties in the project area. Prior to establishing one or more of these programs, the local jurisdictions would have to petition the state legislature through their local representatives to enact enabling legislation that would authorize the three affected counties (and other jurisdictions as may be applicable) within the project area to create the necessary organizations (non-profit) that would administer the TDR and/or PDR programs. Once the enabling legislation is in place, the counties would establish non-profit organizations that would administer the programs and provide start-up funding for administration costs. Then, in cooperation with the Corps of Engineers, the non-profit organizations would determine the boundaries of the sending (high-hazard flood-prone) and receiving (flood-safe) districts for the TDR program or determine only the high-hazard areas from which development rights would be purchased under a PDR program. With property valuation information from the tax assessor's office, the non-profit organization would calculate monetary amounts for the development rights on each property in the sending area.

In addition to these programmatic activities, the local jurisdictions would implement a project wide advertisement and education program informing people of the flood-damage reduction benefits of the TDR/PDR programs and to encourage participation in this voluntary program. In the absence of a Federally-funded permanent acquisition program for the high-hazard zones, the non-profit organization would be unencumbered in their program to either transfer or purchase development rights in those delineated zones. The estimated administrative cost to initiate the TDR and PDR programs is $1.5M for the three counties. Annual costs of acquiring development rights under the PDR program would be funded through non-Federal sources (state and local).

Table 23
Plan NSC-4 – Non-Federal Jurisdiction Plan

Economic Reaches	Land Use Zoning	Cost	Floodplain Management	Cost	TDR & PDR	Cost	Flood Warning and Emergency Evacuation	Cost	Building Codes	Cost	Development Impact Fees	Cost
1	2062	$10,784	2062	$6,042	718	$38,715	2062	$62,540	2062	$0	718	$9,549
2	19363	$101,268	19363	$56,734	6248	$336,892	19363	$587,280	19363	$0	6248	$83,098
3	2673	$13,980	2673	$7,832	182	$9,813	2673	$81,072	2673	$0	182	$2,421
4	901	$4,712	901	$2,640	6	$324	901	$27,327	901	$0	6	$80
5	3109	$16,260	3109	$9,109	346	$18,656	3109	$94,296	3109	$0	346	$4,602
6	1123	$5,873	1123	$3,290	10	$539	1123	$34,061	1123	$0	10	$133
7	1574	$8,232	1574	$4,612	1012	$54,567	1574	$47,739	1574	$0	1012	$13,460
8	8716	$45,585	8716	$25,538	4772	$257,306	8716	$264,356	8716	$0	4772	$63,468
9	52	$272	52	$152	16	$863	52	$1,577	52	$0	16	$213
10	1727	$9,032	1727	$5,060	32	$1,725	1727	$52,380	1727	$0	32	$426
11	44	$230	44	$129	36	$1,941	44	$1,335	44	$0	36	$479
12	2777	$14,524	2777	$8,137	849	$45,778	2777	$84,226	2777	$0	849	$11,292
13	500	$2,615	500	$1,465	0	0	500	$15,165	500	$0	0	0
14	788	$4,121	788	$2,309	221	$11,897	788	$23,900	788	$0	221	$2,935
15	76	$397	76	$223	1	$54	76	$2,305	76	$0	1	$13
16	209	$1,093	209	$612	35	$1,887	209	$6,339	209	$0	35	$466
17	6	$31	6	$18	2	$91	6	$182	6	$0	2	$22
18	1223	$6,396	1223	$3,583	3	$162	1223	$3,7094	1223	$0	3	$40
19	22	$115	22	$64	0	0	22	$667	22	$0	0	0
20	3064	$16,025	3064	$8,978	592	$31,921	3064	$92,931	3064	$0	592	$7,874
21	1867	$9,764	1867	$5,470	497	$26,798	1867	$56,626	1867	$0	497	$6,610
22	157	$821	157	$460	4	$216	157	$4,762	157	$0	4	$53
23	65	$340	65	$190	42	$2,265	65	$1,971	65	$0	42	$559
24	524	$2,741	524	$1,535	119	$6,416	524	$15,893	524	$0	119	$1,583
25	327	$1,710	327	$958	92	$4,937	327	$9,918	327	$0	92	$1,218
26	1279	$6,689	1279	$3,747	289	$15,583	1279	$38,792	1279	$0	289	$3,844
27	2145	$11,218	2145	$6,285	1063	$57,317	2145	$65,058	2145	$0	1063	$14,138
28	1718	$8,985	1718	$5,034	633	$34,131	1718	$52,107	1718	$0	633	$8,419
29	546	$2,856	546	$1,600	231	$12,456	546	$16,560	546	$0	231	$3,072
30	626	$3,274	626	$1,834	64	$3,451	626	$18,987	626	$0	64	$851
31	708	$3,703	708	$2,074	307	$16,553	708	$21,474	708	$0	307	$4,083
32	398	$2,082	398	$1,166	269	$14,504	398	$12,071	398	$0	269	$3,578
33	77	$403	77	$226	22	$1,163	77	$2,335	77	$0	22	$287
34	600	$3,138	600	$1,758	168	$9,059	600	$18,198	600	$0	168	$2,234
35	1599	$8,363	1599	$4,685	758	$40,871	1599	$48,498	1599	$0	758	$10,081
36	62	$324	62	$182	51	$2,750	62	$1,880	62	$0	51	$678
37	540	$2,824	540	$1,582	151	$8,153	540	$16,378	540	$0	151	$2,011
38	364	$1,904	364	$1,067	259	$13,965	364	$11,040	364	$0	259	$3,445
39	25	$131	25	$73	19	$1,024	25	$758	25	$0	19	$253
40	7824	$40,920	7824	$22,924	2191	$118,124	7824	$237,302	7824	$0	2191	$29,137

Economic Reaches	Land Use Zoning	Cost	Floodplain Management	Cost	TDR & PDR	Cost	Flood Warning and Emergency Evacuation	Cost	Building Codes	Cost	Development Impact Fees	Cost
41	536	$2,803	536	$1,570	150	$8,092	536	$16,257	536	$0	150	$1,996
42	667	$3,488	667	$1,954	187	$10,070	667	$20,230	667	$0	187	$2,484
43	25	$10	25	$6	1	$54	25	$61	25	$0	1	$13
44	2587	$13,350	2587	$7,580	724	$39,057	2587	$78,464	2587	$0	724	$9,634
45	2267	$11,856	2267	$6,642	635	$34,226	2267	$68,758	2267	$0	635	$8,442
46	3331	$17,421	3331	$9,760	933	$50,290	3331	$101,029	3331	$0	933	$12,405
47	1303	$6,815	1303	$3,818	365	$19,672	1303	$39,520	1303	$0	365	$4,852
48	1	$10	1	$6	0	0	1	$61	1	$0	0	0
49	338	$1,768	338	$990	95	$5,103	338	$10,252	338	$0	95	$1,259
50	1594	$8,337	1594	$4,670	410	$22,107	1594	$48,346	1594	$0	410	$5,453
51	1089	$5,695	1089	$3,191	302	$16,284	1089	$33,029	1089	$0	302	$4,017
52	7628	$39,894	7628	$22,350	485	$26,151	7628	$231,357	7628	$0	485	$6,451
53	1557	$6,574	1557	$3,683	499	$26,906	1557	$38,125	1557	$0	499	$6,637
54	1548	$8,096	1548	$4,536	726	$39,146	1548	$46,951	1548	$0	726	$9,656
Subtotals	**95931**	**$499,852**	**95931**	**$280,133**	**27822**	**$1,500,025**	**95931**	**$2,899,820**	**95931**	**$0**	**27822**	**$370,004**
Total cost	**Total Nonstructural Parcels in Plan – 95,931**											**$5,550,000**

Note: Building codes are self sufficient through assessed fees for construction permits, therefore the cost to implement and maintain them is $0.00

Figure 83 – Plan NSC-4 Non-Federal Jurisdiction Plan (A1)

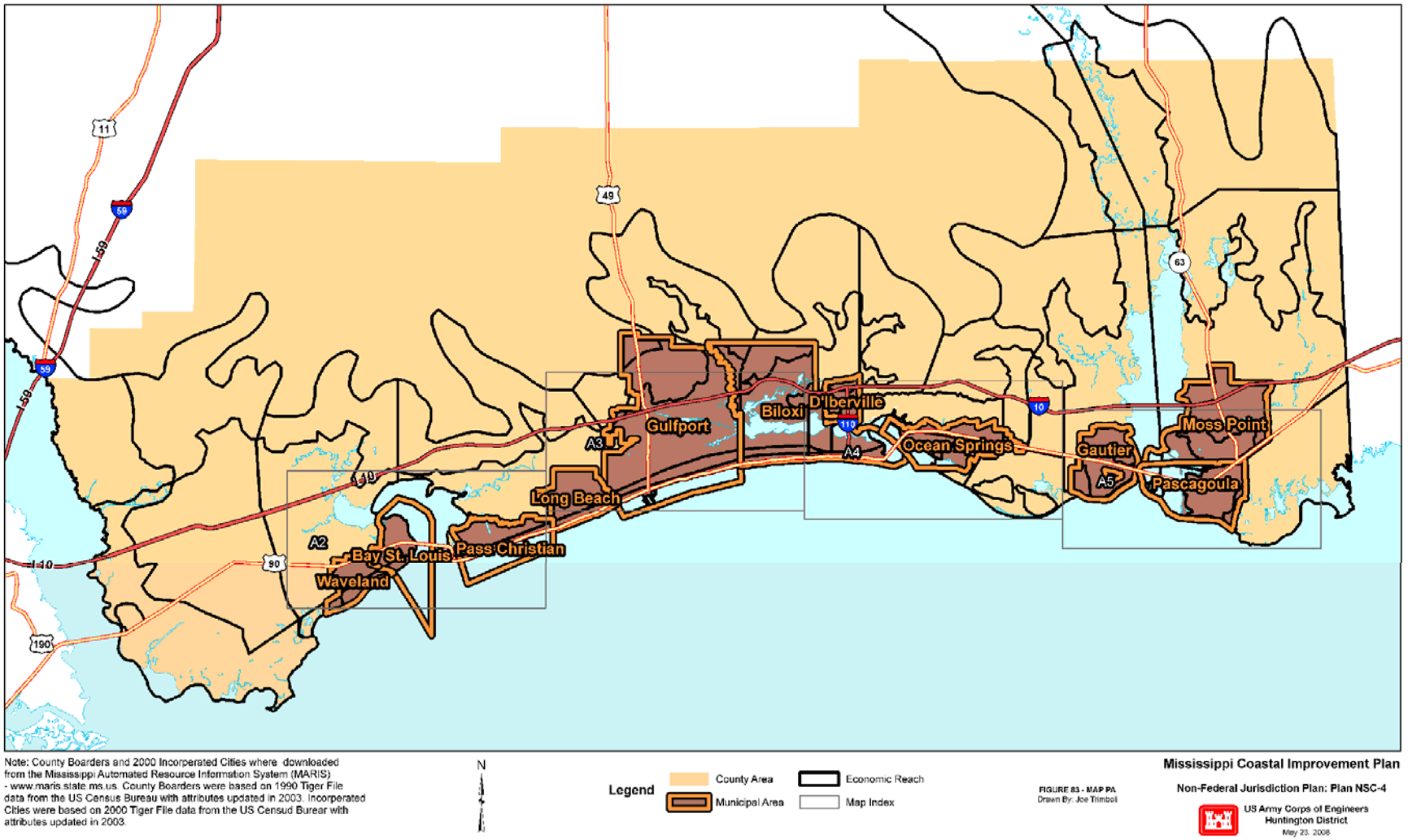


Figure 84 – Plan NSC-4 Non-Federal Jurisdiction Plan (A2)

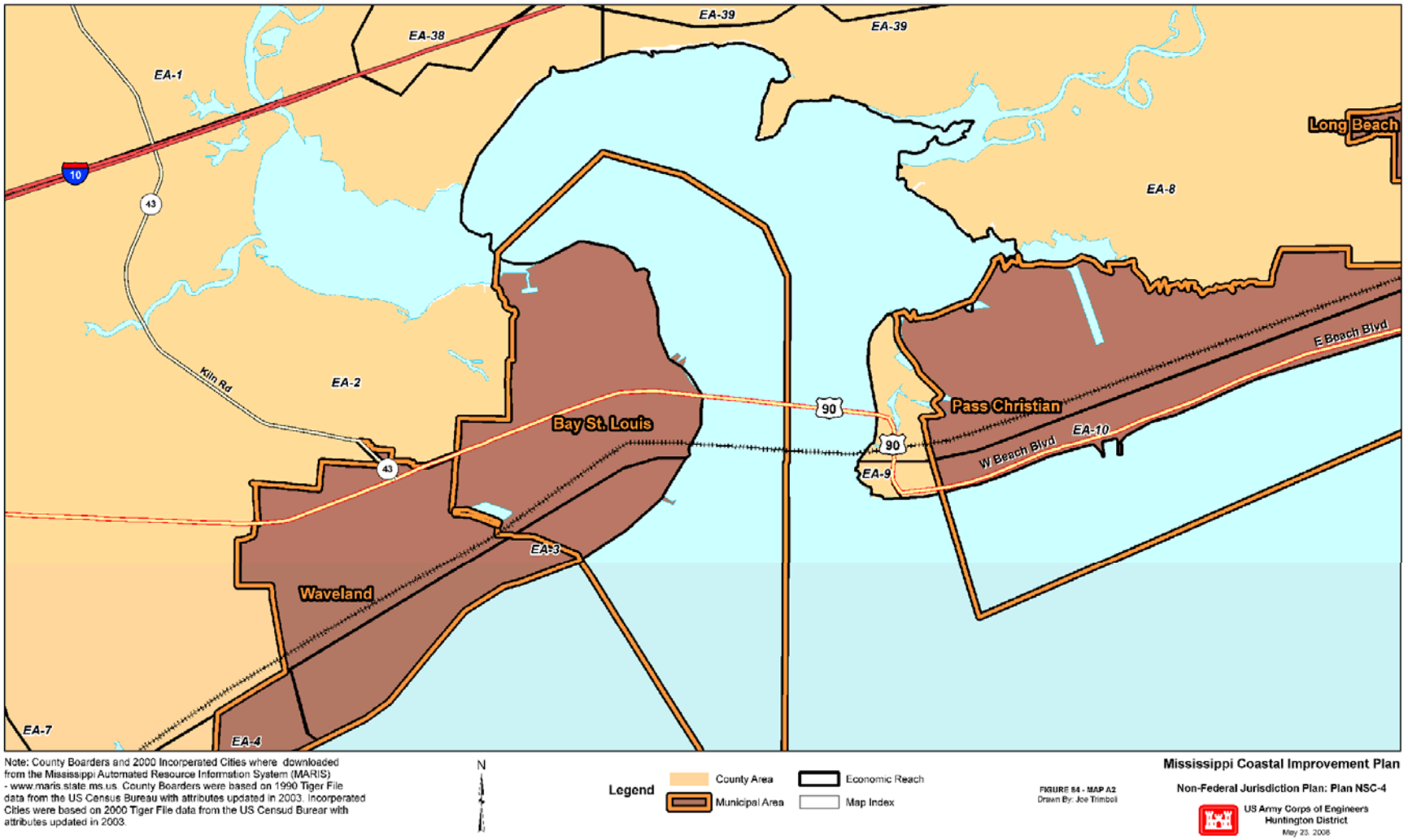


Figure 85 – Plan NSC-4 Non-Federal Jurisdiction Plan (A3)

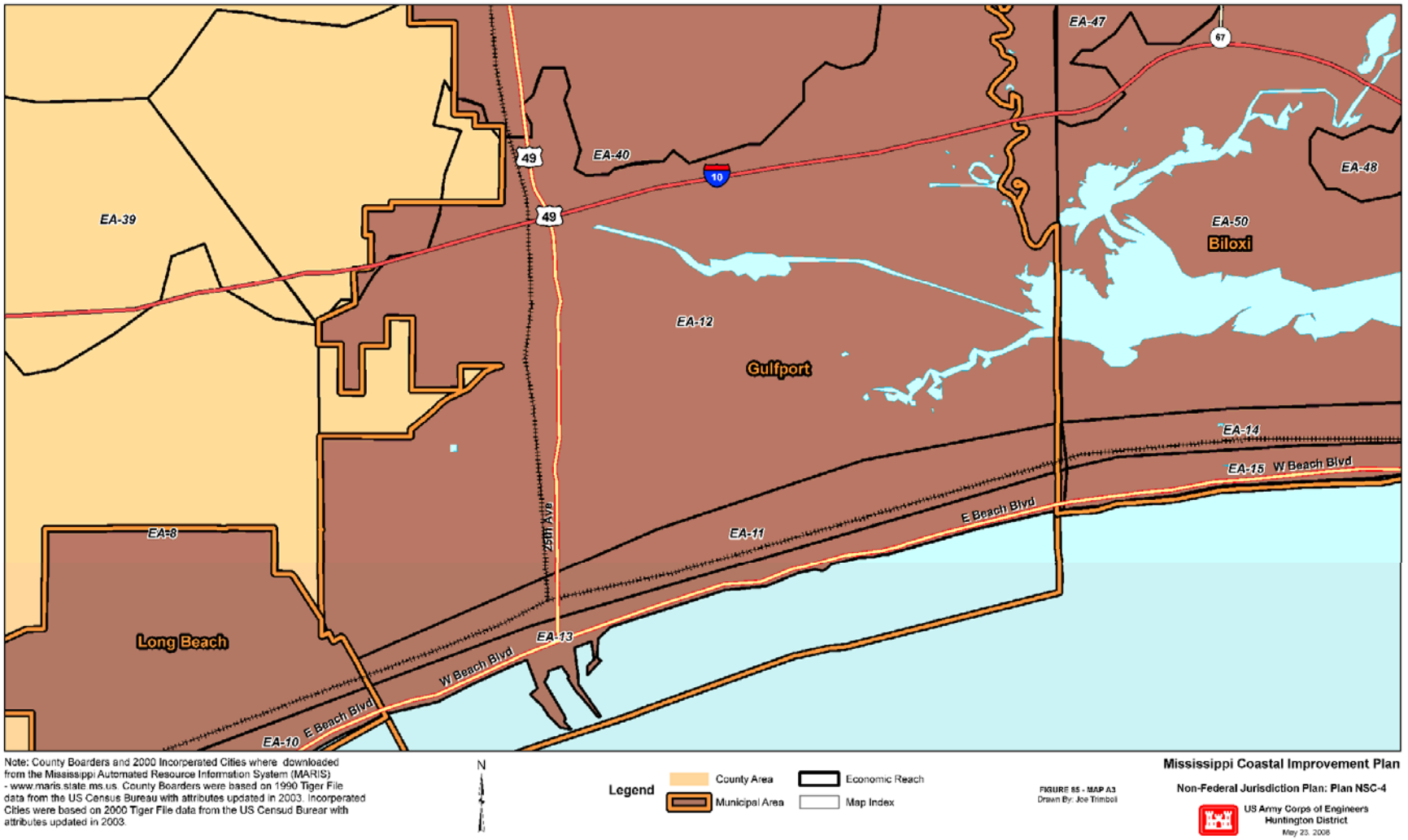


Figure 86 – Plan NSC-4 Non-Federal Jurisdiction Plan (A4)

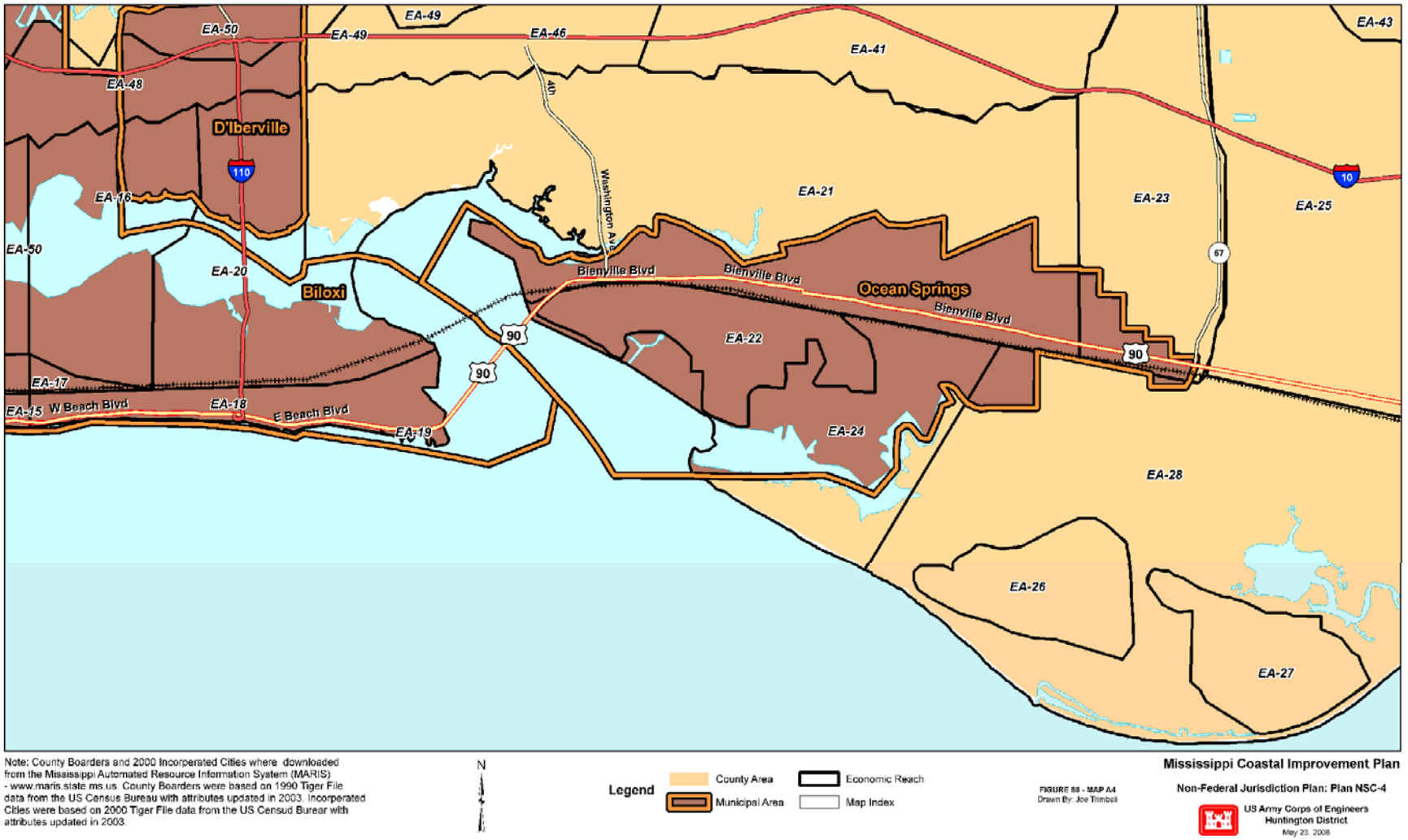
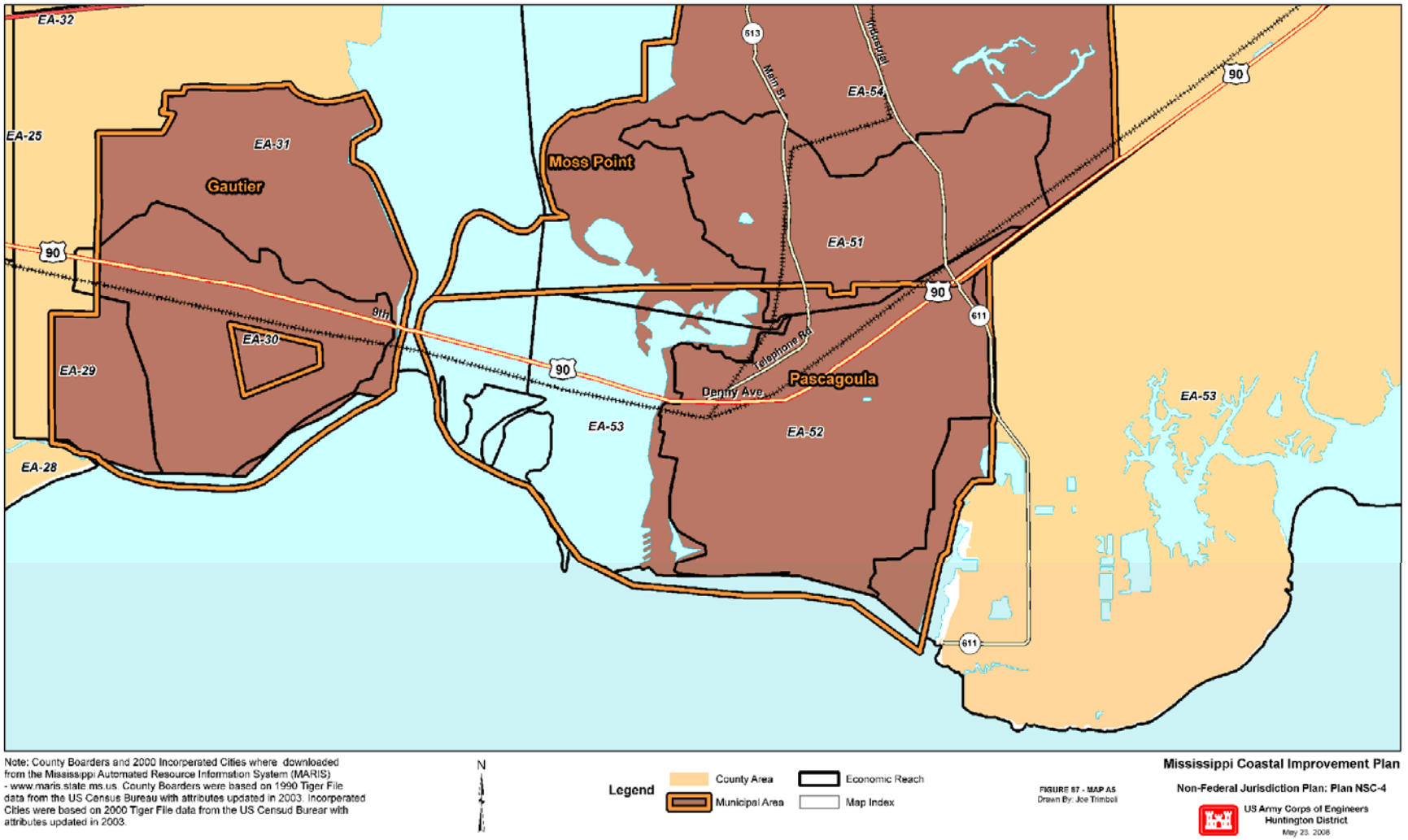


Figure 87 – Plan NSC-4 Non-Federal Jurisdiction Plan (A5)



6.7.2.5 Plan NSC-5 – Loss of Life Reduction Plan

This plan is a mixture of Federal and local measures that specifically address project objectives for reducing losses of life in high and moderate-hazard zones. The approximate number of structures that would be affected by these measures and the estimated costs are shown in Table 24. Figures 88 through 92 show the application of these measures. The Plan relies on three primary measures: 1) Permanent acquisition of parcels, structures and facilities in the high-hazard zones, 2) Flood Preparedness and Emergency Evacuation and 3) Relocations of Public Buildings.

Floodproofing is not included as a measure in this plan since its primary purpose is protection of structures and their contents in-place. A floodproofed structure is not considered to be a reliable shelter for its occupants during a hurricane. Too many uncertainties exist in determining the elevation of the first floor, supporting foundation design and construction to condone using elevated structures as human shelters that may be surrounded by surge inundation and buffeted by hurricane force winds.

Real property and structures and facilities (with some exceptions previously noted) in the high hazard zone identified in the permanent acquisition measure (the HHZ composed of the V-zone, catastrophic damages zone and the 800 foot buffer zone) would be acquired through the Corps' authorized program. That total number of acquisitions is estimated to be 14,997 parcels within the high hazard zone. Current estimates are that approximately 7,500 structures remain in this area and would be purchased during this process. Relocation benefits under the Uniform Relocations Act would be offered to assure that relocatees would have sufficient financial resources to acquire DSS replacement housing. As in other plans featuring permanent acquisitions in the high-hazard zone this plan assumes that the parcels made vacant by Katrina would be redeveloped by the time this plan would be authorized and funded as was described in the future without-project condition. The costs for permanent acquisition include structure and land purchase, relocations assistance and structure demolition.

In addition to the cost of the real estate acquisition, relocations assistance and structure demolition associated with this alternative, the large number of displaced households would probably trigger the need for replacement DSS housing over and above what normal market resources could provide. Based upon current housing construction capacity in the project area, as much as 40 percent of the need may be unmet by the market area. In view of this anticipated shortage of suitable DSS housing, the plan would include several redevelopment sites (at least one in each county) that would hold approximately 3,000 residential lots. Lot sizes would vary within the redevelopment sites but would be no less than quarter-acre in size. At an average cost of $45,000 per lot for site acquisition, site development, infrastructure and site amenities, the total cost of these redevelopment sites would be approximately $135.0M

The total cost for this measure including the redevelopment sites is estimated to be $6.1B and is shown in Table 24 by economic reach. The extent of the permanent acquisitions in the high-hazard zone is shown in Figures 88 through 92.

The second measure in the Plan will be the full application of all components of the flood preparedness and emergency evacuation measure including installation of additional reporting buoys in the Gulf, installation of sirens and flashing strobe lights within communities, acquisition and distribution of weather emergency radios, training and education seminars on appropriate actions following a warning for the public and emergency personnel, dissemination of emergency procedures information brochures and pamphlets to area residents and visitors alike, adjustment of hurricane warning times from 24 to 36 hours for hurricanes greater than Category 3, and development of emergency evacuation plans for those structures and facilities that cannot be moved from the waterfront. In addition to these components, there would be improvements to the

evacuation routes themselves including new signage designating evacuation routes, messaging boards that provide needed information to evacuees, and procedures for reverse flow or contraflow routing during emergency evacuation situations.

Also, improvements would be made to all modal crossings that can potentially impede traffic flow, correction of undersized culverts and other stream crossing infrastructure that could endanger evacuees, and improvements to intersections (turning lanes, signaling, etc.). Additional improvements would include enroute emergency resources (fuel, food, emergency services, etc.) along evacuation routes and pre-arranged, safe sheltering with emergency supplies located away from the coast. The estimated cost to implement the improvements to the flood preparedness and emergency evacuation system is approximately $2.9M.

Relocating public buildings would remove several public buildings within the permanent acquisition zones described above that are routinely filled with residents that have special needs (medical, incarcerated, elderly, children, etc.) for evacuation in advance of a approaching hurricane. A total of 7 structures and facilities determined at this level of planning to be publicly-owned would be eligible for relocations to reduce flood damages. This number would include some schools that would serve as emergency evacuation centers. The total cost of these relocations is estimated to be $51.2M. Relocating those facilities to a flood-safe location in a new building constructed to current standards would significantly reduce the chances for loss of life due to flooding during a hurricane or during the evacuation that would precede such an event. Table 24 shows the total number of units by economic reach and the total estimated cost.

Table 24
NSC-5 Loss of Life Reduction Plan

Economic Reaches	Permanent Acquisition Parcels*	Cost	Public Buildings Relocations	Cost	Flood Warning and Emergency Evacuation	Cost
1	0	0	0	0	2062	$62,540
2	1056	$459,548,812	0	0	19363	$587,280
3	2099	$851,631,850	0	0	2673	$81,072
4	823	$202,919,893	0	0	901	$27,327
5	971	$107,653,678	0	0	3109	$94,296
6	210	$114,862,969	1	$8,536,147	1123	$34,061
7	125	$9,562,216	0	0	1574	$47,739
8	1565	$431,782,512	4	$25,608,442	8716	$264,356
9	4	$6,652,740	0	0	52	$1,577
10	1695	$736,216,496	0	0	1727	$52,380
11	0	0	0	0	44	$1,335
12	450	$138,318,777	0	0	2777	$84,226
13	595	$821,785,431	0	0	500	$15,165
14	0	0	0		788	$23,900
15	66	$88,566,796	0	0	76	$2,305
16	36	$14,594,008	0	0	209	$6,339
17	0	0	0	0	6	$182
18	285	$608,152,730	0	0	1223	$3,7094
19	12	$17,246,403	0	0	22	$667
20	1150	$316,031,090	1	$8,536,147	3064	$92,931

Economic Reaches	Permanent Acquisition Parcels*	Cost	Public Buildings Relocations	Cost	Flood Warning and Emergency Evacuation	Cost
21	2082	$695,355,710	0	0	1867	$56,626
22	62	$39,368,916	0	0	157	$4,762
23	0	0	0	0	65	$1,971
24	138	$45,373,108	0	0	524	$15,893
25	0	0	0	0	327	$9,918
26	31	$11,221,913	0	0	1279	$38,792
27	37	$5,996,209	0	0	2145	$65,058
28	583	$10,167,976	0	0	1718	$52,107
29	132	$14,287,454	0	0	546	$16,560
30	81	$24,818,841	0	0	626	$18,987
31	37	$9,281,900	0	0	708	$21,474
32	0	0	0	0	398	$12,071
33	0	0	0	0	77	$2,335
34	0	0	0	0	600	$18,198
35	0	0	0	0	1599	$48,498
36	0	0	0	0	62	$1,880
37	0	0	0	0	540	$16,378
38	0	0	0	0	364	$11,040
39	0	0	0	0	25	$758
40	0	0	0	0	7824	$237,302
41	0	0	0	0	536	$16,257
42	0	0	0	0	667	$20,230
43	0	0	0	0	25	$61
44	0	0	0	0	2587	$78,464
45	0	0	0	0	2267	$68,758
46	0	0	0	0	3331	$101,029
47	0	0	0	0	1303	$39,520
48	0	0	0	0	1	$61
49	0	0	0	0	338	$10,252
50	96	$24,190,783	0	0	1594	$48,346
51	0	0	0	0	1089	$33,029
52	275	$68,789,089	1	$8,536,147	7628	$231,357
53	300	$46,723,811	0	0	1557	$38,125
54	0	0	0	0	1548	$46,951
Subtotals	**14,997**	**$5,921,102,111**	**7**	**$51,216,883**	**95931**	**$2,899,820**
H&CD Sites		Jackson, Harrison and Hancock		3,000 lots at $45,000 each		**$135,000,000**
Total Plan Cost						**$6,110,218,814**

Notes: The Flood Warning and Emergency Evacuation improvements may be accomplished by other Federal Agencies (FEMA and NOAA) but would be supported by the Corps.

* The total parcel count for acquisition within the high-hazard zone includes approximately 7,500 existing structures (residential and commercial)..

Figure 88 – Plan NSC-5 Loss of Life Reduction Plan (A1)

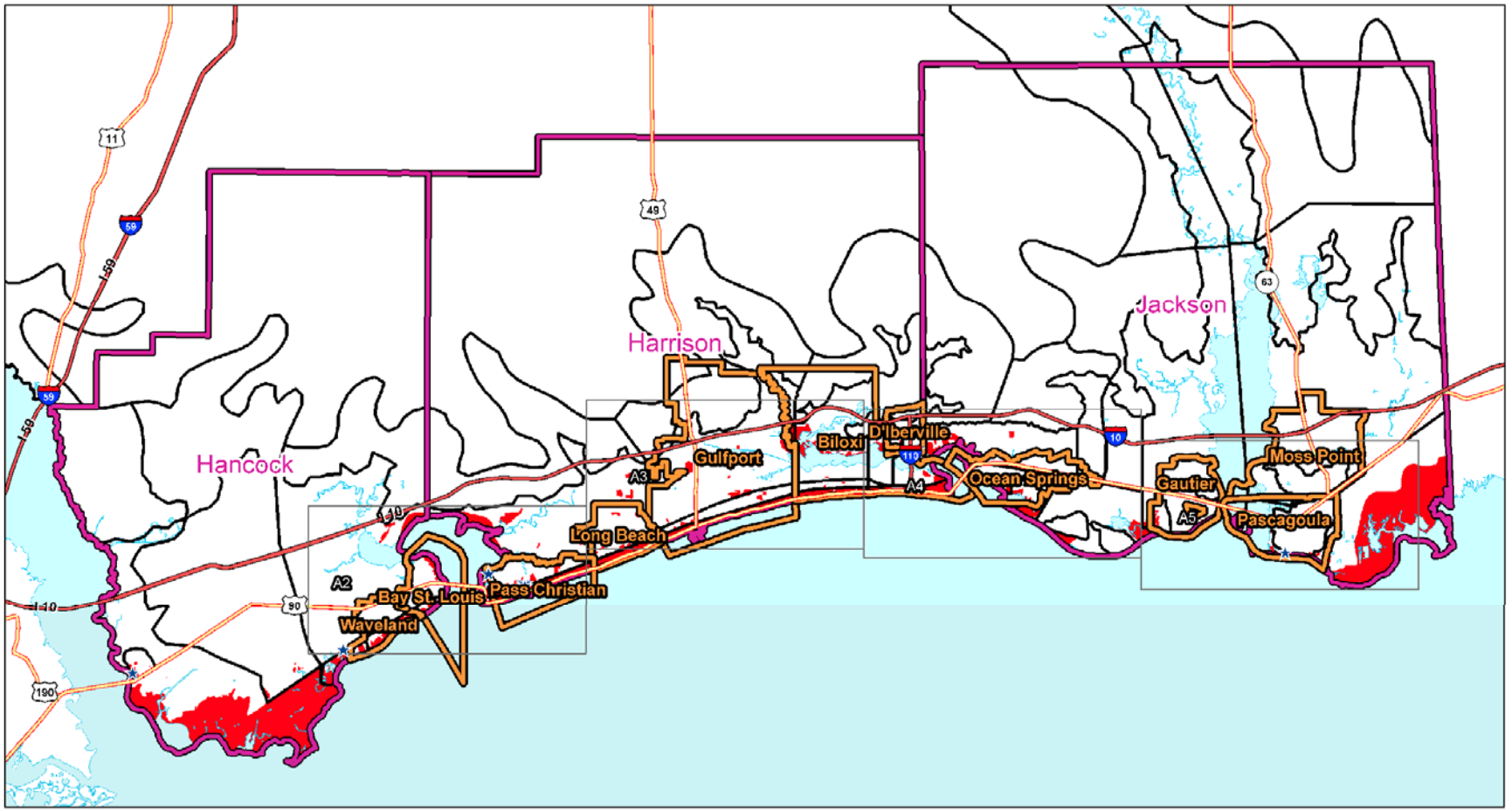


Figure 89 – Plan NSC-5 Loss of Life Reduction Plan (A2)

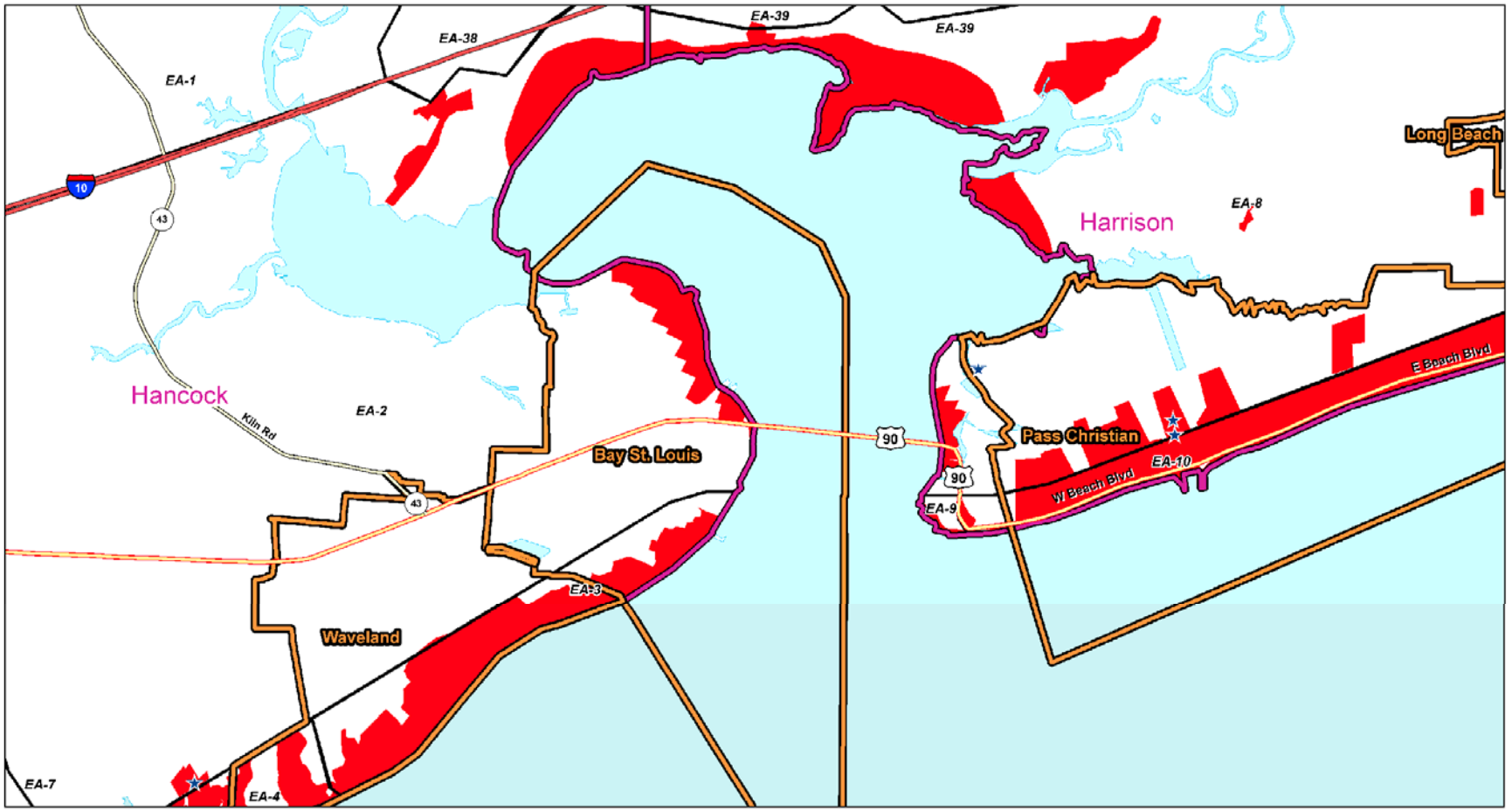


Figure 90 – Plan NSC-5 Loss of Life Reduction Plan (A3)

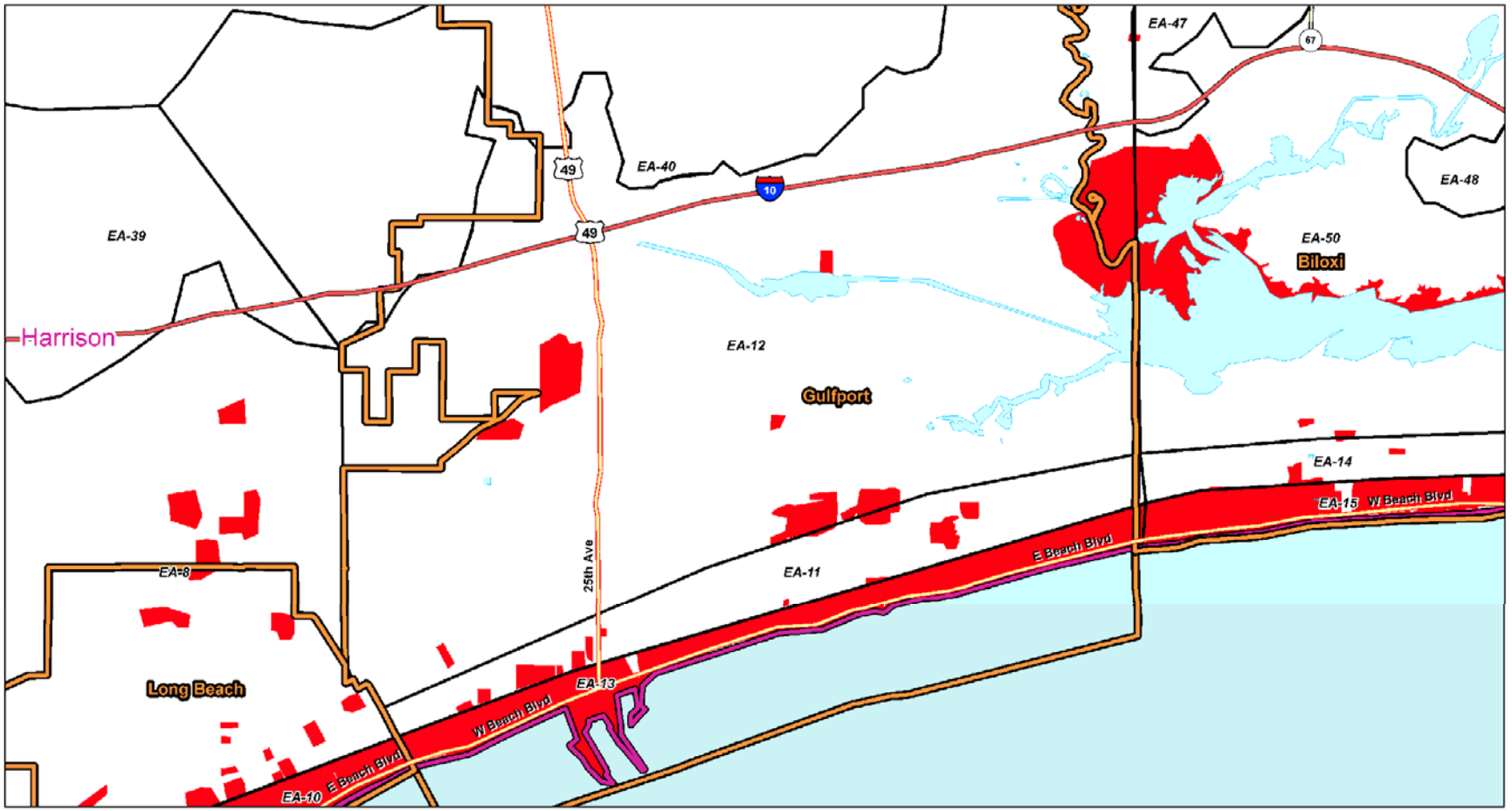


Figure 91 – Plan NSC-5 Loss of Life Reduction Plan (A4)

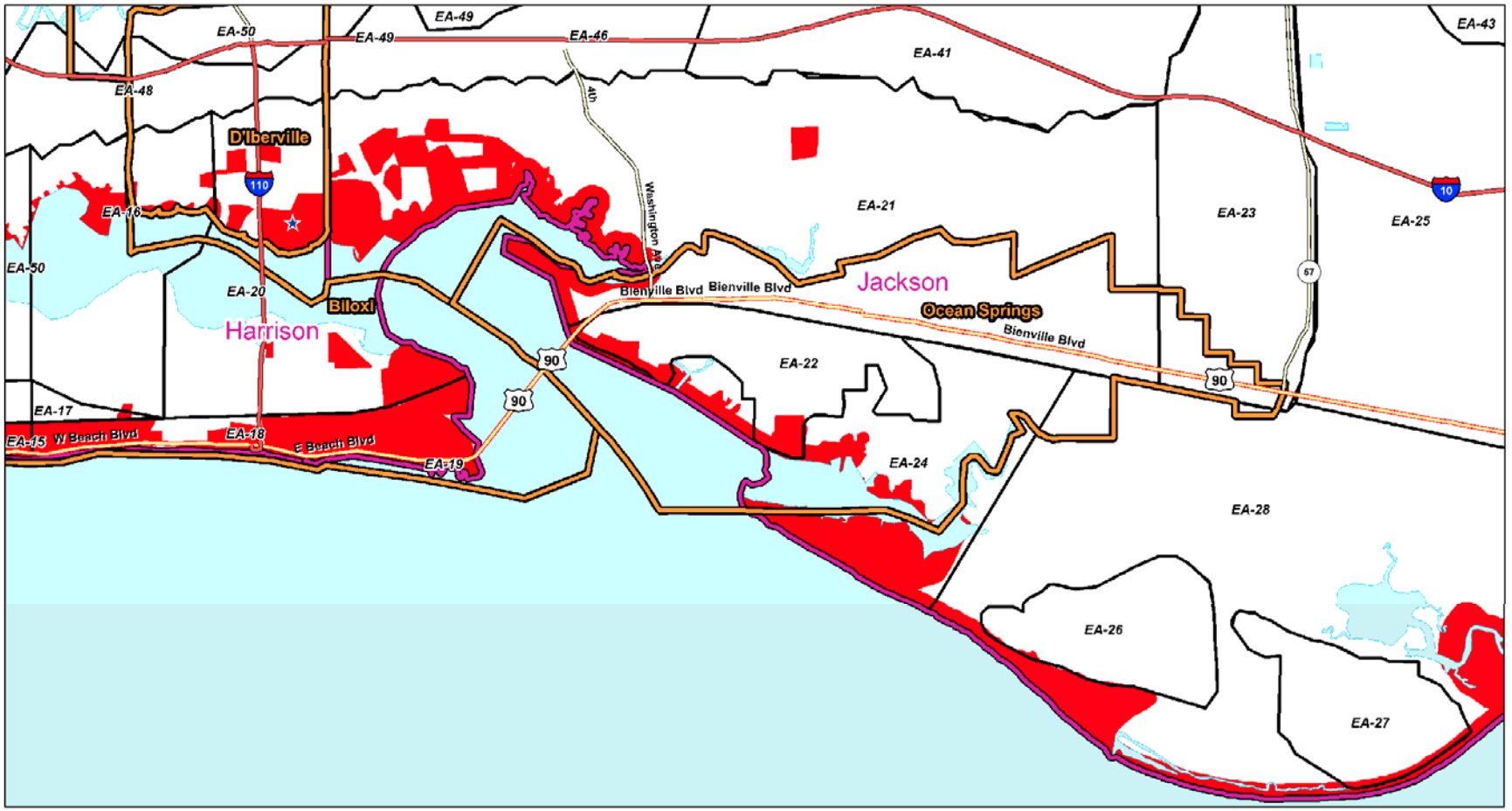
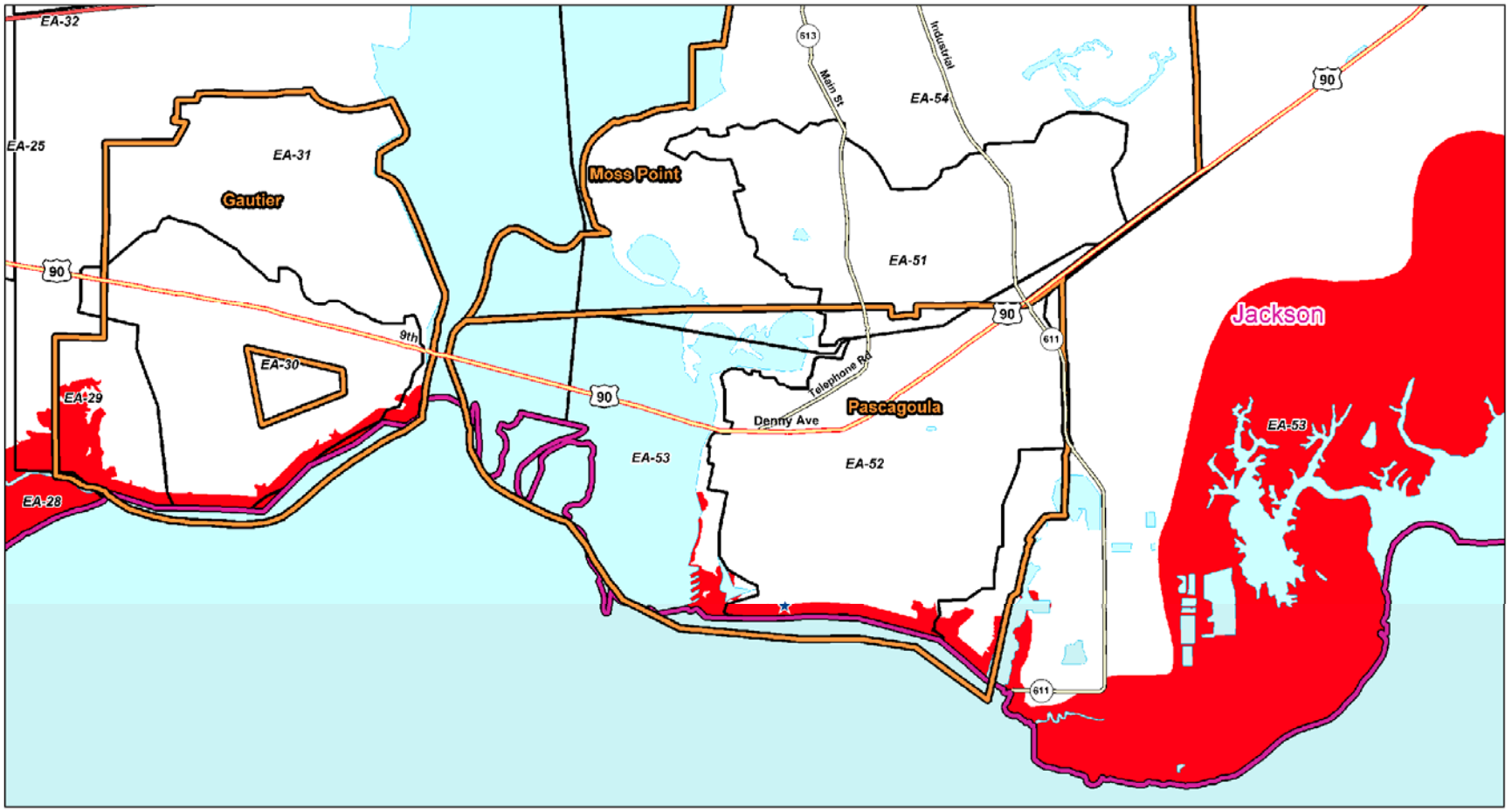


Figure 92 – Plan NSC-5 Loss of Life Reduction Plan (A5)



6.7.2.6. Plan NSC-6 – Combined Structural/Nonstructural Plan

This Plan would consist of nonstructural measures applied to structures and facilities that would be located outside the protection limits of structural projects described in the comprehensive plan. Line of Defense 4 (LOD 4) and various ringwalls or ring-levees that protect portions of named communities in the project area or any combination of the structural protection schemes are included in these plans. The number of structures that would be affected by these measures and the estimated costs are shown in Tables 26 through 33. The costs for nonstructural measures (primarily permanent acquisition outside the line of protection) that support structural projects are shown for each proposed structural alternative in the tables. These “buffer zones” or areas located outside the line of protection provided by the structural components would be addressed in the nonstructural program using the same procedures already described for other nonstructural alternatives.

Since the protection features of each structural plan are designed with cost effectiveness in mind, there would be many structures and facilities located outside the limits of structural protection. Case in point would be the many structures remaining outside the lines of protection provided by ring levees designed around high-density urban areas in the project area such as Gautier, Pascagoula, Ocean Springs, and Moss Point. In many cases the structural feature alignment was influenced by the ground elevations of the site and in several cases the alignment was adjusted to avoid impacts to wetlands or other environmentally sensitive ecosystems. Likewise the LOD 4 structural component would not provide protection for structures or facilities located between the Gulf and the levee alignment along the CSX railway right-of-way.

The nonstructural plans described in the tables represent the measures that would be available for all of those structures and facilities not protected by the lines of protection provided by structural measures at the various levels of protection. The two primary structural measures considered in the tables are the various ringwalls and ring-levees formulated for individual municipal or communities (i.e. Pascagoula, Moss Point, Gulf Park Estates, Pearlington, Belle Fontaine, and Gautier) and LOD 4 (trackside levee and surge gates at the inlets) with various levels of protection (20 feet, 30 feet and 40 feet of surge inundation). The nonstructural measures applied to these unprotected areas would be the suite of measures described in NSC-1 above with one exception. That exception would be the costs for relocating municipal structures that would be affected by surge inundation at the 20 foot, 30 foot and 40 foot levels of inundation. Numbers of public structures to be relocated and their costs were determined for the ABFE-2 feet inundation level, but time constraints and database constraints (FEMA HAZUS does not calculate surge profiles for 20, 30 and 40 feet of inundation) did not permit determinations of the numbers or costs of public building relocations at the higher levels of inundation. In those higher inundation scenarios, the public buildings were considered to be standard acquisition items and included in the Real Estate permanent acquisition category. Therefore, those costs may be slightly understated at this level of study.

The appropriate nonstructural measures applied to those structures and facilities would be in keeping with the basic parameters of other nonstructural plans regarding potential location in a high-hazard zone, depth of flooding at the structure, condition and use of the structure, and whether the structure or facility is publicly or privately owned. In addition, vacant property would be either acquired (permanent acquisition), or the development rights secured through either a locally administered TDR or PDR program. Structures and facilities located adjacent to structural protection works may experience slightly greater inundation due to hydraulic effects of surge and waves against the protection works, but those effects can be compensated for in the nonstructural measures’ design.

The estimated numbers of structures to be protected by nonstructural measures lying outside the structural alignments for each economic reach are shown in Tables 26 through 33. Figures 93

through 140 show the locations of the proposed nonstructural measures that would be implemented in combination with structural measures.

Of note is the progressively greater number of parcels being included in the nonstructural program as the level of surge inundation increases from the ABFE-2 feet (a minimum level of protection in accordance with local floodplain management ordinances) to the 20 foot, 30 foot and 40 foot levels of inundation. At the ABFE-2 feet level of inundation only 44,098 parcels are included in the program. At the 20 foot level of inundation that total parcel number increases to 77,523 and at the 30 and 40 foot levels that number tops out at 85,447 parcels. There is no difference in total parcels between the 30 foot and 40 foot levels of inundation because the 30 foot level captures all of the eligible parcels.

Also of note is the progression of parcels moving from the floodproofing category to the permanent acquisition category of nonstructural measures. Initially at the 20 foot level the number of parcels eligible for floodproofing increases above that shown for the ABFE-2 level, but at the 30 foot and 40 foot levels that number decreases dramatically. This migration is due to the ever-deepening surge inundation levels that exceed the 13 feet water depth permitted for elevating structures in this program. Table 25 shows the relationship of total parcels and both acquisition and floodproofing parcels among the scales of the NSC-6 plan. As discussed for Plan NSC-1 at the greater levels of inundation (20, 30 and 40 feet of surge), plan costs do not increase in direct proportion to the increase in numbers of structures becoming eligible for the project (exempting the lot costs for displaced landowners). Since permanent acquisition costs per parcel used in the plan are on average slightly less that floodproofing costs per parcel, the migration of parcels from the floodproofing measure to the permanent acquisition measure (due to increased water depths) actually results in lower plan costs. Plan costs at the 30 and 40 foot levels do rise only because of the need for more redevelopment lots for a greater number of displaced owners.

Table 25

Plan NSC-6 - Comparison of Eligible Parcels in Acquisitions and Floodproofing

Plan Designation	Total Parcels	Acquisition Parcels	Potential Lives Protected	Floodproofing Parcels	Potential Lives Protected
NSC-6 ABFE w/ring-levees	44,088	29,445	76,557	14,620	38,012
NSC-6a 20 feet w/ring-levees	77,523	36,559	95,053	40,964	106,506
NSC-6b 30 feet w/ring-levees	85,447	71,448	185,765	13,999	36,397
NSC-6c 40 feet w/ring-levees	85,447	85,447	222,162	0	0
NSC-6d ABFE w/LOD-4 **	30,508	20,156	52,406	10,347	26,902
NSC-6e 20 feet w/LOD-4**	46,315	19,556	50,846	26,759	69,573
NSC-6f 30 feet w/LOD-4**	51,935	40,125	104,325	11,810	30,706
MSC-6g 40 feet w/LOD-4**	51,935	51,935	135,031	0	0

** (See discussion of the status of the LOD 4 structural alternative in the Executive Summary)

Table 26
NSC-6 – Combined Structural and Nonstructural – ABFE w/Ring-Levees

Reaches	Acquisition Parcels	Acquisitions Cost	Public Relocations	Public Relocations Cost	Public Floodproofing	Public Floodproofing Cost	Public Buildings Costs	Floodproofing Parcels	Floodproofing Costs	Subtotal Nonstructural Costs
1	997	$194,118,217.88	0	$0.00	0	$0.00	$0.00	394	$101,229,150.00	$295,347,367.88
2	9911	$2,990,789,131.25	1	$392,586.21	5	$23,778,209.33	$24,170,795.55	3289	$1,543,195,389.00	$4,558,155,315.80
3	2202	$668,691,436.88	0	$0.00	0	$0.00	$0.00	376	$269,175,578.00	$937,867,014.88
4	922	$120,307,916.63	0	$0.00	0	$0.00	$0.00	16	$24,642,670.00	$144,950,586.63
7	450	$33,210,173.75	0	$0.00	0	$0.00	$0.00	232	$149,936,910.00	$183,147,083.75
8	3623	$476,088,332.50	3	$25,478,083.02	1	$3,815,128.75	$29,293,211.77	1729	$569,574,546.00	$1,074,956,090.27
9	44	$16,132,782.50	0	$0.00	0	$0.00	$0.00	16	$13,361,448.00	$29,494,230.50
10	1945	$432,581,233.50	0	$0.00	0	$0.00	$0.00	62	$20,028,706.00	$452,609,939.50
11	0	$0.00	0	$0.00	0	$0.00	$0.00	8	$1,727,008.00	$1,727,008.00
12	1047	$179,614,825.00	0	$0.00	1	$3,815,128.75	$3,815,128.75	1135	$358,050,524.00	$541,480,477.75
13	650	$583,121,543.00	0	$0.00	0	$0.00	$0.00	0	$0.00	$583,121,543.00
15	85	$44,354,843.00	0	$0.00	0	$0.00	$0.00	9	$22,725,000.00	$67,079,843.00
16	78	$16,399,728.00	0	$0.00	0	$0.00	$0.00	121	$31,715,348.00	$48,115,076.00
18	1502	$409,411,532.00	0	$0.00	0	$0.00	$0.00	5	$1,138,504.00	$410,550,036.00
19	46	$292,728,063.00	0	$0.00	0	$0.00	$0.00	0	$0.00	$292,728,063.00
20	1397	$238,433,082.00	1	$8,492,694.34	5	$19,075,643.74	$27,568,338.08	2045	$692,997,655.00	$958,999,075.08
21	2108	$301,798,271.81	0	$0.00	4	$15,260,514.99	$15,260,514.99	415	$142,103,926.00	$459,162,712.81
22	61	$26,330,662.50	0	$0.00	0	$0.00	$0.00	92	$36,587,106.00	$62,917,768.50
23	0	$0.00	0	$0.00	0	$0.00	$0.00	44	$19,986,176.00	$19,986,176.00
24	220	$65,229,820.63	0	$0.00	0	$0.00	$0.00	178	$47,664,846.00	$112,894,666.63
28	961	$90,294,696.75	0	$0.00	0	$0.00	$0.00	122	$47,989,150.00	$138,283,846.75
29	147	$23,394,828.50	0	$0.00	0	$0.00	$0.00	168	$51,396,802.00	$74,791,630.50
31	51	$14,946,829.31	0	$0.00	0	$0.00	$0.00	447	$168,990,104.00	$183,936,933.31
32	1	$216,228.13	0	$0.00	0	$0.00	$0.00	208	$51,710,800.00	$51,927,028.13
35	12	$682,228.13	0	$0.00	0	$0.00	$0.00	1406	$350,816,536.00	$351,498,764.13
36	32	$3,834,485.38	0	$0.00	0	$0.00	$0.00	2	$5,050,000.00	$8,884,485.38
38	50	$21,424,866.13	0	$0.00	0	$0.00	$0.00	78	$15,883,024.00	$37,307,890.13
39	0	$0.00	0	$0.00	0	$0.00	$0.00	6	$991,302.00	$991,302.00
43	0	$0.00	0	$0.00	0	$0.00	$0.00	1	$170,304.00	$170,304.00
48	0	$0.00	0	$0.00	0	$0.00	$0.00	2	$366,298.00	$366,298.00
50	495	$89,247,660.50	0	$0.00	0	$0.00	$0.00	848	$215,363,629.00	$304,611,289.50
53	399	$113,015,334.56	0	$0.00	0	$0.00	$0.00	360	$204,582,670.00	$317,598,004.56
54	9	$1,114,862.06	0	$0.00	2	$7,630,257.50	$7,630,257.50	806	$319,497,144.00	$328,242,263.56
Subtotals	29445	$7,447,513,615	5	$34,363,363	18	$73,374,883	$107,738,246	14620	$5,478,648,253	$13,033,900,114
	H&CD sites		Hancock, Harrison and Jackson Counties			Approx 10,300 lots at $45,000 per lot				$464,000,000
Total Cost	Total Nonstructural Parcels – 44,088									$ 13,497,627,949

Table 27
NSC-6a – Combined Structural and Nonstructural Plan w/20 Feet inundation and Ring-Levees

Reaches	Acquisition Parcels	Acquisitions Cost	Floodproofing Parcels	Floodproofing Costs	Nonstructural Total Costs by Reach
1	795	$242,760,352.63	1068	$111,644,220	$354,404,572.63
2	6119	$1,982,505,118.75	12206	$2,270,306,077	$4,252,811,195.75
3	2029	$869,599,919.38	502	$261,603,614	$1,131,203,533.38
4	769	$137,140,841.63	55	$41,048,722	$178,189,563.63
7	343	$28,183,289.75	1092	$123,833,026	$152,016,315.75
8	6585	$721,036,617.25	2761	$268,481,369	$989,517,986.25
9	23	$10,006,258.75	15	$4,155,724	$14,161,982.75
10	3052	$687,523,634.50	36	$9,985,596	$697,509,230.50
11	45	$13,955,967.50	882	$131,996,005	$145,951,972.50
12	1617	$398,388,336.75	2184	$925,803,107	$1,324,191,443.75
13	2284	$1,059,037,972.50	1	$275,000	$1,059,312,972.50
14	10	$3,531,145.00	3	$0	$3,531,145.00
15	407	$321,467,398.75	5	$195,994	$321,663,392.75
16	178	$45,986,843.00	420	$89,816,180	$135,803,023.00
18	1650	$531,842,684.50	29	$7,968,172	$539,810,856.50
19	15	$238,143,653.50	0	$0	$238,143,653.50
20	1046	$197,002,707.50	1756	$491,997,409	$689,000,116.50
21	2142	$698,779,207.38	1688	$518,126,016	$1,216,905,223.38
22	314	$142,425,847.38	1921	$475,539,586	$617,965,433.38
23	59	$18,831,864.50	104	$23,208,676	$42,040,540.50
24	301	$134,113,558.00	854	$131,106,828	$265,220,386.00
25	0	$0.00	27	$3,700,964	$3,700,964.00
28	1318	$162,484,163.75	444	$40,032,082	$202,516,245.75
29	491	$115,704,667.88	1081	$180,905,804	$296,610,471.88
31	472	$150,421,617.50	810	$206,865,030	$357,286,647.50
32	236	$44,686,667.38	461	$71,960,724	$116,647,391.38
35	630	$92,739,948.25	1277	$453,335,528	$546,075,476.25
36	0	$0.00	29	0	$0.00
37	0	$0.00	5	0	$0.00
38	33	$23,256,254.25	304	$16,587,864	$39,844,118.25
39	8	$1,627,170.00	287	$16,374,482	$18,001,652.00
40	1	$100,211.25	4	0	$100,211.25
43	0	$0.00	4	$366,298	$366,298.00
46	0	$0.00	3	$114,092	$114,092.00
47	0	$0.00	5	$587,982	$587,982.00
48	1	$1,457,777.50	5	$587,982	$2,045,759.50
49	0	$0.00	63	$2318648	$2,318,648.00
52	1840	$535,059,176.25	7305	$4,108,479,076	$4,643,538,252.25
53	646	$134,435,107.63	613	$207,158,892	$341,593,999.63
54	1100	$276,596,580.13	655	$219,619,572	$496,216,152.13
Subtotals	**36559**	**$10,020,832,560**	**40964**	**$ 11,416,086,341**	**$21,436,918,901**
H&CD Sites	Hancock, Harrison & Jackson Co		Approx 12,700 Lots at $45,000/lot		**$572,000,000**
Total Plan Costs	**Total Nonstructural Parcels – 77,523**				**$22,008,918,901**

Table 28
NSC-6b – Combined Structural and Nonstructural Plan w/30 feet inundation and Ring-Levees

Reaches	Acquisition Parcels	Acquisitions Costs	Floodproofing Parcels	Floodproofing Costs	Nonstructural Total Costs by Reach
1	1591	$470,268,503.50	511	$ 80,353,606.00	$550,622,109.50
2	15864	$3,364,937,903.75	6331	$ 2,006,692,184.00	$5,371,630,087.75
3	2565	$1,036,199,788.88	557	$ 239,155,950.00	$1,275,355,738.88
4	823	$143,859,191.50	1	$ 195,994.00	$144,055,185.50
7	1222	$127,404,692.38	267	$ 18,389,310.00	$145,794,002.38
8	8591	$913,966,937.50	755	$ 201,679,104.00	$1,115,646,041.50
9	38	$12,583,953.75	0	$ -	$12,583,953.75
10	3088	$696,444,472.00	0	$ -	$696,444,472.00
11	79	$17,236,421.25	848	$ 315,371,358.00	$332,607,779.25
12	3801	$1,250,095,756.75	0	$ -	$1,250,095,756.75
13	2284	$1,059,037,972.50	1	$ 2,525,000.00	$1,061,562,972.50
14	10	$3,531,145.00	3	$ -	$3,531,145.00
15	412	$326,617,775.00	0	$ -	$326,617,775.00
16	598	$173,917,626.75	0	$ -	$173,917,626.75
18	1655	$533,199,240.00	24	$ 11,739,556.00	$544,938,796.00
19	15	$238,143,653.50	0	$ -	$238,143,653.50
20	2144	$416,967,996.50	1802	$ 861,061,816.00	$1,278,029,812.50
21	3830	$1,483,891,217.50	0	$ -	$1,483,891,217.50
22	2235	$872,740,336.25	0	$ -	$872,740,336.25
23	163	$57,221,763.88	0	$ -	$57,221,763.88
24	539	$264,338,265.75	616	$ 110,725,374.00	$375,063,639.75
25	27	$11,661,813.00	0	$ -	$11,661,813.00
28	1687	$241,776,845.63	1742	$ 249,531,974.00	$491,308,819.63
29	1572	$359,722,100.25	0	$ -	$359,722,100.25
31	1282	$415,121,092.13	0	$ -	$415,121,092.13
32	697	$173,934,340.75	0	$ -	$173,934,340.75
35	1907	$416,542,564.88	0	$ -	$416,542,564.88
36	15	$2,306,708.13	36	$ -	$2,306,708.13
37	1	$340,434.38	4	$ -	$340,434.38
38	198	$59,672,860.88	452	$ 74,116,316.00	$133,789,176.88
39	295	$34,977,357.00	0	$ -	$34,977,357.00
40	5	$417,288.75	0	$ -	$417,288.75
43	4	$1,269,975.00	0	$ -	$1,269,975.00
46	3	$322,862.50	0	$ -	$322,862.50
47	5	$1,720,815.00	0	$ -	$1,720,815.00
48	6	$5,485,907.50	0	$ -	$5,485,907.50
49	63	$8,814,550.50	0	$ -	$8,814,550.50
52	9145	$3,199,336,671.63	0	$ -	$3,199,336,671.63
53	1234	$464,412,757.75	49	$ 26,056,898.00	$490,469,655.75
54	1755	$541,259,959.00	0	$ -	$541,259,959.00
Subtotals	**71448**	**$19,401,701,518**	**13999**	**$4,197,594,440**	**$23,599,295,958**
H&CD Sites	**Hancock, Harrison & Jackson Co**		**Approx. 25,000 lots at $45,000/lot**		**$ 1,125,000,000**
Total Cost	**Total Nonstructural Parcels – 85,447**				**$24,724,295,958**

Table 29

NSC-6c – Combined Structural and Nonstructural w/40 inundation and Ring-Levees

Reaches	Acquisition Parcels	Acquisitions Cost	Floodproofing Parcels	Floodproofing Costs	Nonstructural Costs by Reach
1	2102	$632,549,786.38	0	0	$632,549,786.38
2	22195	$5,686,835,321.25	0	0	$5,686,835,321.25
3	3122	$1,266,472,734.00	0	0	$1,266,472,734.00
4	824	$144,644,086.50	0	0	$144,644,086.50
7	1489	$159,349,868.63	0	0	$159,349,868.63
8	9346	$1,119,589,307.50	0	0	$1,119,589,307.50
9	38	$12,583,953.75	0	0	$12,583,953.75
10	3088	$696,444,472.00	0	0	$696,444,472.00
11	927	$238,310,263.50	0	0	$238,310,263.50
12	3801	$1,250,095,756.75	0	0	$1,250,095,756.75
13	2285	$1,059,287,941.25	0	0	$1,059,287,941.25
14	13	$5,321,020.00	0	0	$5,321,020.00
15	412	$326,617,775.00	0	0	$326,617,775.00
16	598	$173,917,626.75	0	0	$173,917,626.75
18	1679	$542,567,877.25	0	0	$542,567,877.25
19	15	$238,143,653.50	0	0	$238,143,653.50
20	3946	$829,880,446.50	0	0	$829,880,446.50
21	3830	$1,483,891,217.50	0	0	$1,483,891,217.50
22	2235	$872,740,336.25	0	0	$872,740,336.25
23	163	$57,221,763.88	0	0	$57,221,763.88
24	1155	$598,237,712.00	0	0	$598,237,712.00
25	27	$11,661,813.00	0	0	$11,661,813.00
28	3429	$714,783,499.38	0	0	$714,783,499.38
29	1572	$359,722,100.25	0	0	$359,722,100.25
31	1282	$415,121,092.13	0	0	$415,121,092.13
32	697	$173,934,340.75	0	0	$173,934,340.75
35	1907	$416,542,564.88	0	0	$416,542,564.88
36	51	$6,438,158.75	0	0	$6,438,158.75
37	5	$1,911,196.25	0	0	$1,911,196.25
38	650	$214,970,390.38	0	0	$214,970,390.38
39	295	$34,977,357.00	0	0	$34,977,357.00
40	5	$417,288.75	0	0	$417,288.75
43	4	$1,269,975.00	0	0	$1,269,975.00
46	3	$322,862.50	0	0	$322,862.50
47	5	$1,720,815.00	0	0	$1,720,815.00
48	6	$5,485,907.50	0	0	$5,485,907.50
49	63	$8,814,550.50	0	0	$8,814,550.50
52	9145	$3,199,336,671.63	0	0	$3,199,336,671.63
53	1283	$496,107,037.25	0	0	$496,107,037.25
54	1755	$541,259,959.00	0	0	$541,259,959.00
Subtotals	**85447**	**$23,999,500,500**	**0**	**0**	**$23,999,500,500**
H&CD Sites	Hancock, Harrison & Jackson C.		Approx. 29,900 lots at $45,000/lot		$ 1,345,500,000
Total Cost	**Total Nonstructural Parcels – 85,447**				**$25,345,000,500**

Table 30

NSC-6d – Combined Structural and Nonstructural - ABFE w/LOD4 **

Reaches	Acquisition Parcels	Acquisition Parcels Cost	Public Relocations	Public Relocations Cost	Public Floodproofing	Public Floodproofing Costs	Public Buildings Costs	Floodproofing parcels	Floodproofing Costs	Total Nonstructural Costs by Reach
1	997	$194,118,217.88	0	$0.00	0	$0.00	$0.00	394	$101,229,150.00	$295,347,367.88
2	9911	$2,990,789,131.25	1	$392,586.21	5	$23,778,209.33	$24,170,795.55	3289	$1,543,195,389.00	$4,558,155,315.80
7	450	$33,210,173.75	0	$0.00	0	$0.00	$0.00	232	$149,936,910.00	$183,147,083.75
8	3623	$476,088,332.50	3	$25,478,083.02	1	$3,815,128.75	$29,293,211.77	1729	$569,574,546.00	$1,074,956,090.27
11	0	$0.00	0	$0.00	0	$0.00	$0.00	8	$1,727,008.00	$1,727,008.00
12	1047	$179,614,825.00	0	$0.00	1	$3,815,128.75	$3,815,128.75	1135	$358,050,524.00	$541,480,477.75
16	78	$16,399,728.00	0	$0.00	0	$0.00	$0.00	121	$31,715,348.00	$48,115,076.00
20	1397	$238,433,082.00	1	$8,492,694.34	5	$19,075,643.74	$27,568,338.08	2045	$692,997,655.00	$958,999,075.08
21	2108	$301,798,271.81	0	$0.00	4	$15,260,514.99	$15,260,514.99	415	$142,103,926.00	$459,162,712.81
23	0	$0.00	0	$0.00	0	$0.00	$0.00	44	$19,986,176.00	$19,986,176.00
38	50	$21,424,866.13	0	$0.00	0	$0.00	$0.00	78	$15,883,024.00	$37,307,890.13
39	0	$0.00	0	$0.00	0	$0.00	$0.00	6	$991,302.00	$991,302.00
43	0	$0.00	0	$0.00	0	$0.00	$0.00	1	$170,304.00	$170,304.00
48	0	$0.00	0	$0.00	0	$0.00	$0.00	2	$366,298.00	$366,298.00
50	495	$89,247,660.50	0	$0.00	0	$0.00	$0.00	848	$215,363,629.00	$304,611,289.50
Subtotals	**20156**	**$4,541,124,288**	**5**	**$34,363,363**				**10347**	**$3,843,291,189**	**$8,484,523,466**
H&CD Sites	**Hancock, Harrison & Jackson Counties**					**Approx. 7,000 lots at $45,000 per lot**				**$315,000,000**
Totals	**Total Parcels in Nonstructural Plan – 30,508**									**$8,799,523,466**

** (See discussion of the LOD 4 structural alternative in the Executive Summary)

Table 31

NSC-6e – Combined Structural and Nonstructural 20 Feet Inundation w/LOD4 **

Reaches	Acquisition Parcels	Acquisitions Cost	Floodproofing Parcels	Floodproofing Costs	Total Nonstructural Costs by Reach
1	795	$242,760,352.63	1068	$ 111,644,220.00	$354,404,572.63
2	6119	$1,982,505,118.75	12206	$2,270,306,077.00	$4,252,811,195.75
7	343	$28,183,289.75	1092	$ 123,833,026.00	$152,016,315.75
8	6585	$721,036,617.25	2761	$ 268,481,369.00	$989,517,986.25
11	45	$13,955,967.50	882	$ 131,996,005.00	$145,951,972.50
12	1617	$398,388,336.75	2184	$ 925,803,107.00	$1,324,191,443.75
14	10	$3,531,145.00	3	$	$3,531,145.00
16	178	$45,986,843.00	420	$ 89,816,180.00	$135,803,023.00
20	1046	$197,002,707.50	1756	$ 491,997,409.00	$689,000,116.50
21	2142	$698,779,207.38	1688	$ 518,126,016.00	$1,216,905,223.38
23	59	$18,831,864.50	104	$ 23,208,676.00	$42,040,540.50
37	0	$0.00	5	$ -	$0.00
38	33	$23,256,254.25	304	$ 16,587,864.00	$39,844,118.25
39	8	$1,627,170.00	287	$ 16,374,482.00	$18,001,652.00
40	1	$100,211.25	4	$	$100,211.25
43	0	$0.00	4	$ 366,298.00	$366,298.00
46	0	$0.00	3	$ 114,092.00	$114,092.00
47	0	$0.00	5	$ 587,982.00	$587,982.00
48	1	$1,457,777.50	5	$ 587,982.00	$2,045,759.50
49	0	$0.00	63	$ 2,318,648.00	$2,318,648.00
50	574	$204,376,584.50	1915	$ 363,408,582.00	$567,785,166.50
Subtotals	**19556**	**$4,581,779,447**	**26759**	**$5,355,558,015**	**$9,937,337,462**
H&CD Sites	Hancock, Harrison &Jackson		Approx. 6,800 lots at $45,000/lot		**$306,000,000**
Totals	**Total Nonstructural Parcels – 46,315**				**$10,243,337,462**

** (See discussion of the LOD 4 structural alternative in the Executive Summary)

Table 32

NSC-6f – Combined Structural and Nonstructural 30 Feet Inundation w/LOD4 **

Reaches	Acquisition Parcels	Acquisition Costs	Floodproofing Parcels	Floodproofing Costs	Total Nonstructural Costs by Reach
1	1591	$470,268,503.50	511	$ 80,353,606.00	$550,622,109.50
2	15864	$3,364,937,903.75	6331	$ 2,006,692,184.00	$5,371,630,087.75
7	1222	$127,404,692.38	267	$ 18,389,310.00	$145,794,002.38
8	8591	$913,966,937.50	755	$ 201,679,104.00	$1,115,646,041.50
11	79	$17,236,421.25	848	$ 315,371,358.00	$332,607,779.25
12	3801	$1,250,095,756.75	0	$ -	$1,250,095,756.75
14	10	$3,531,145.00	3	$ -	$3,531,145.00
16	598	$173,917,626.75	0	$ -	$173,917,626.75
20	2144	$416,967,996.50	1802	$ 861,061,816.00	$1,278,029,812.50
21	3830	$1,483,891,217.50	0	$ -	$1,483,891,217.50
23	163	$57,221,763.88	0	$ -	$57,221,763.88
37	1	$340,434.38	4	$ -	$340,434.38
38	198	$59,672,860.88	452	$ 74,116,316.00	$133,789,176.88
39	295	$34,977,357.00	0	$ -	$34,977,357.00
40	5	$417,288.75	0	$ -	$417,288.75
43	4	$1,269,975.00	0	$ -	$1,269,975.00
46	3	$322,862.50	0	$ -	$322,862.50
47	5	$1,720,815.00	0	$ -	$1,720,815.00
48	6	$5,485,907.50	0	$ -	$5,485,907.50
49	63	$8,814,550.50	0	$ -	$8,814,550.50
50	1652	$665,887,180.75	837	$ 176,952,378.00	$842,839,558.75
Subtotals	**40125**	**$9,058,349,197**	**11810**	**$ 3,734,616,072**	**$12,792,965,269**
H&CD Sites	Hancock, Harrison & Jackson		Approx 14,000 lots at $45,000/lot		**$630,000,000**
Totals	**Total Nonstructural Parcels – 51,935**				**$13,422,965,269**

** (See discussion of the LOD 4 structural alternative in the Executive Summary)

Table 33

NSC-6g – Combined Structural and Nonstructural 40 Feet Inundation with LOD4 **

Reaches	Acquisition Parcels	Acquisition Costs	Floodproofing Parcels	Floodproofing Costs	Total Nonstructural Costs by Reach
1	2102	$632,549,786.38	0	0	$632,549,786.38
2	22195	$5,686,835,321.25	0	0	$5,686,835,321.25
7	1489	$159,349,868.63	0	0	$159,349,868.63
8	9346	$1,119,589,307.50	0	0	$1,119,589,307.50
11	927	$238,310,263.50	0	0	$238,310,263.50
12	3801	$1,250,095,756.75	0	0	$1,250,095,756.75
14	13	$5,321,020.00	0	0	$5,321,020.00
16	598	$173,917,626.75	0	0	$173,917,626.75
20	3946	$829,880,446.50	0	0	$829,880,446.50
21	3830	$1,483,891,217.50	0	0	$1,483,891,217.50
23	163	$57,221,763.88	0	0	$57,221,763.88
37	5	$1,911,196.25	0	0	$1,911,196.25
38	650	$214,970,390.38	0	0	$214,970,390.38
39	295	$34,977,357.00	0	0	$34,977,357.00
40	5	$417,288.75	0	0	$417,288.75
43	4	$1,269,975.00	0	0	$1,269,975.00
46	3	$322,862.50	0	0	$322,862.50
47	5	$1,720,815.00	0	0	$1,720,815.00
48	6	$5,485,907.50	0	0	$5,485,907.50
49	63	$8,814,550.50	0	0	$8,814,550.50
50	2489	$1,063,036,000.75	0	0	$1,063,036,000.75
Subtotals	**51935**	**$12,969,888,722**	**0**	**0**	**$12,969,888,722**
H&CD Sites	Hancock, Harrison & Jackson Counties		Approx. 18,200 Lots at $45,000/lot		**$819,000,000**
Totals	**Total Nonstructural Parcels in Plan – 51,935**				**$13,788,888,722**

** (See discussion of the LOD 4 structural alternative in the Executive Summary)

Figure 93 – Plan NSC-6 Combined Nonstructural and Structural Plan (A1)

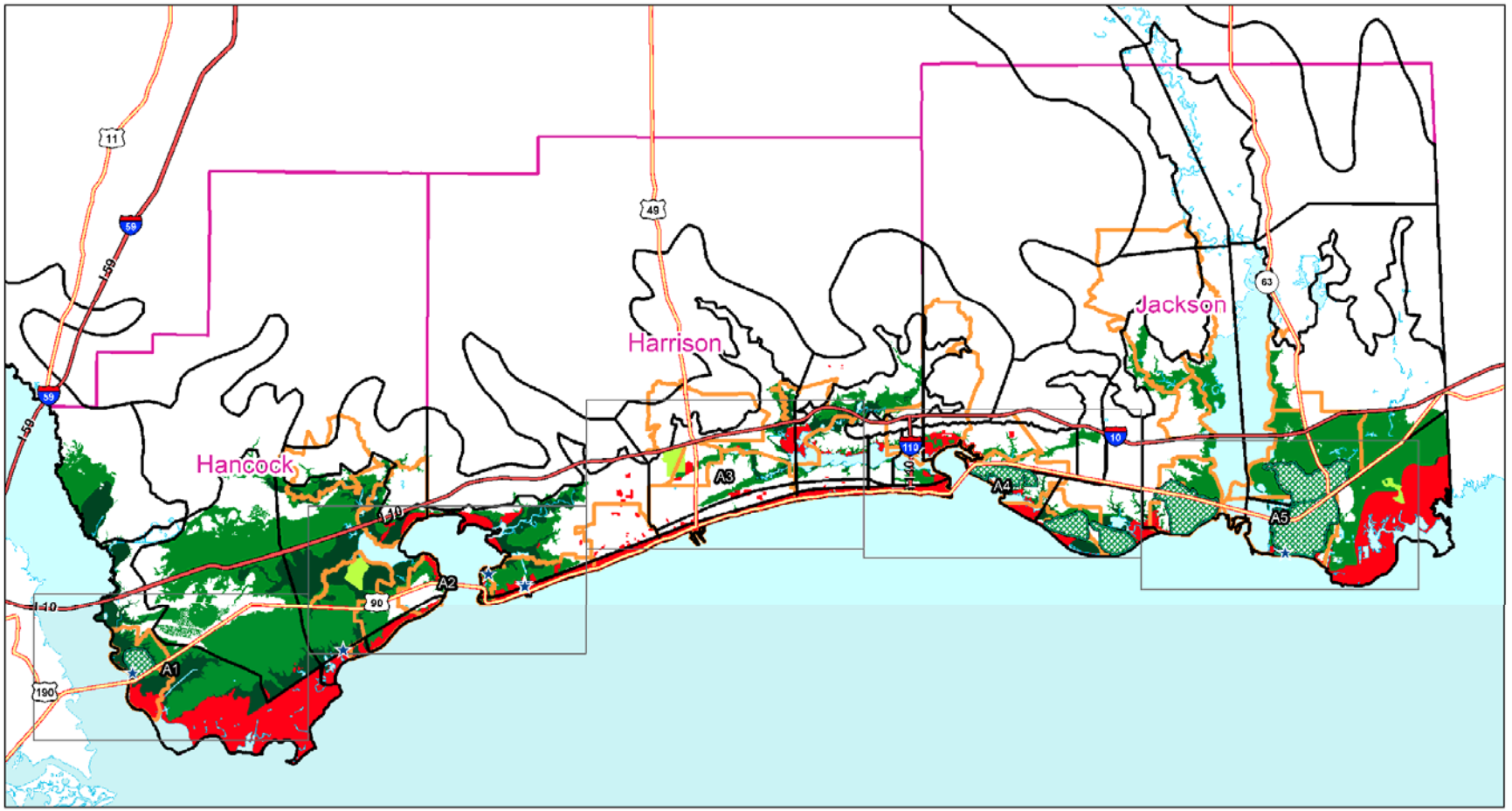


Figure 94 – Plan NSC-6 Combined Nonstructural and Structural Plan (A2)

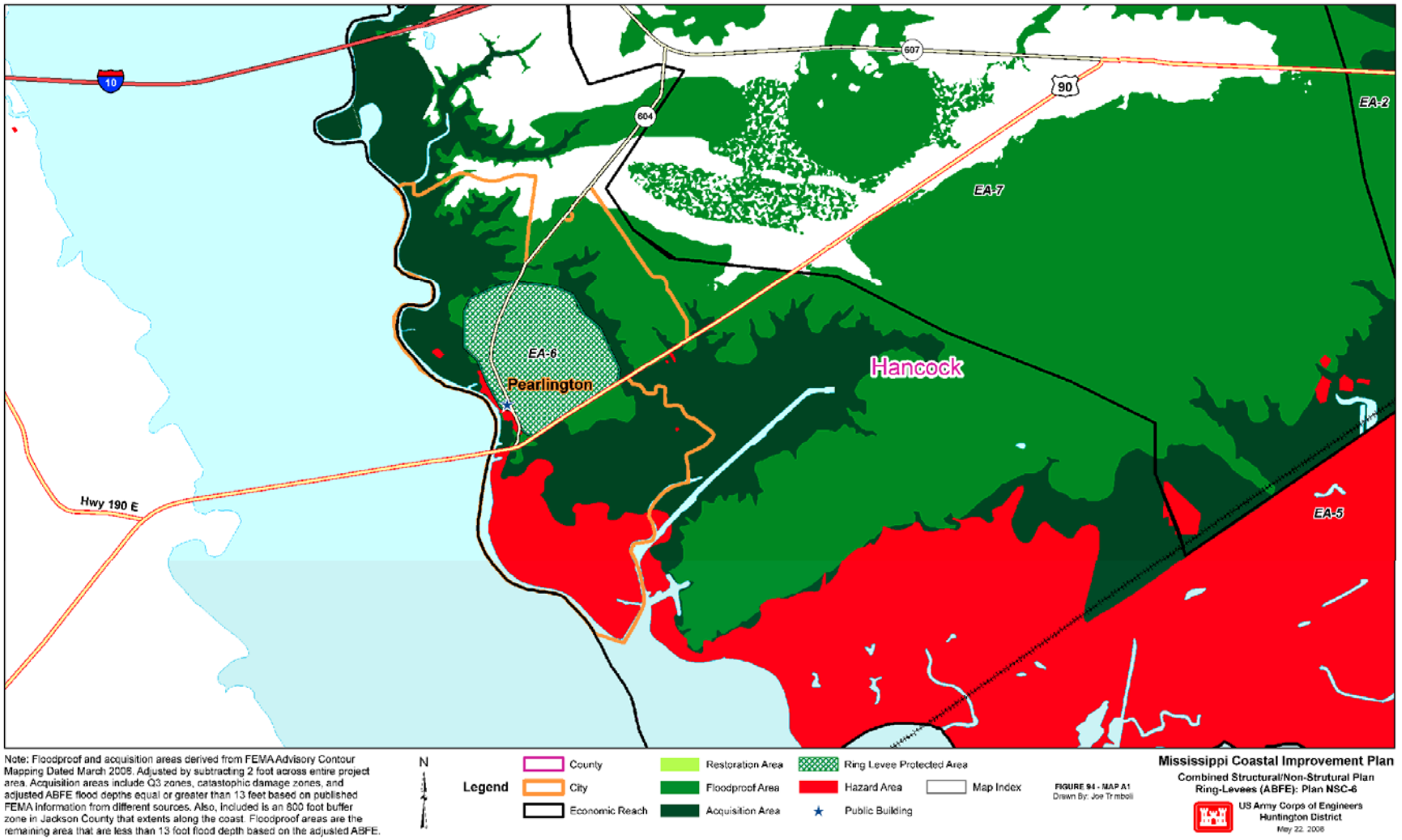


Figure 95 – Plan NSC-6 Combined Nonstructural and Structural Plan (A3)

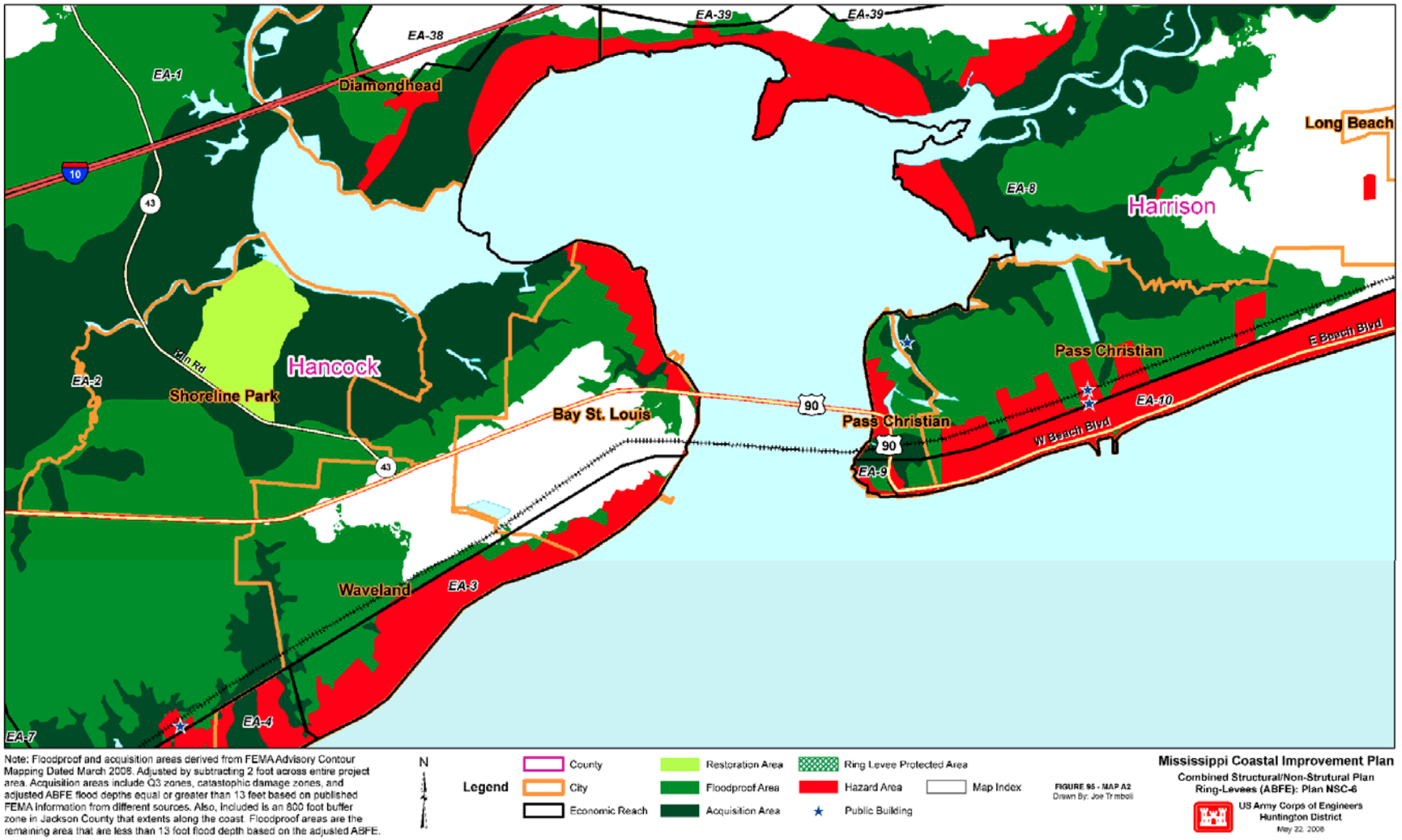


Figure 96 – Plan NSC-6 Combined Nonstructural and Structural Plan (A4)

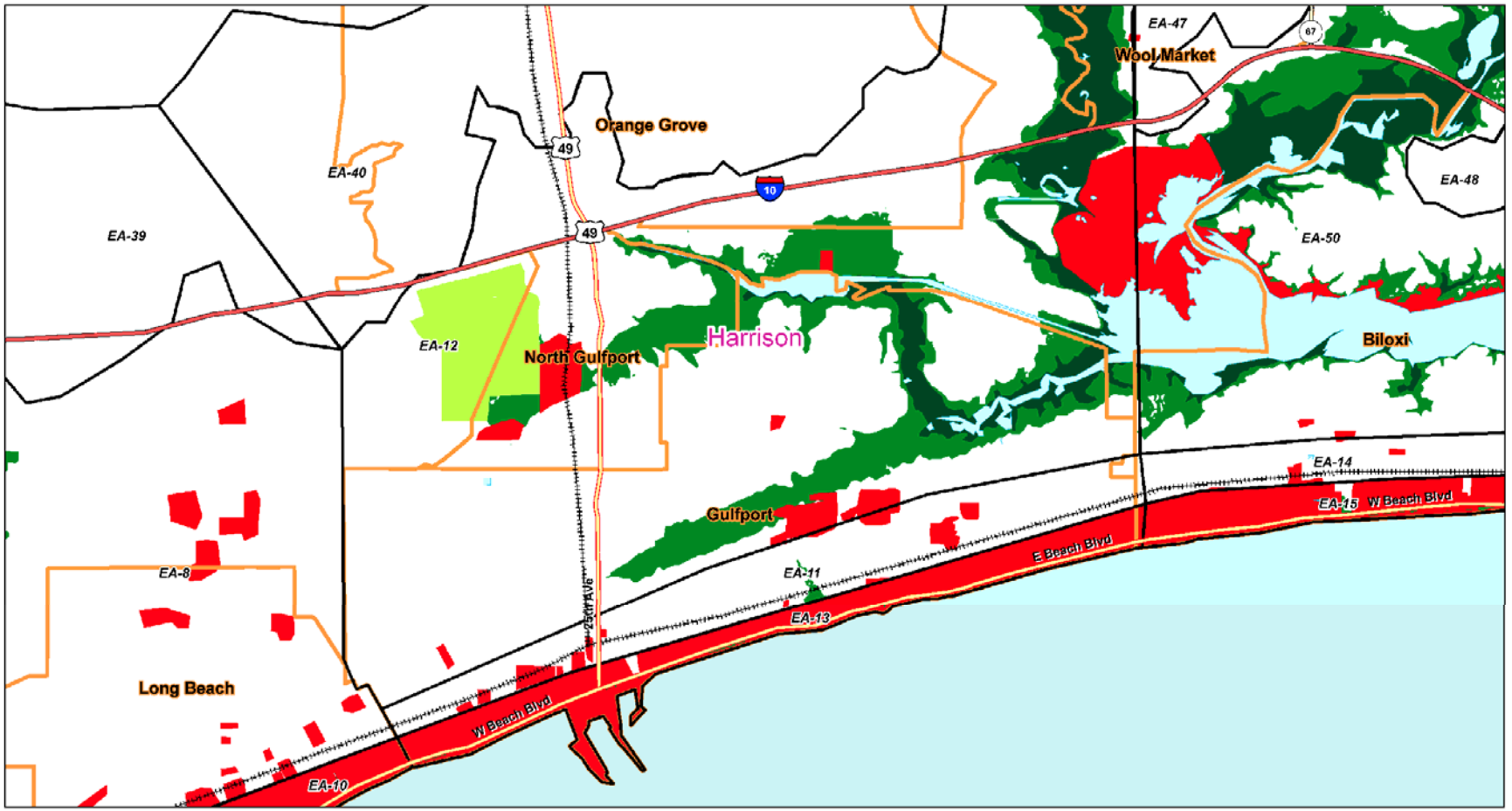


Figure 97 – Plan NSC-6 Combined Nonstructural and Structural Plan (A5)

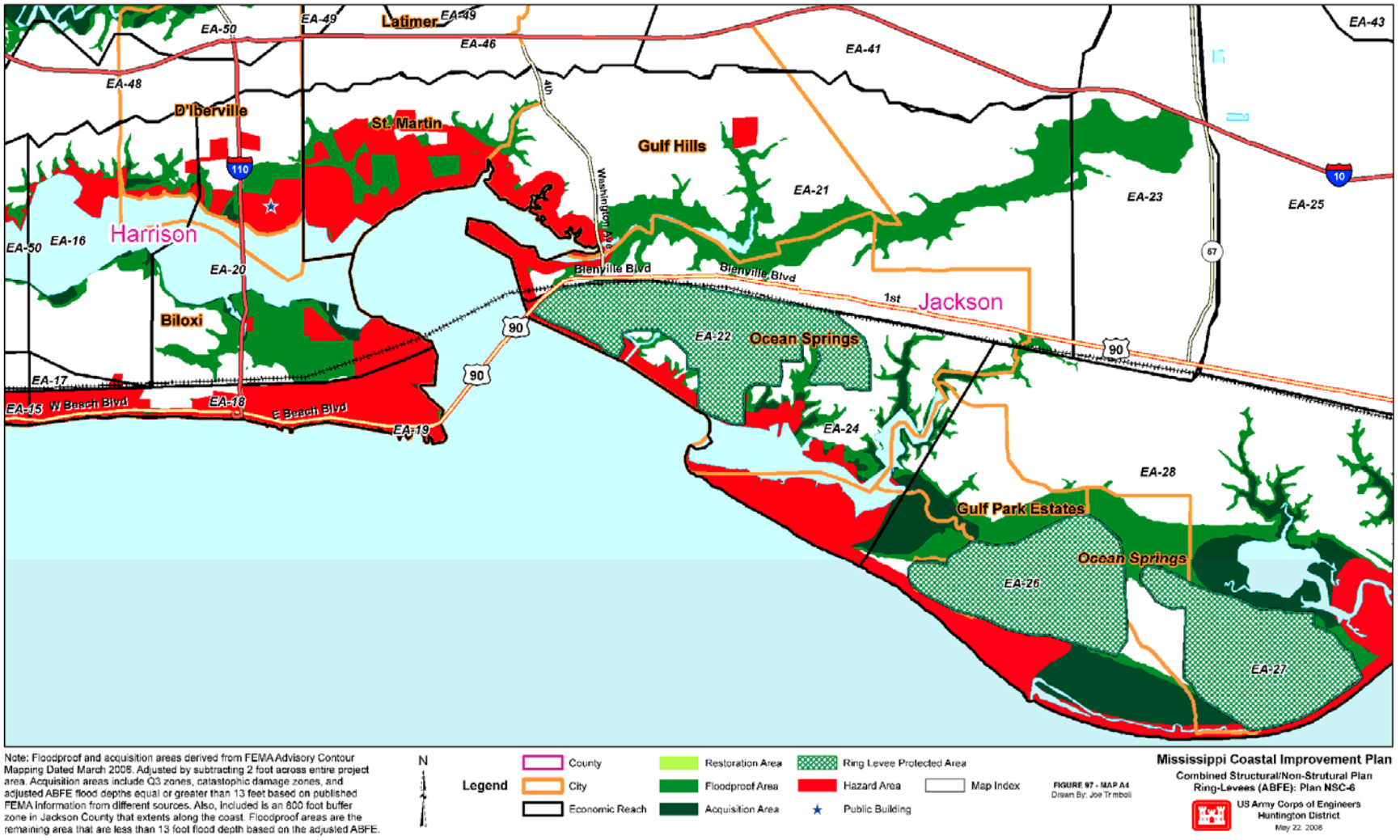


Figure 98 – Plan NSC-6 Combined Nonstructural and Structural Plan (A6)

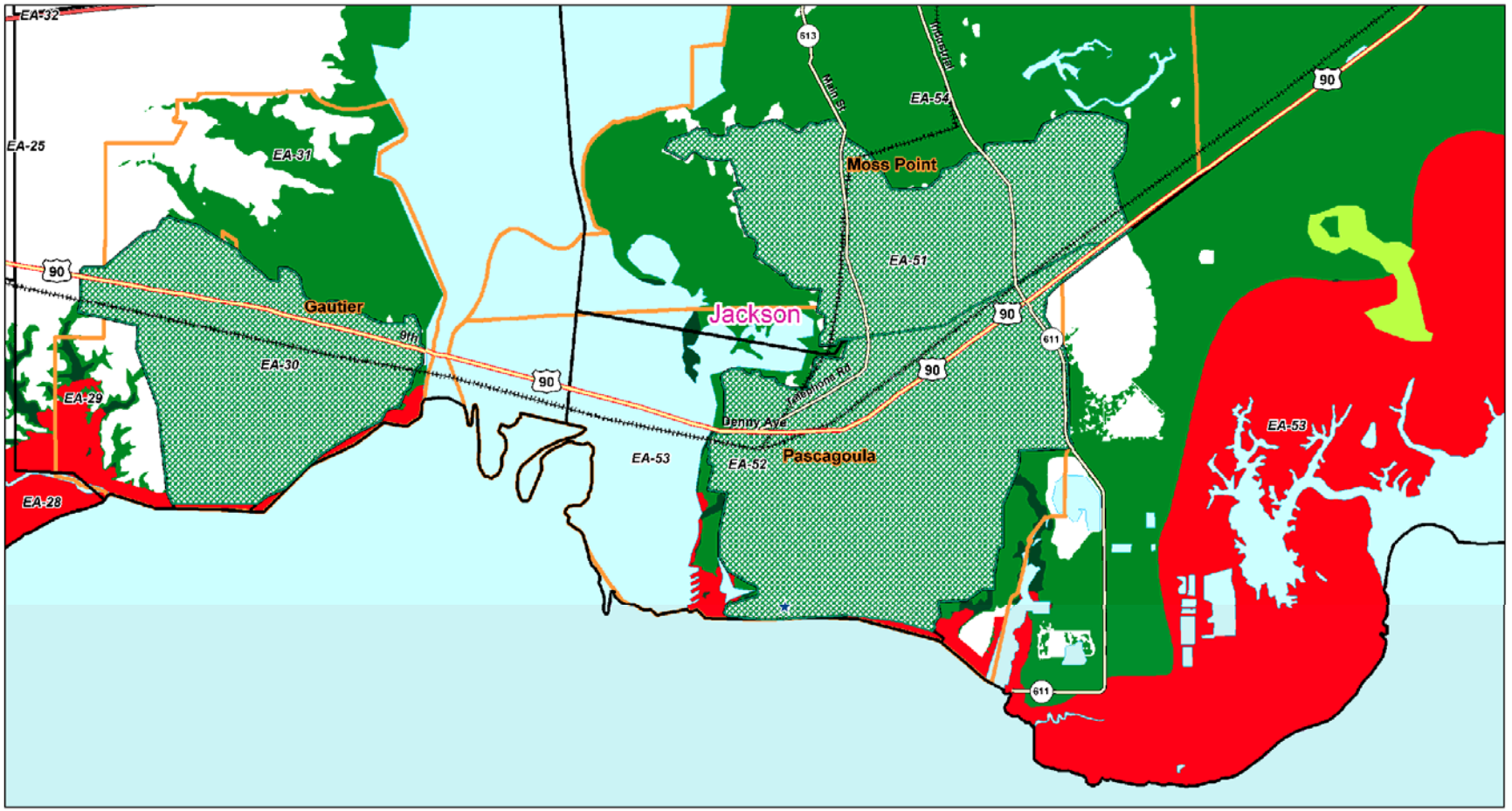


Figure 99 - Plan NSC-6a Combined Nonstructural and Structural Plan (A1)

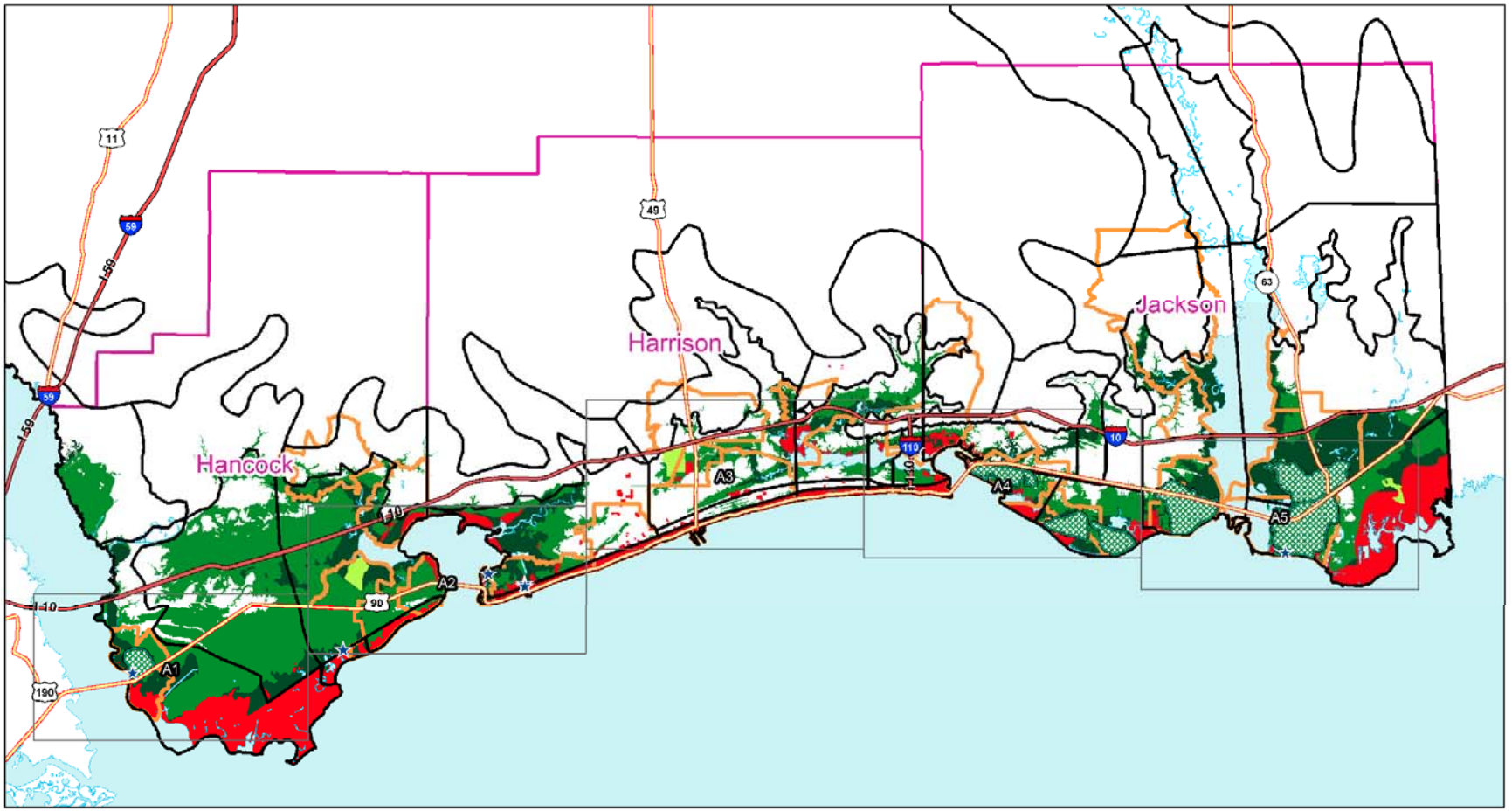


Figure 100 - Plan NSC-6a Combined Nonstructural and Structural Plan (A2)

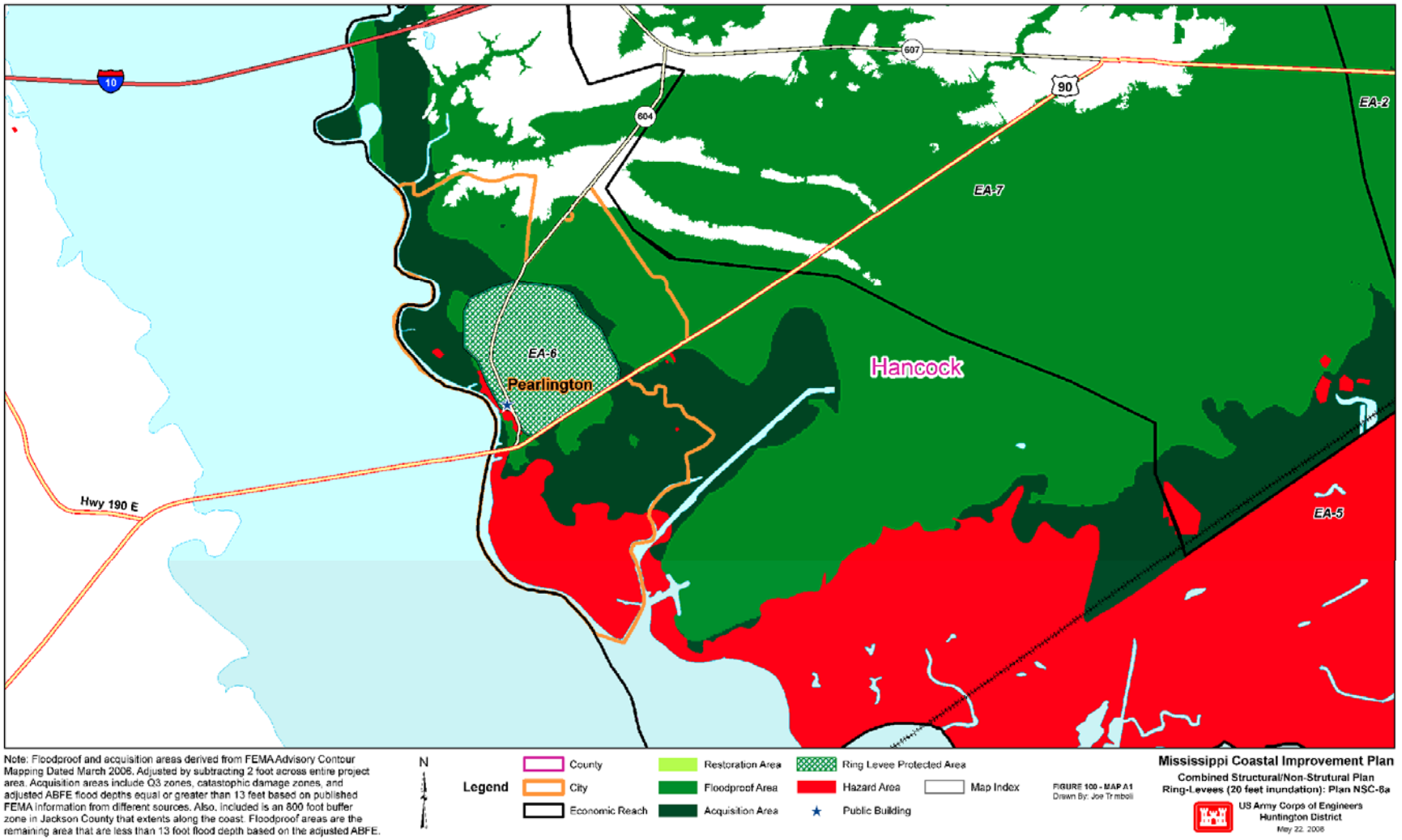


Figure 101 - Plan NSC-6a Combined Nonstructural and Structural Plan (A3)

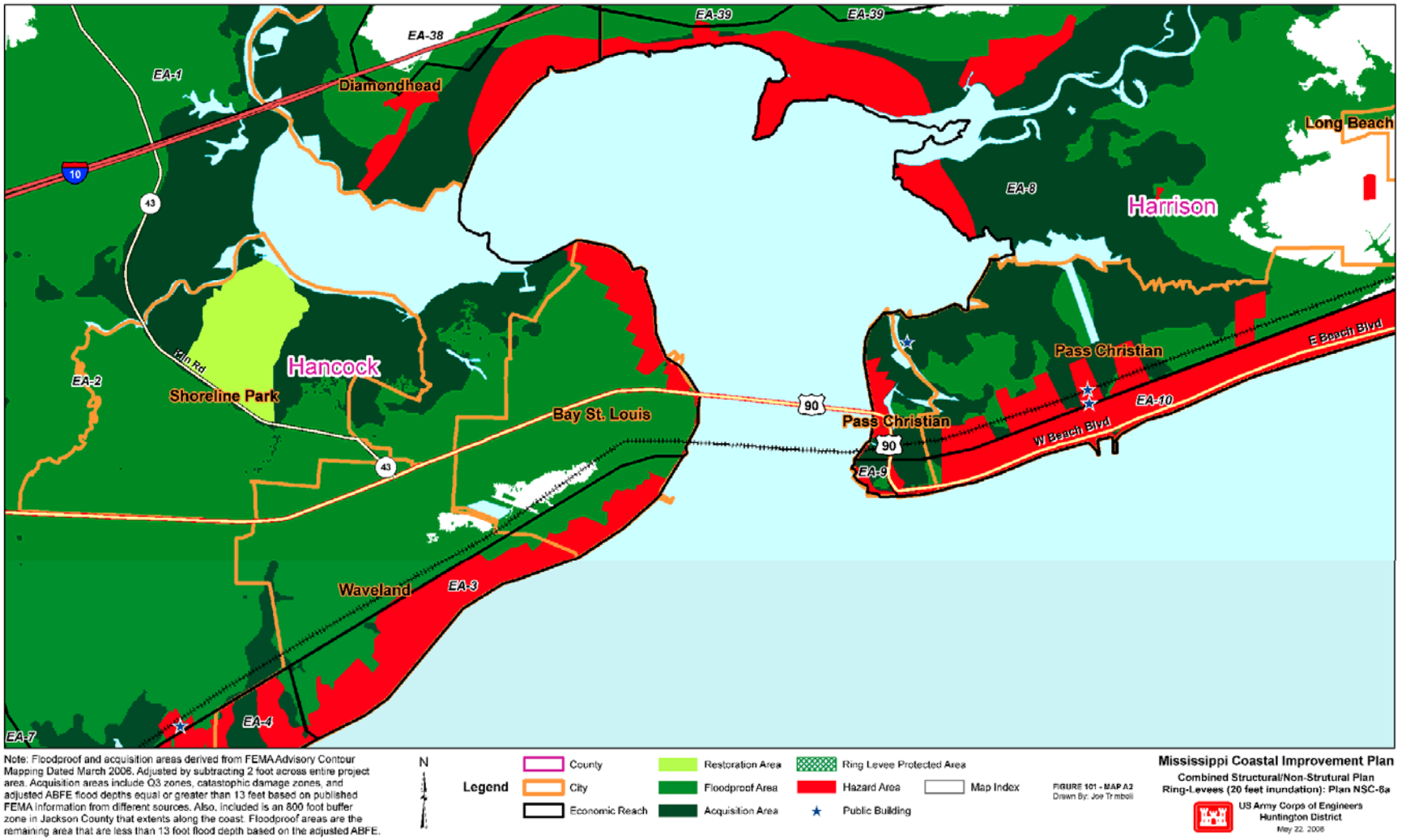


Figure 102 - Plan NSC-6a Combined Nonstructural and Structural Plan (A4)

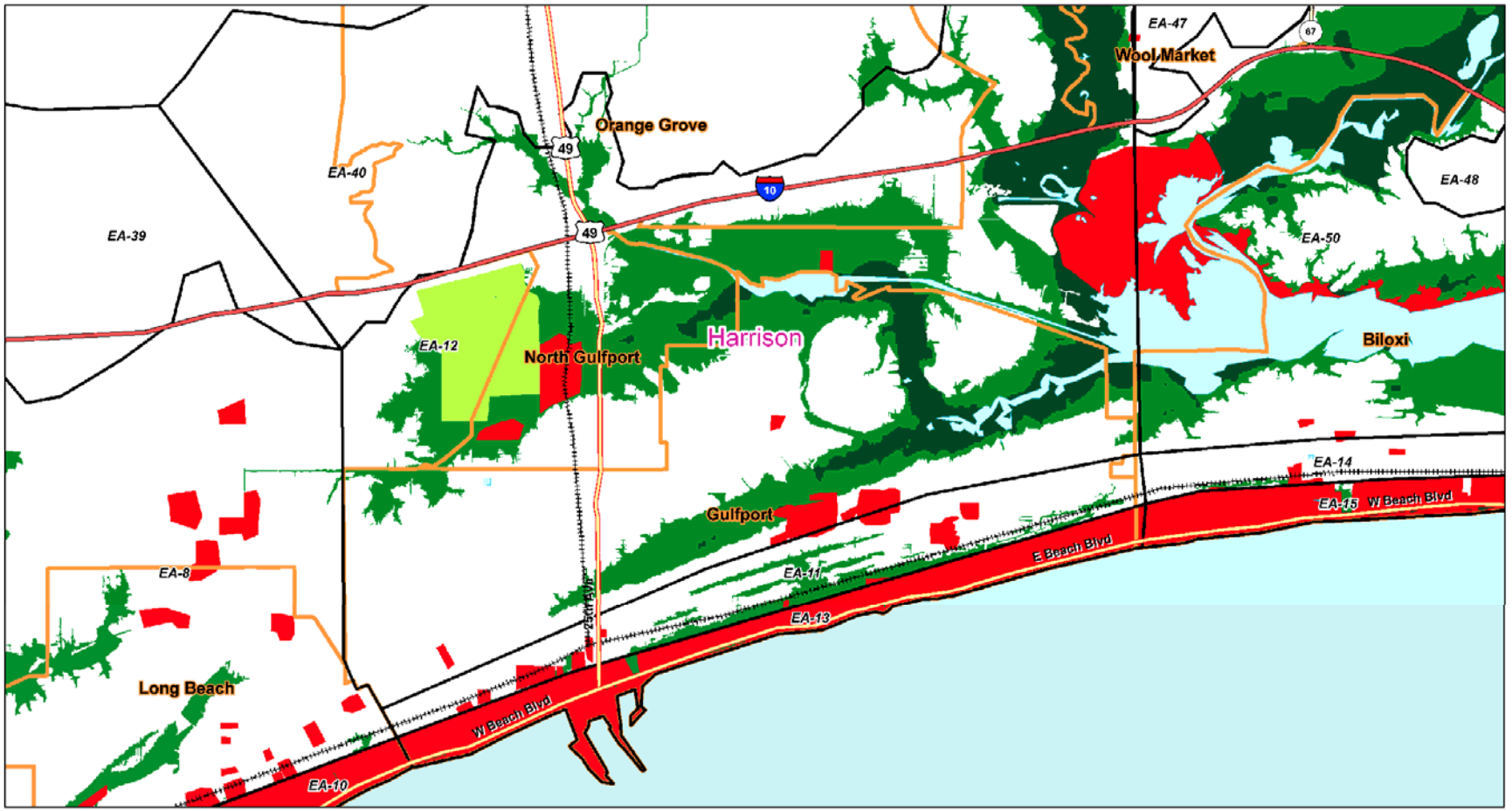


Figure 103 - Plan NSC-6a Combined Nonstructural and Structural Plan (A5)

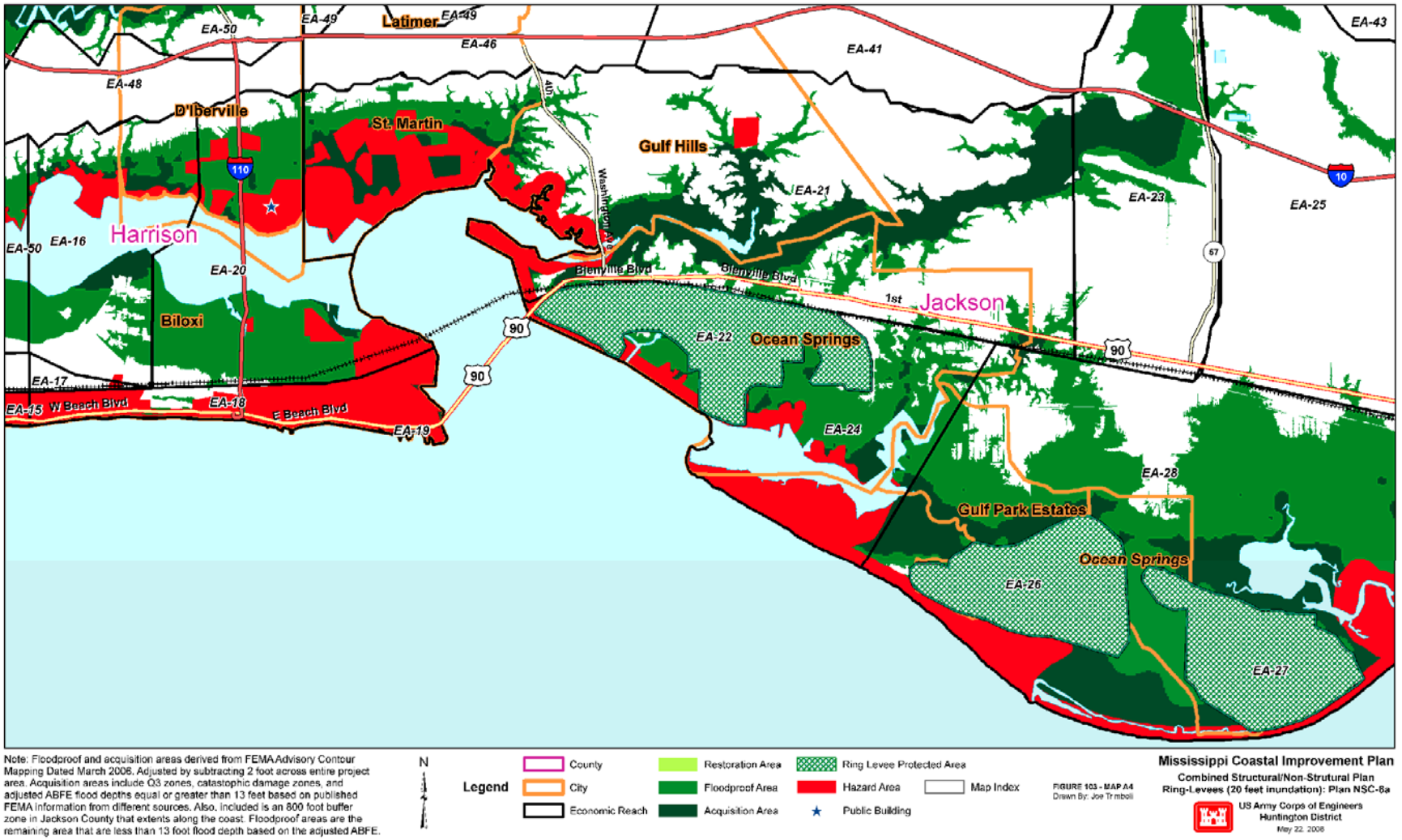


Figure 104 - Plan NSC-6a Combined Nonstructural and Structural Plan (A6)

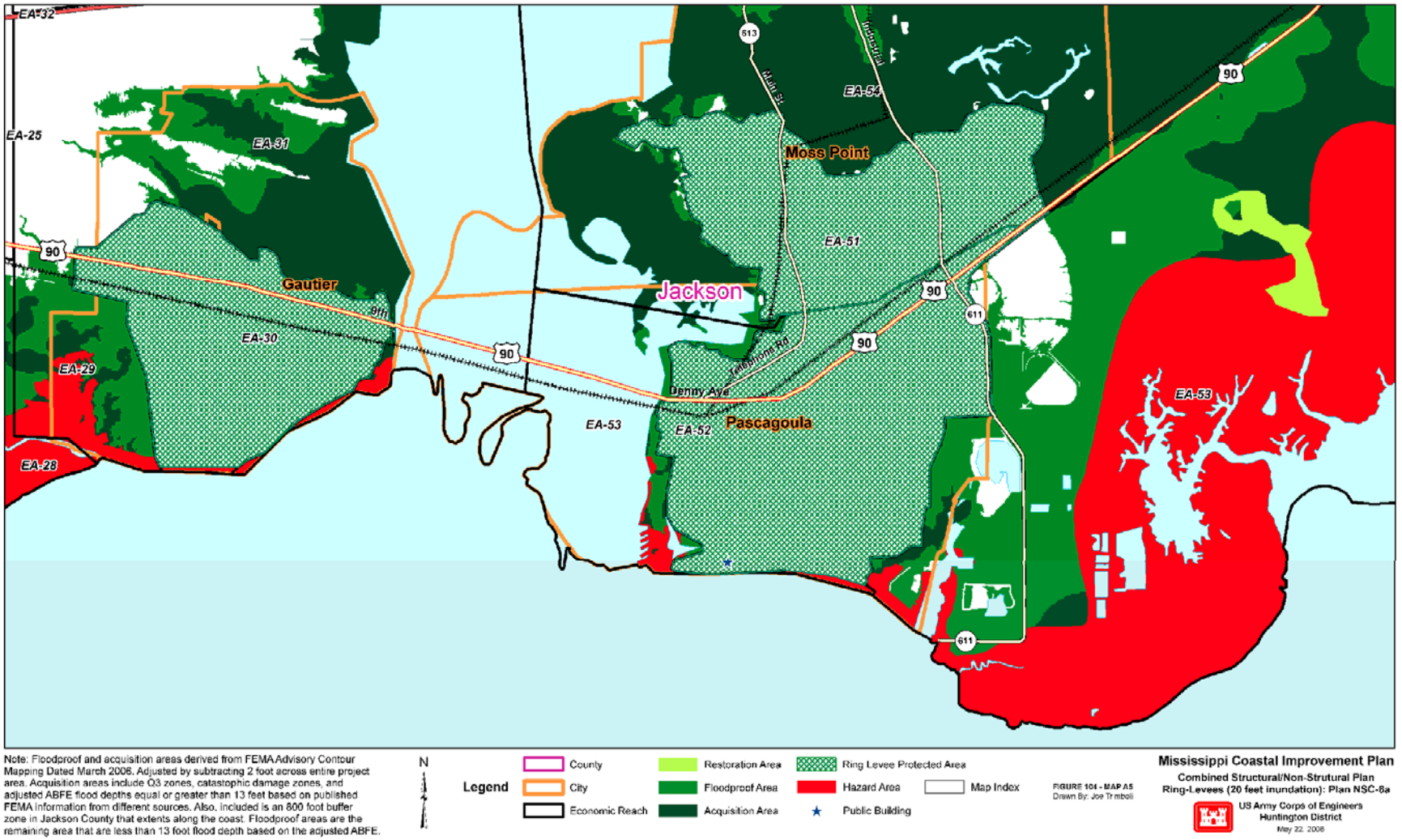


Figure 105 - Plan NSC-6b Combined Nonstructural and Structural Plan (A1)

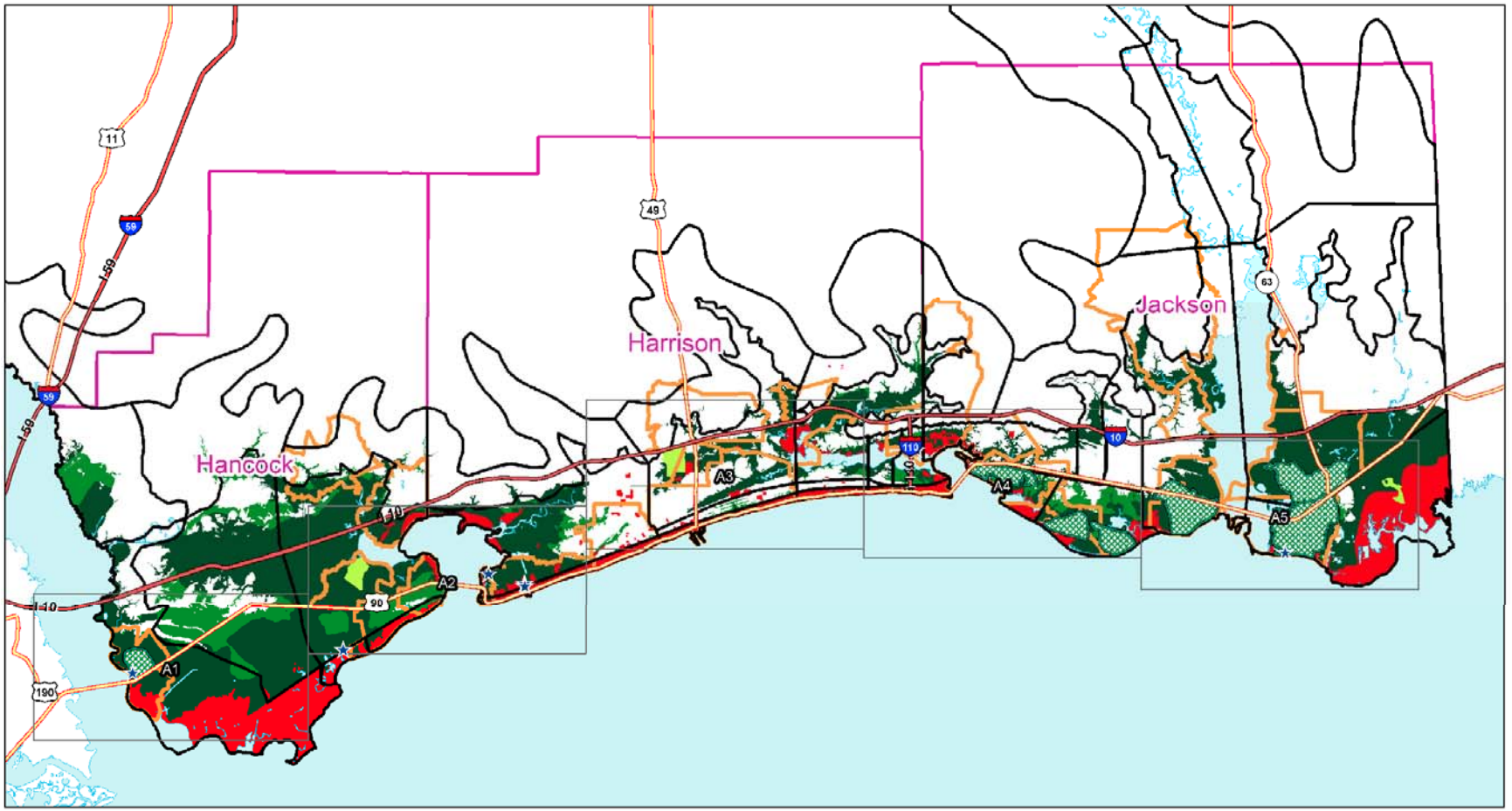


Figure 106 - Plan NSC-6b Combined Nonstructural and Structural Plan (A2)

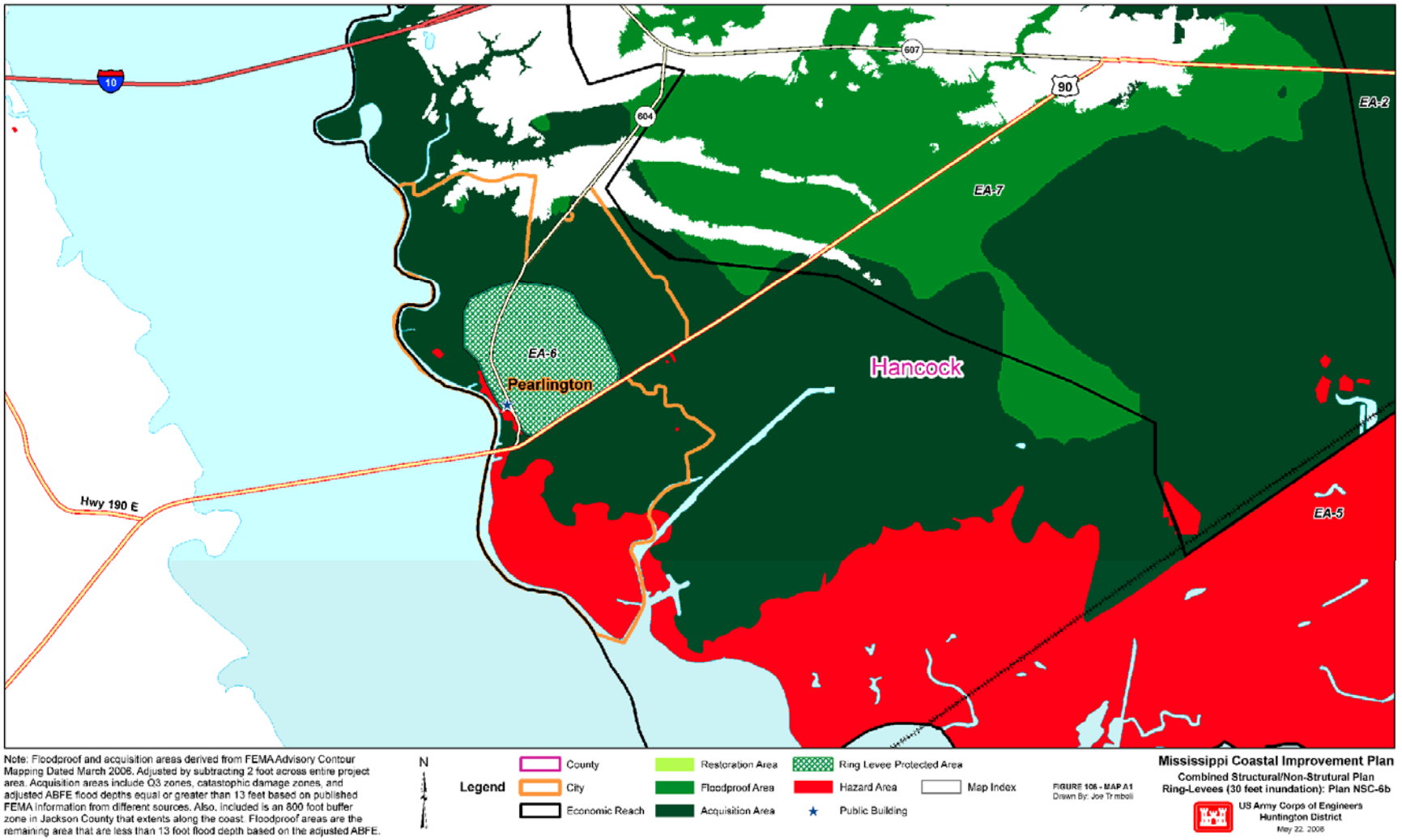


Figure 107 - Plan NSC-6b Combined Nonstructural and Structural Plan (A3)

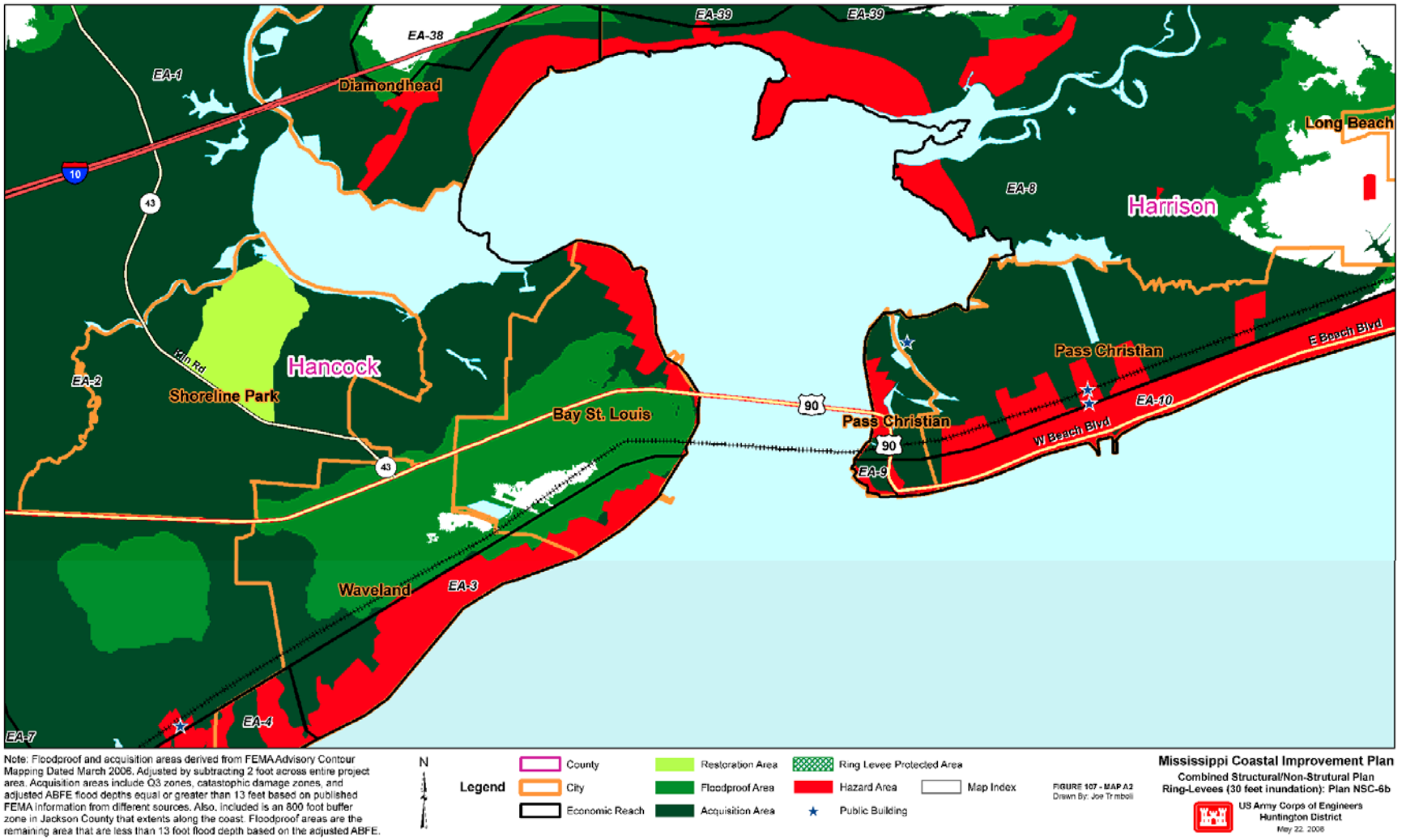


Figure 108 - Plan NSC-6b Combined Nonstructural and Structural Plan (A4)

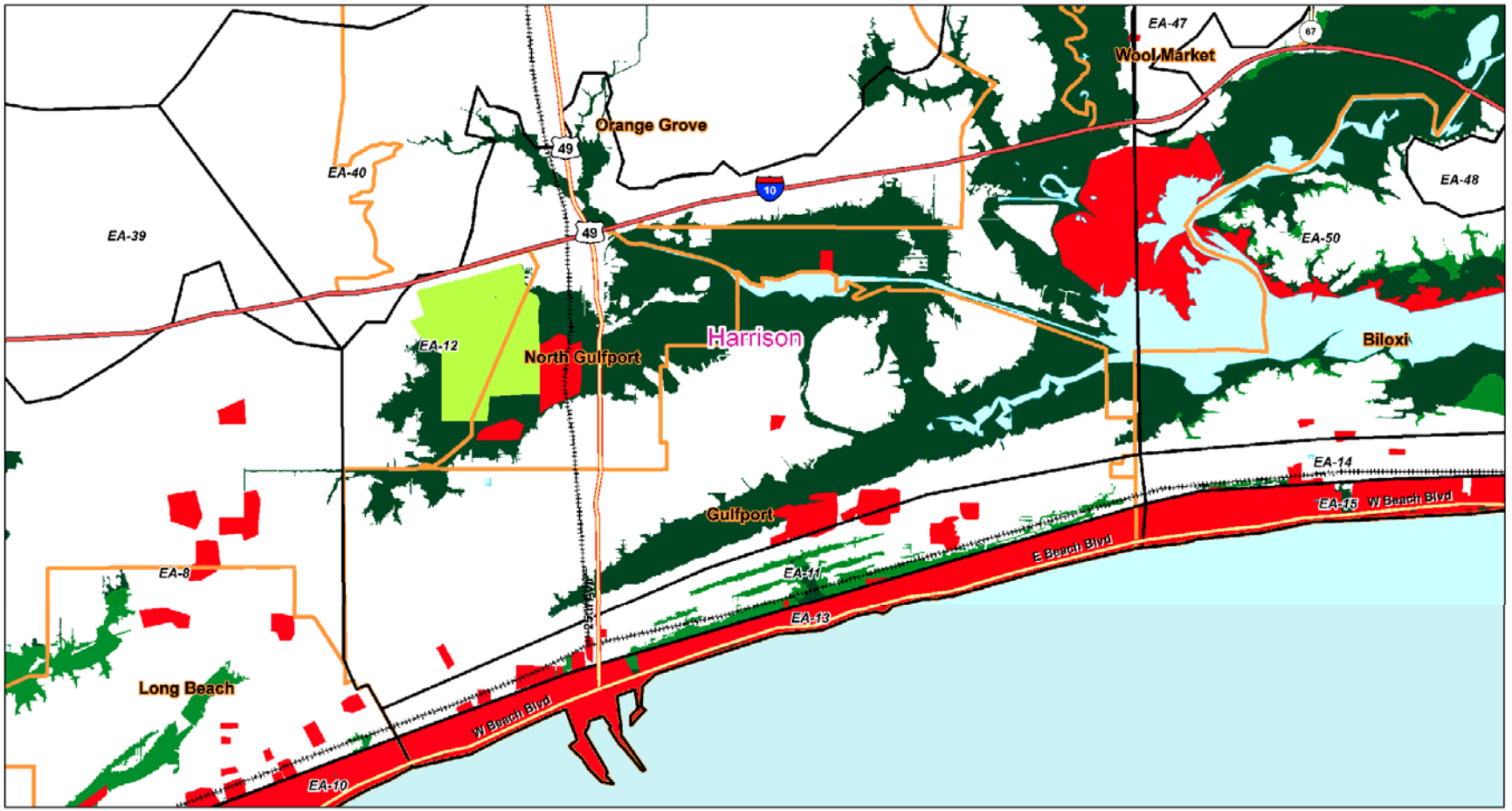


Figure 109 - Plan NSC-6b Combined Nonstructural and Structural Plan (A5)

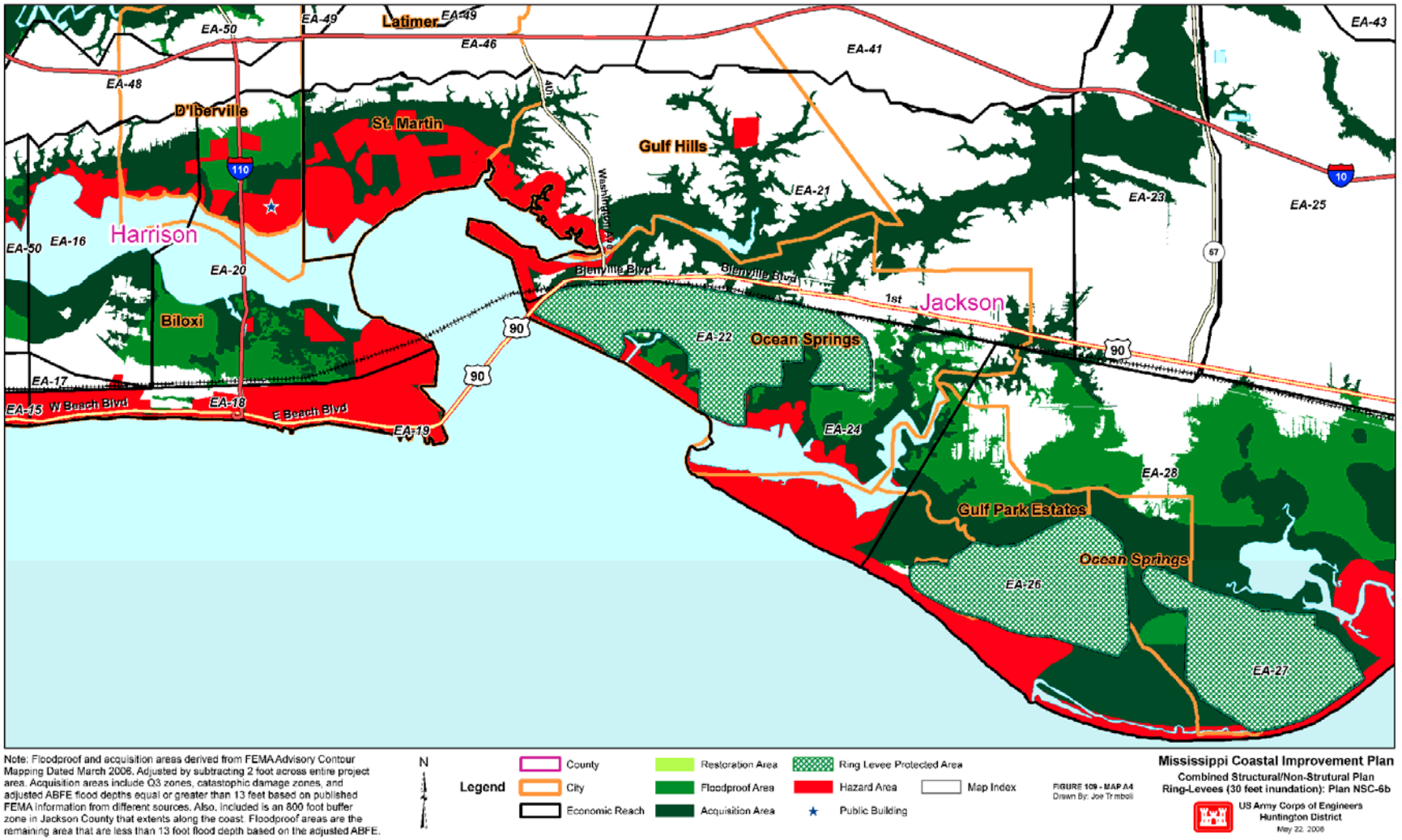


Figure 110 - Plan NSC-6b Combined Nonstructural and Structural Plan (A6)

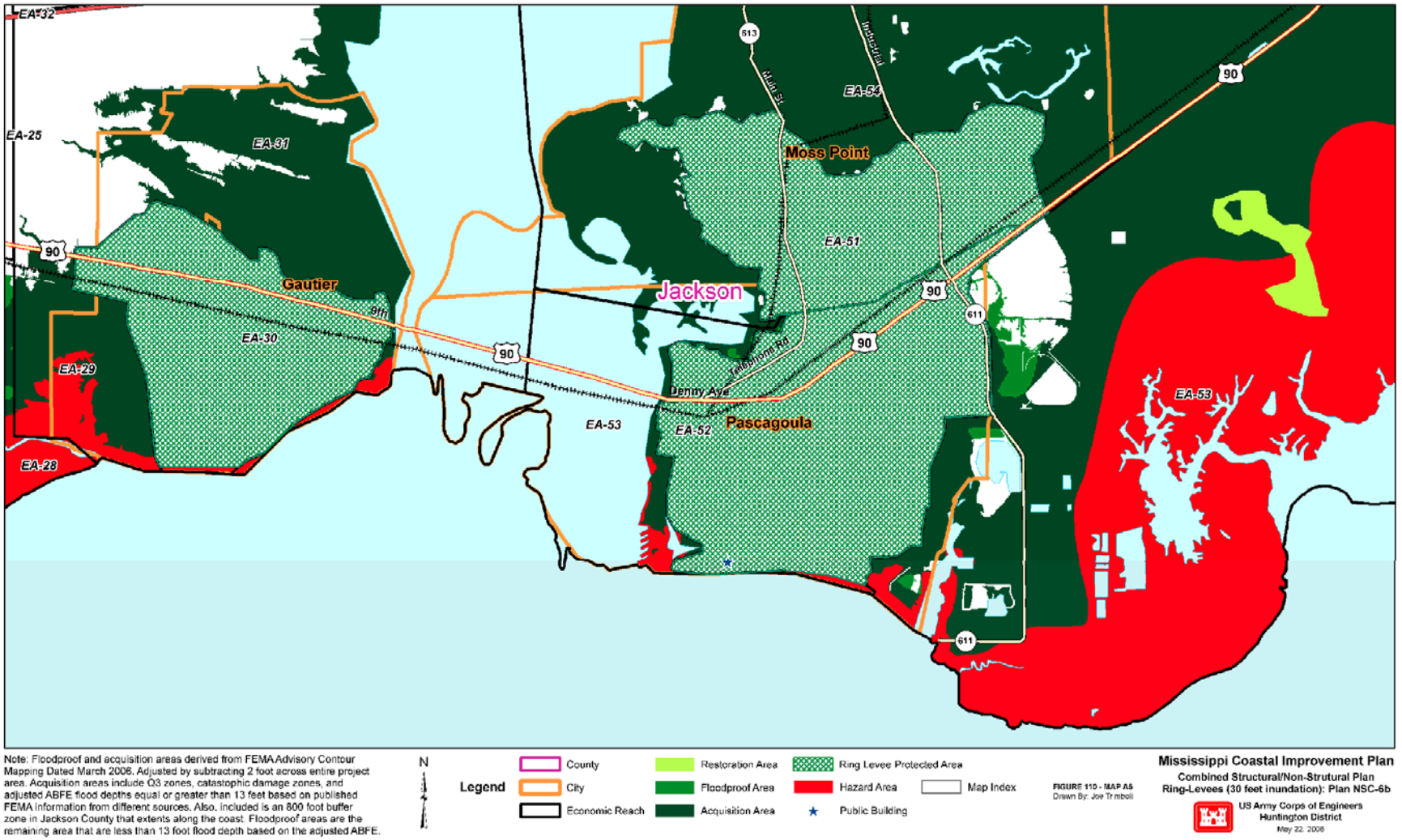


Figure 111 - Plan NSC-6c Combined Nonstructural and Structural Plan (A1)

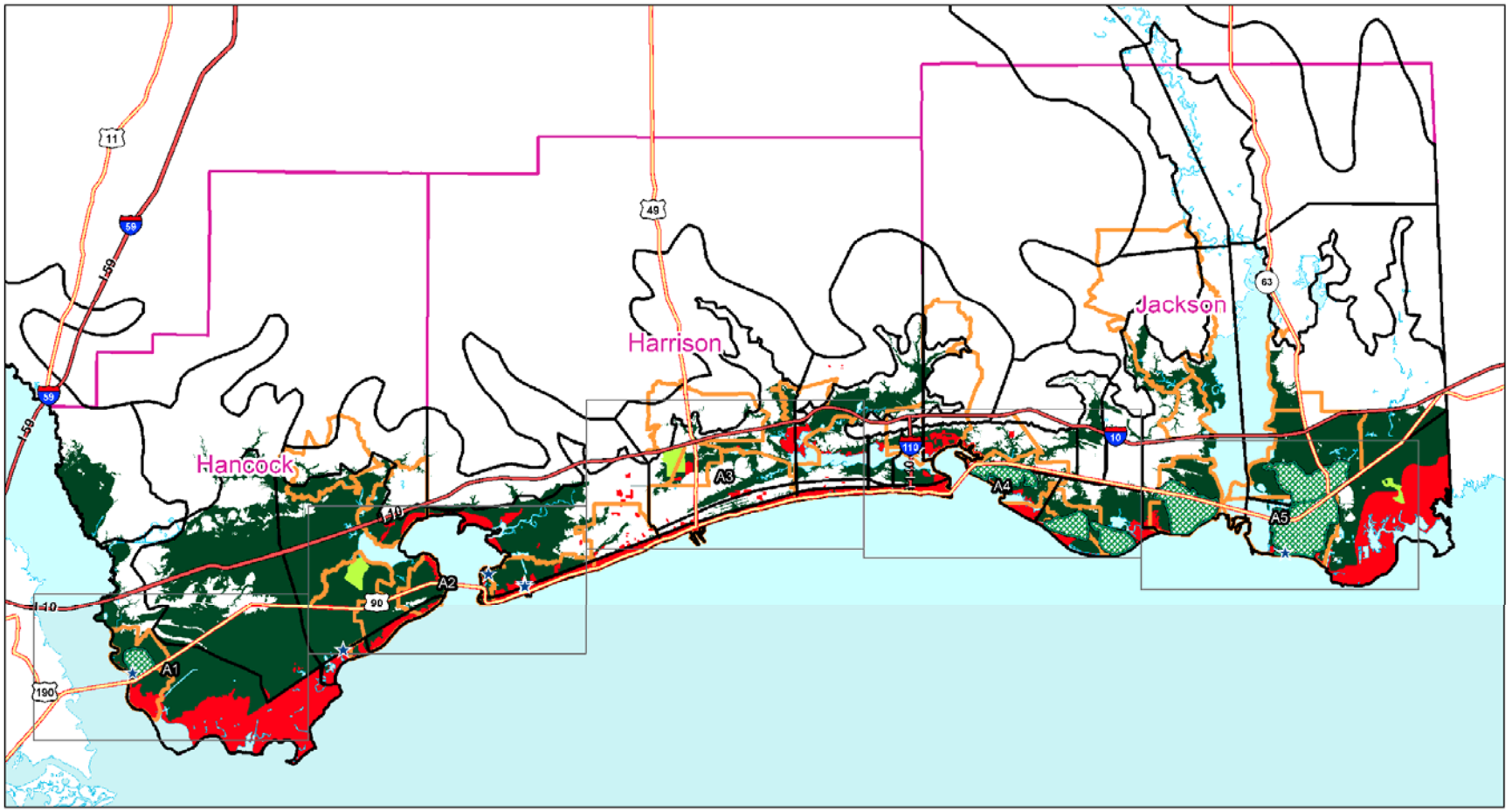


Figure 112 - Plan NSC-6c Combined Nonstructural and Structural Plan (A2)

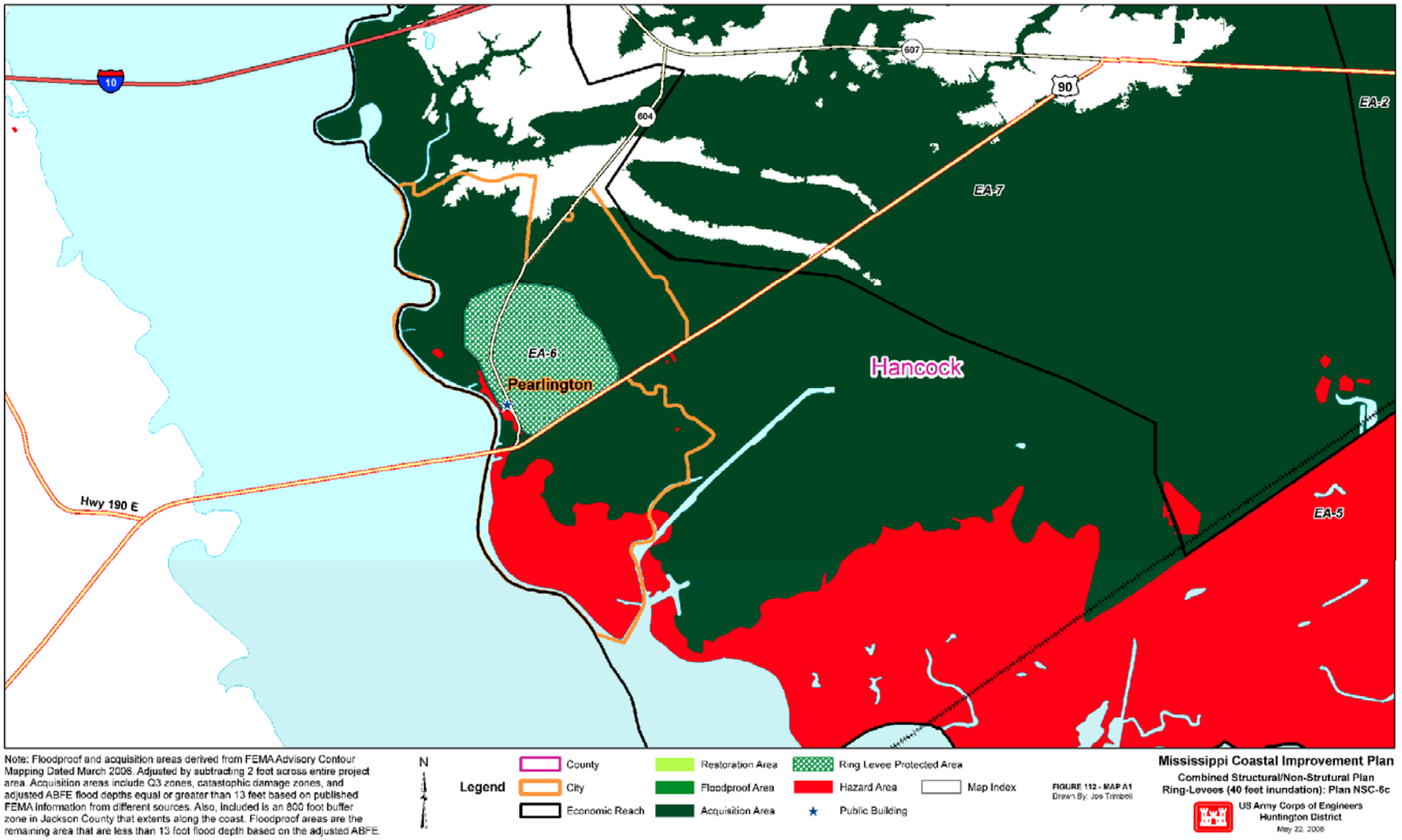


Figure 113 - Plan NSC-6c Combined Nonstructural and Structural Plan (A3)

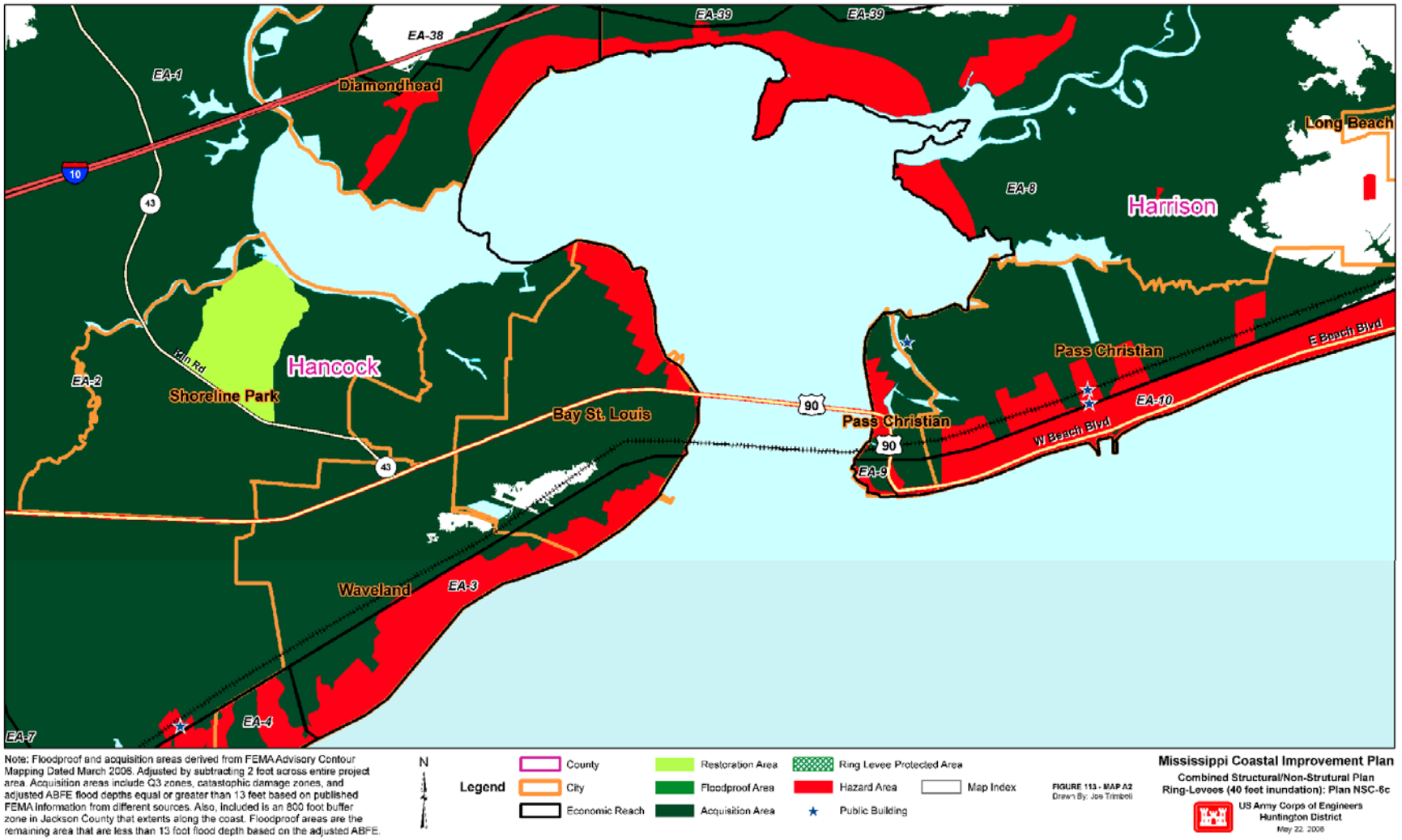


Figure 114 - Plan NSC-6c Combined Nonstructural and Structural Plan (A4)

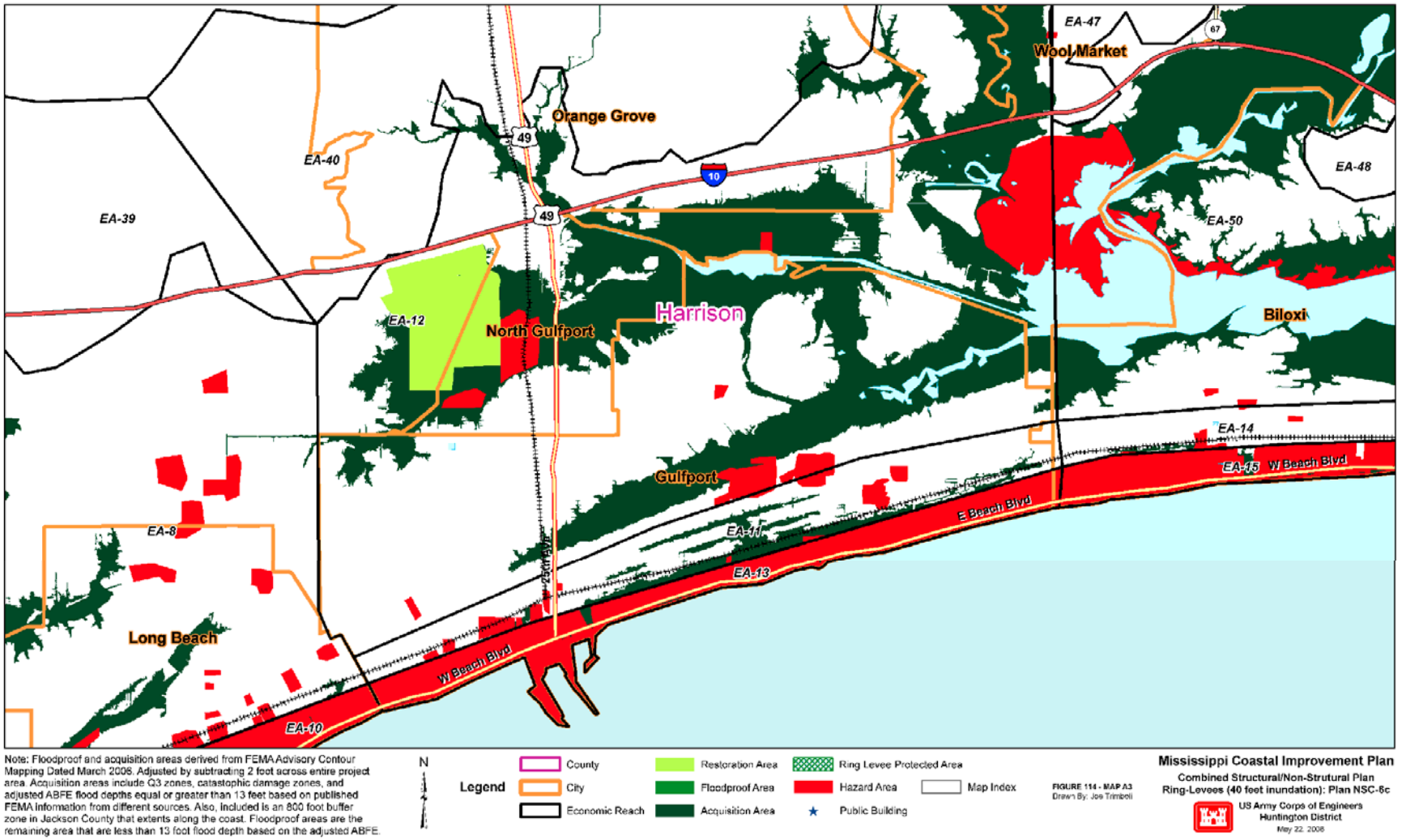


Figure 115 - Plan NSC-6c Combined Nonstructural and Structural Plan (A5)

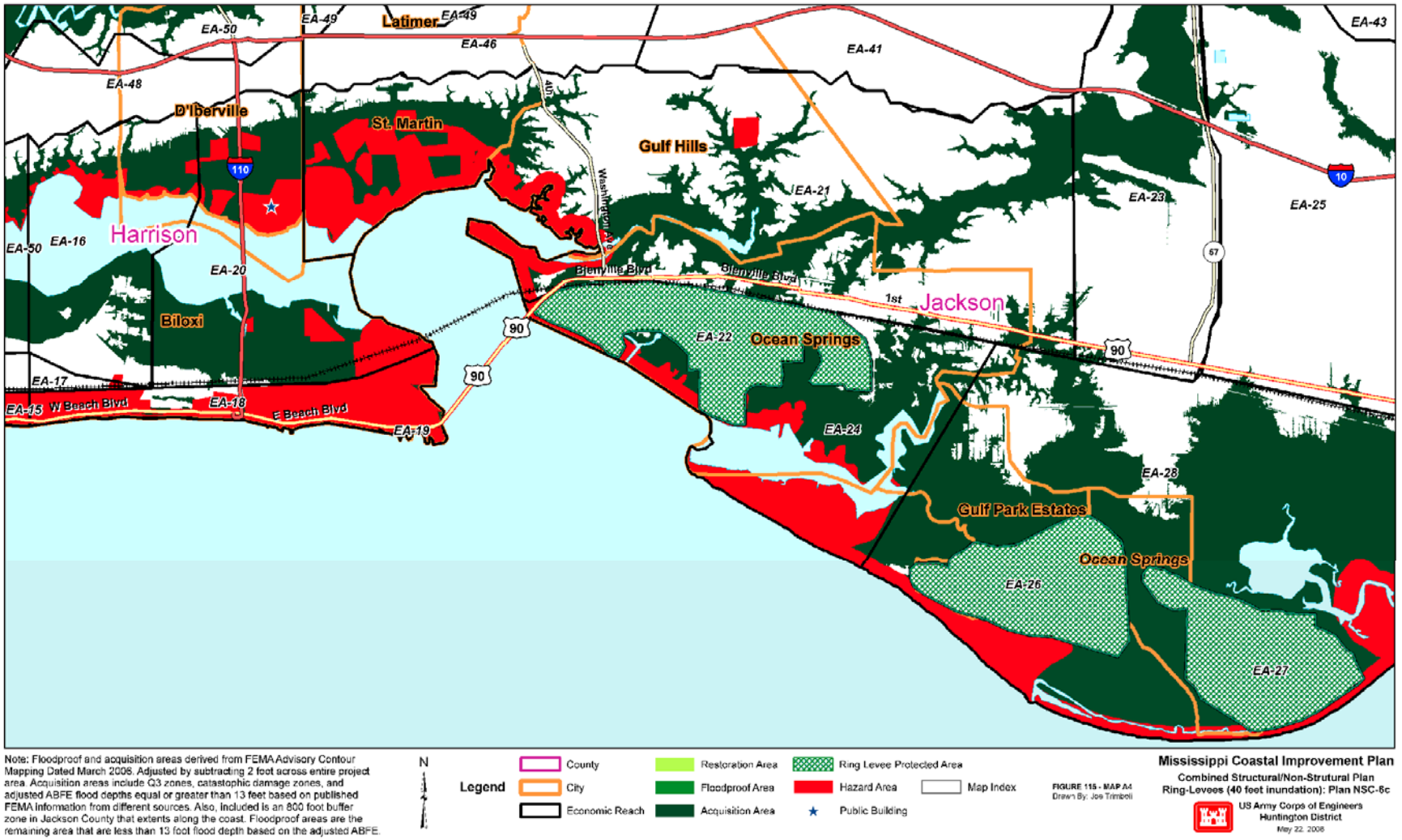


Figure 116 - Plan NSC-6c Combined Nonstructural and Structural Plan (A6)

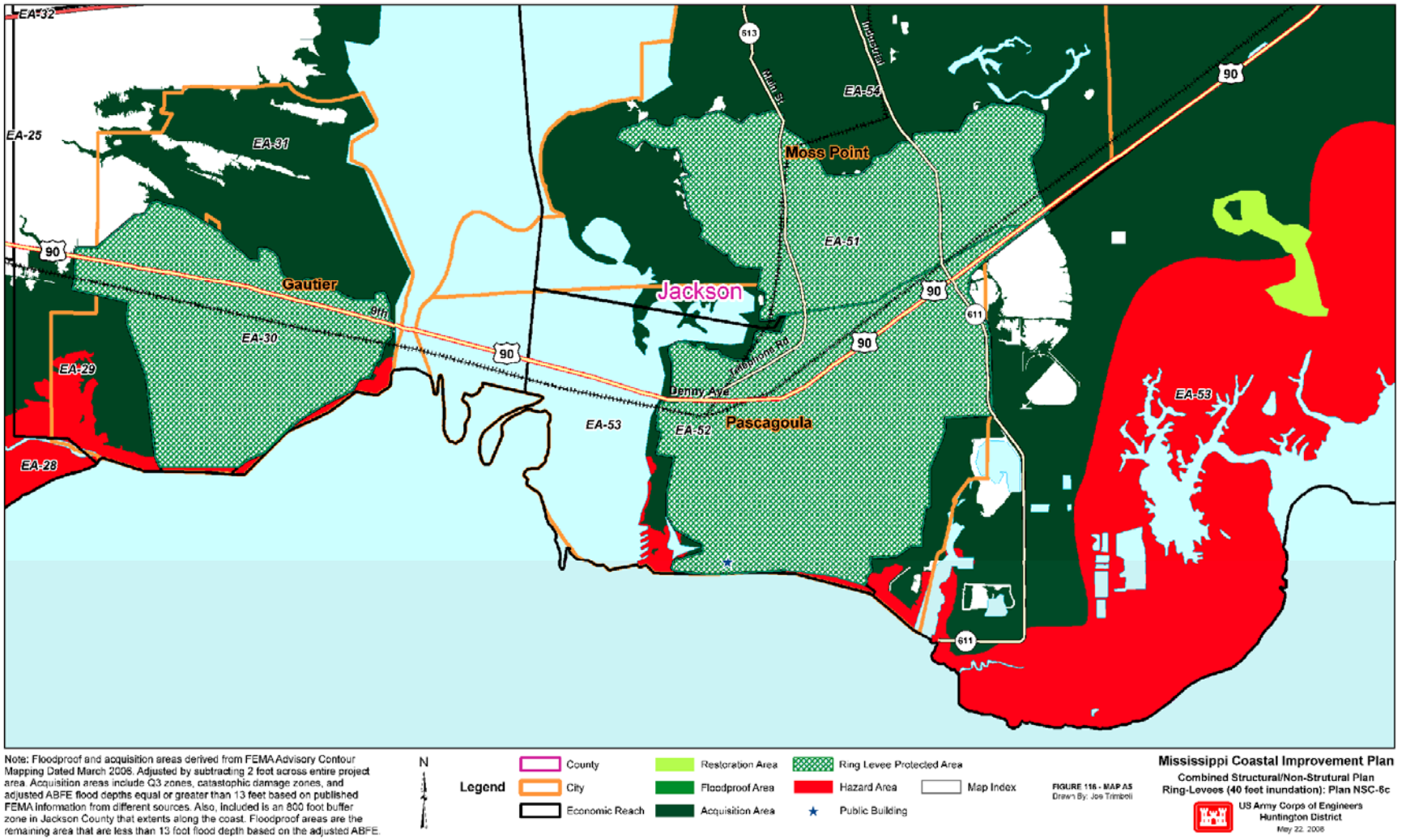


Figure 117 - Plan NSC-6d Combined Nonstructural and Structural Plan (A1)

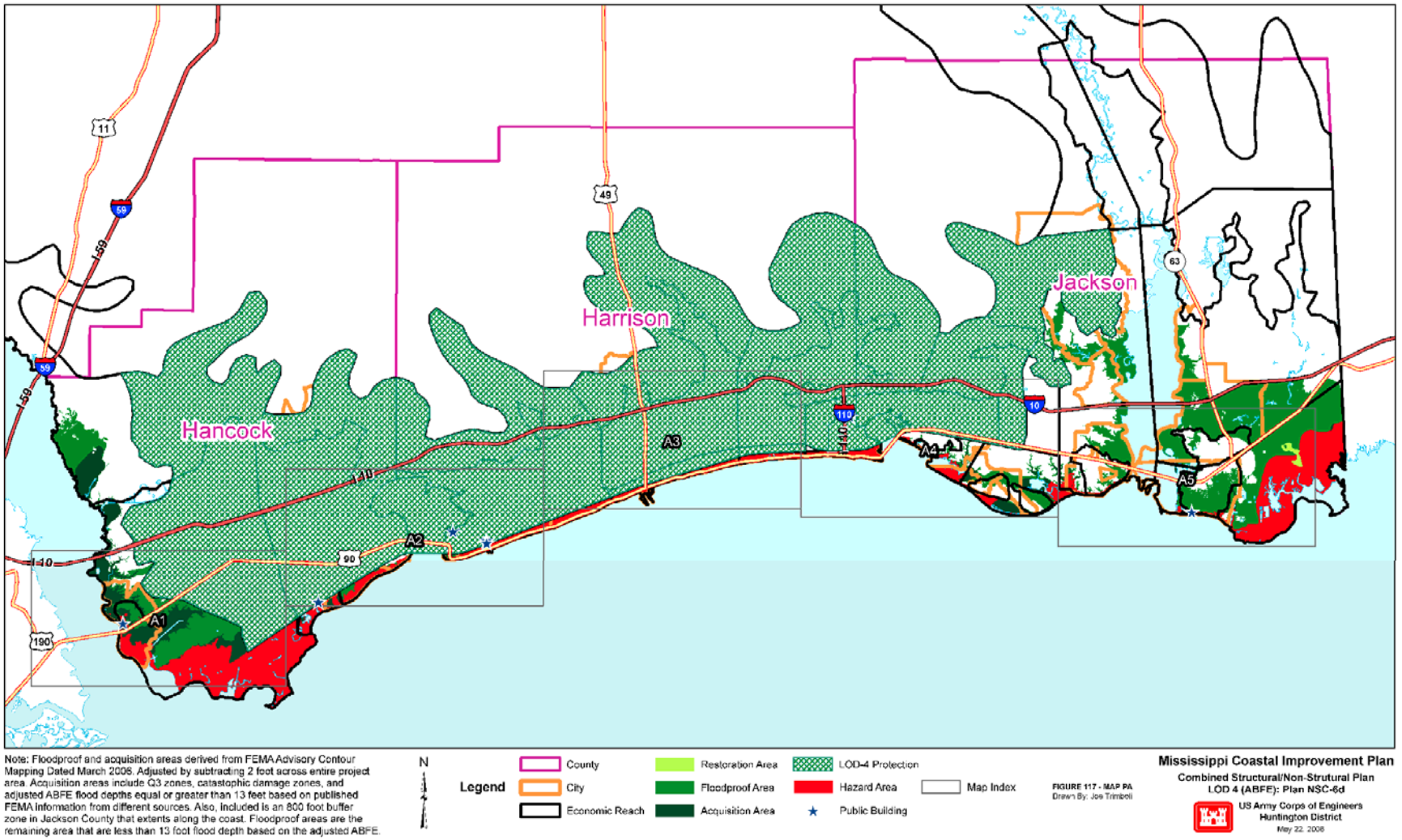


Figure 118 - Plan NSC-6d Combined Nonstructural and Structural Plan (A2)

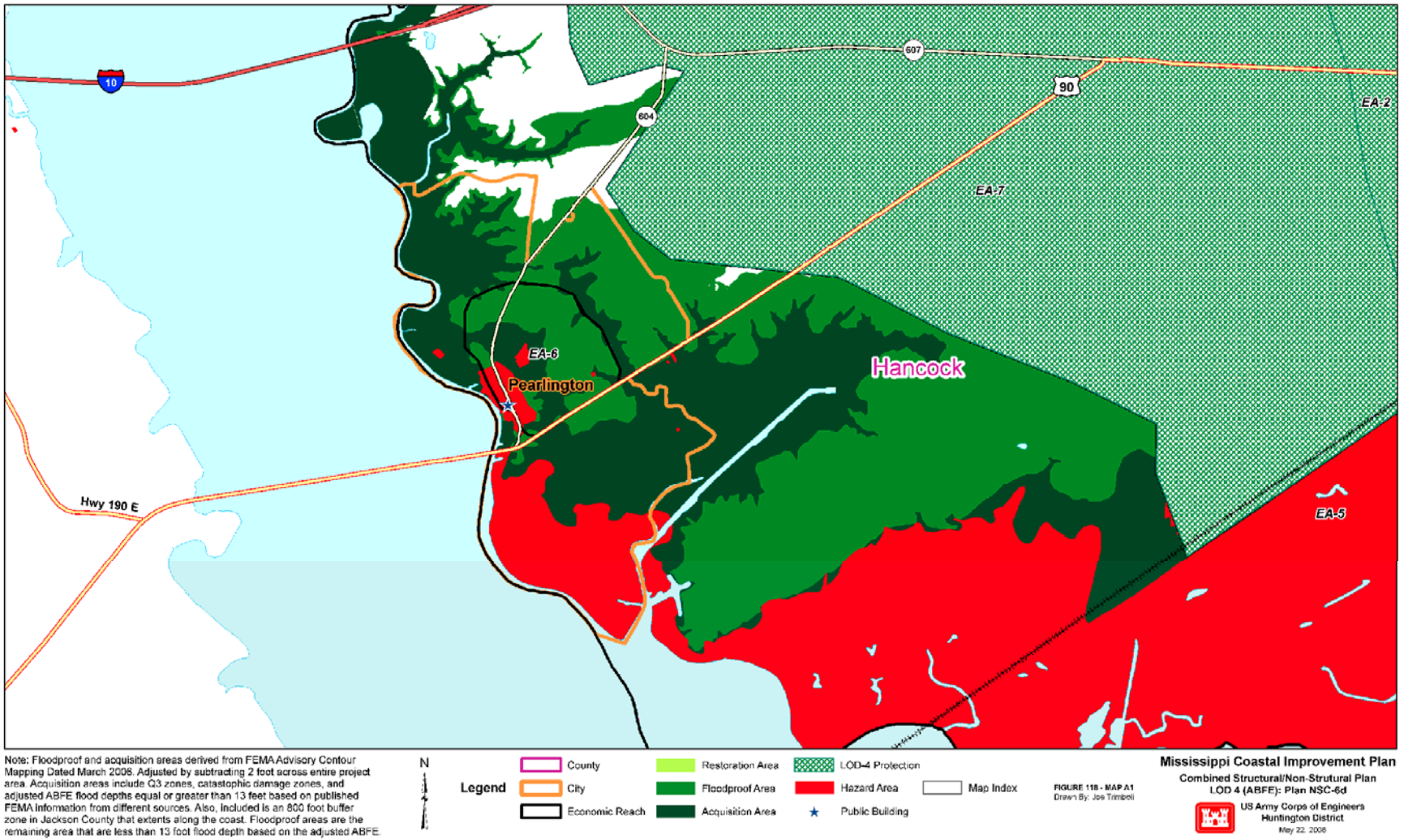


Figure 119 - Plan NSC-6d Combined Nonstructural and Structural Plan (A3)

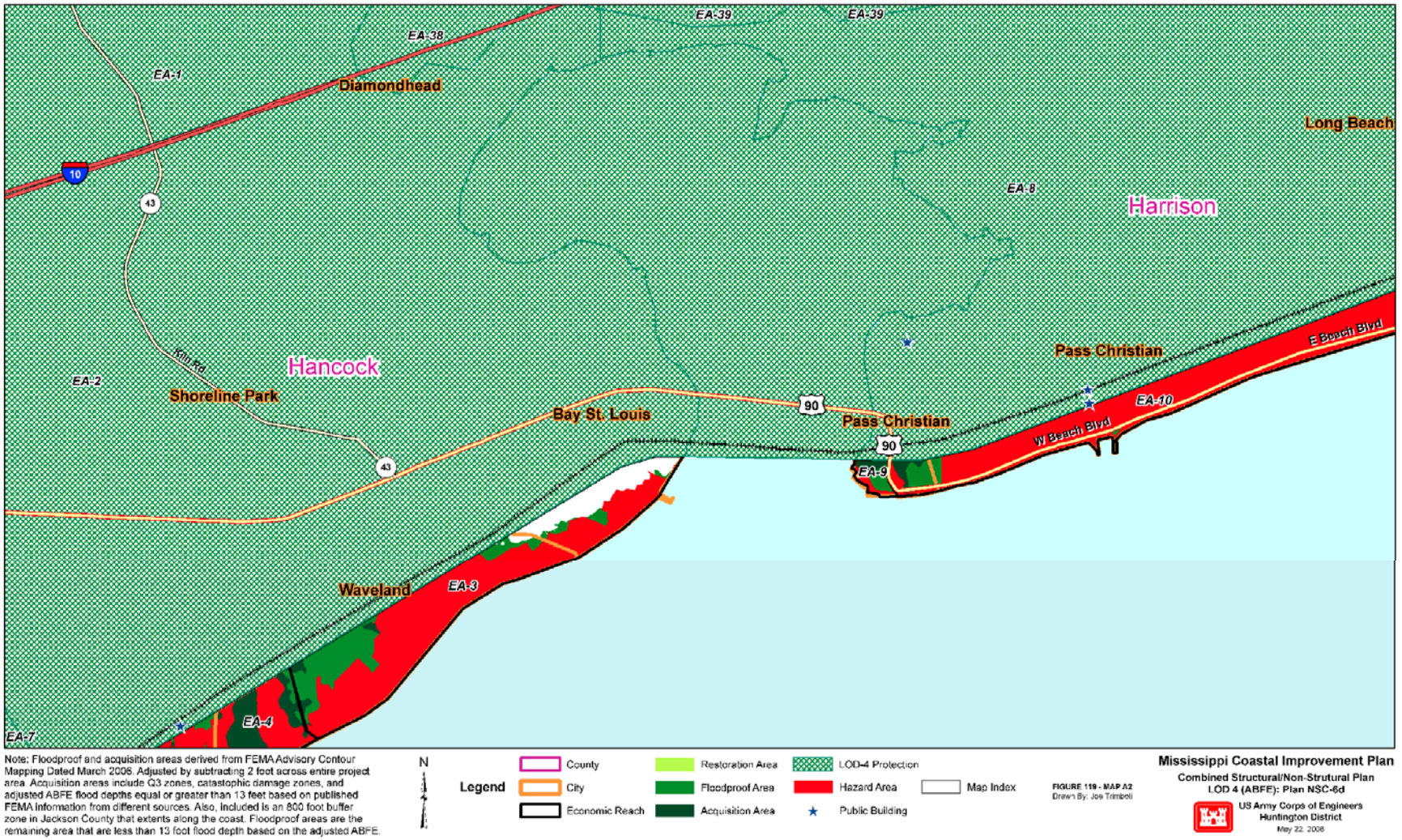


Figure 120 - Plan NSC-6d Combined Nonstructural and Structural Plan (A4)

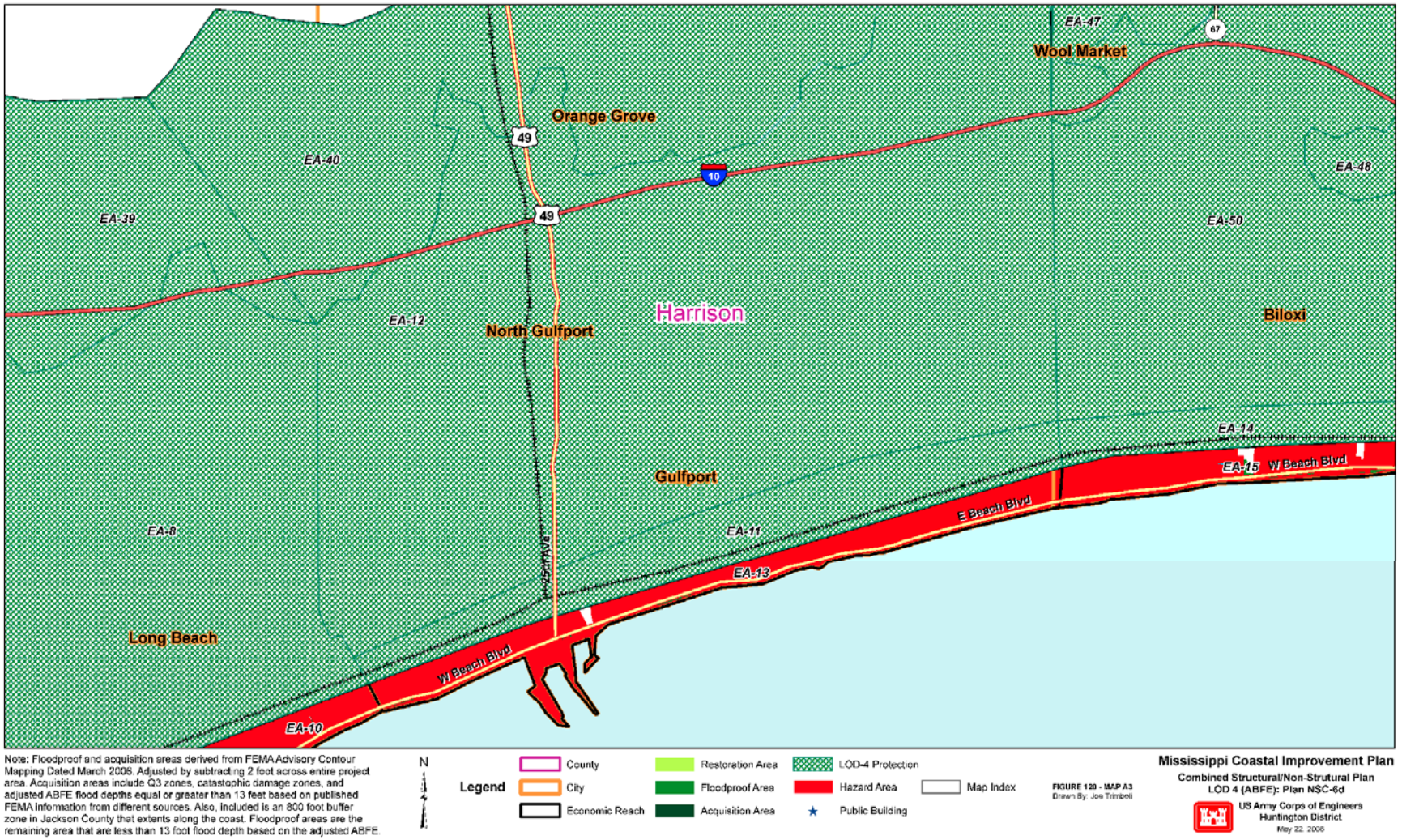


Figure 121 - Plan NSC-6d Combined Nonstructural and Structural Plan (A5)

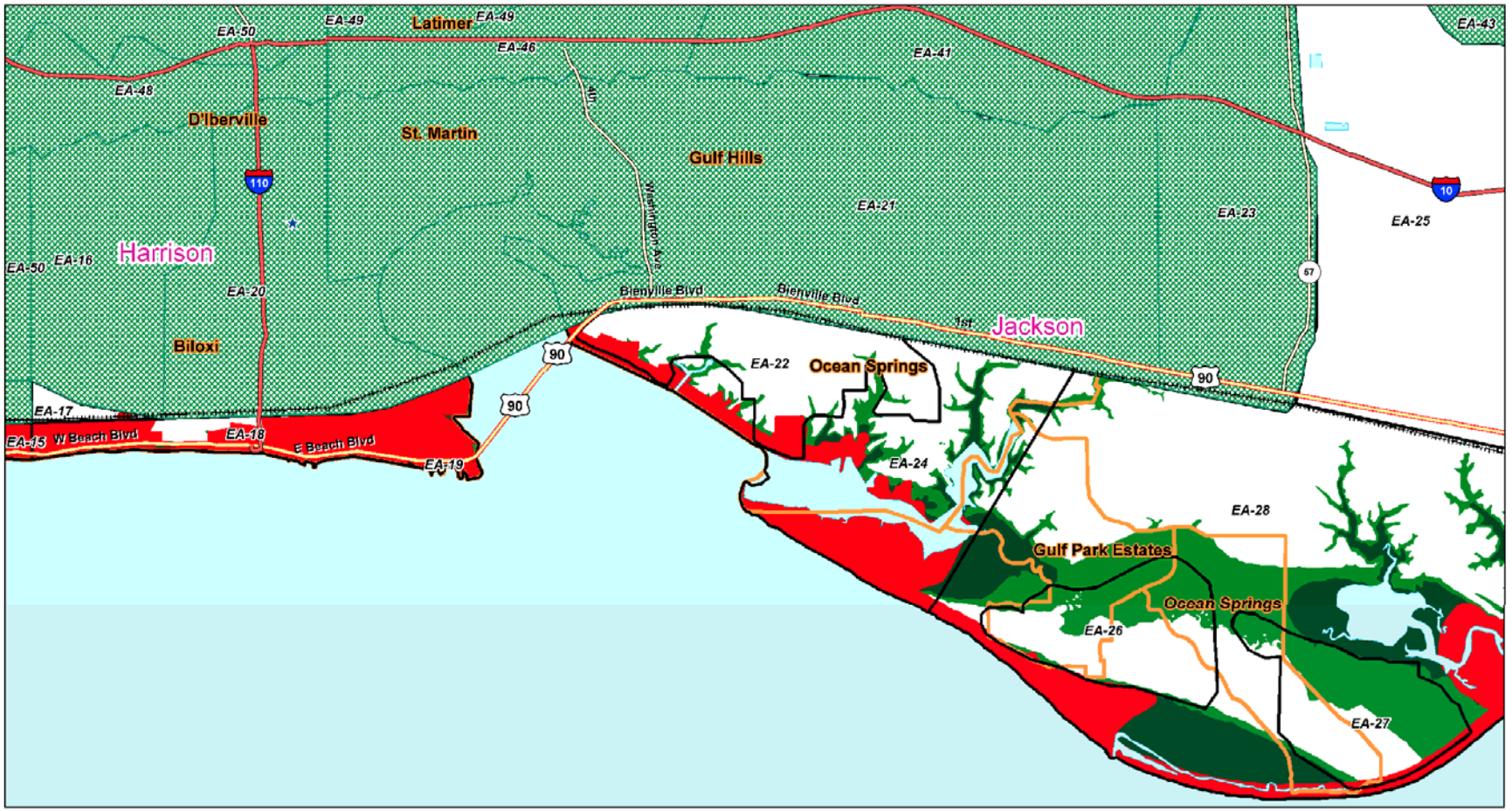


Figure 122- Plan NSC-6d Combined Nonstructural and Structural Plan (A6)

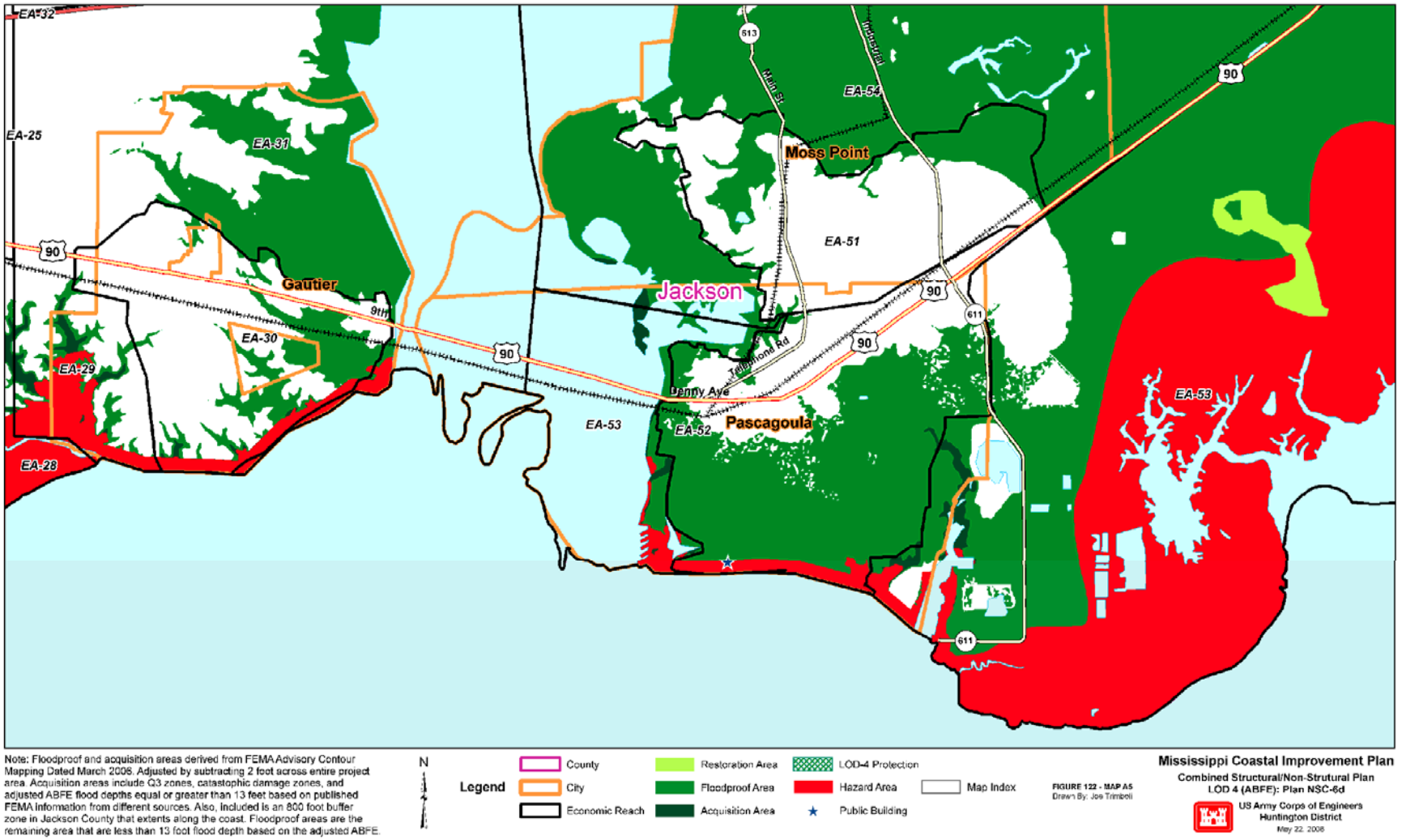


Figure 123- Plan NSC-6e Combined Nonstructural and Structural Plan (A1)

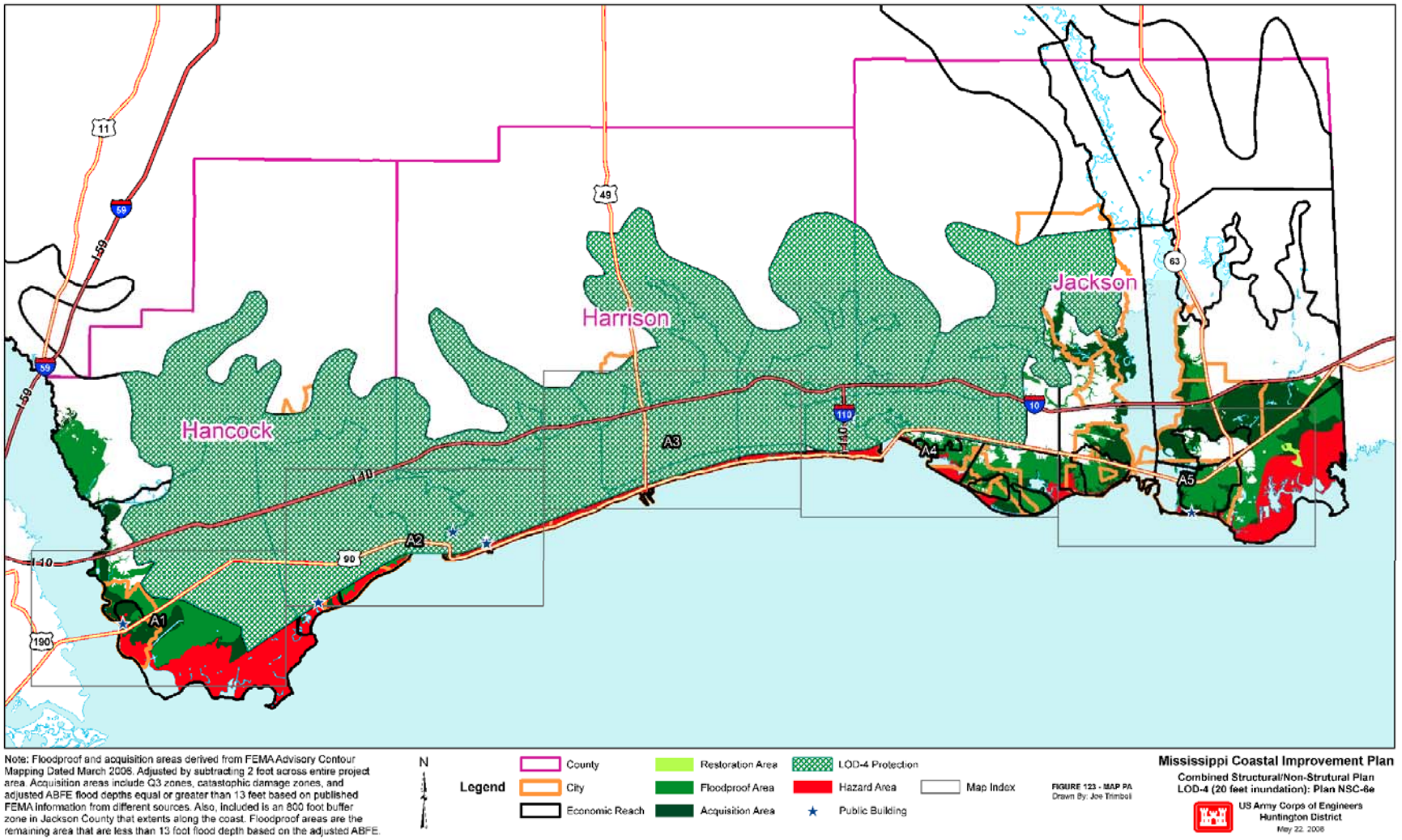


Figure 124- Plan NSC-6e Combined Nonstructural and Structural Plan (A2)

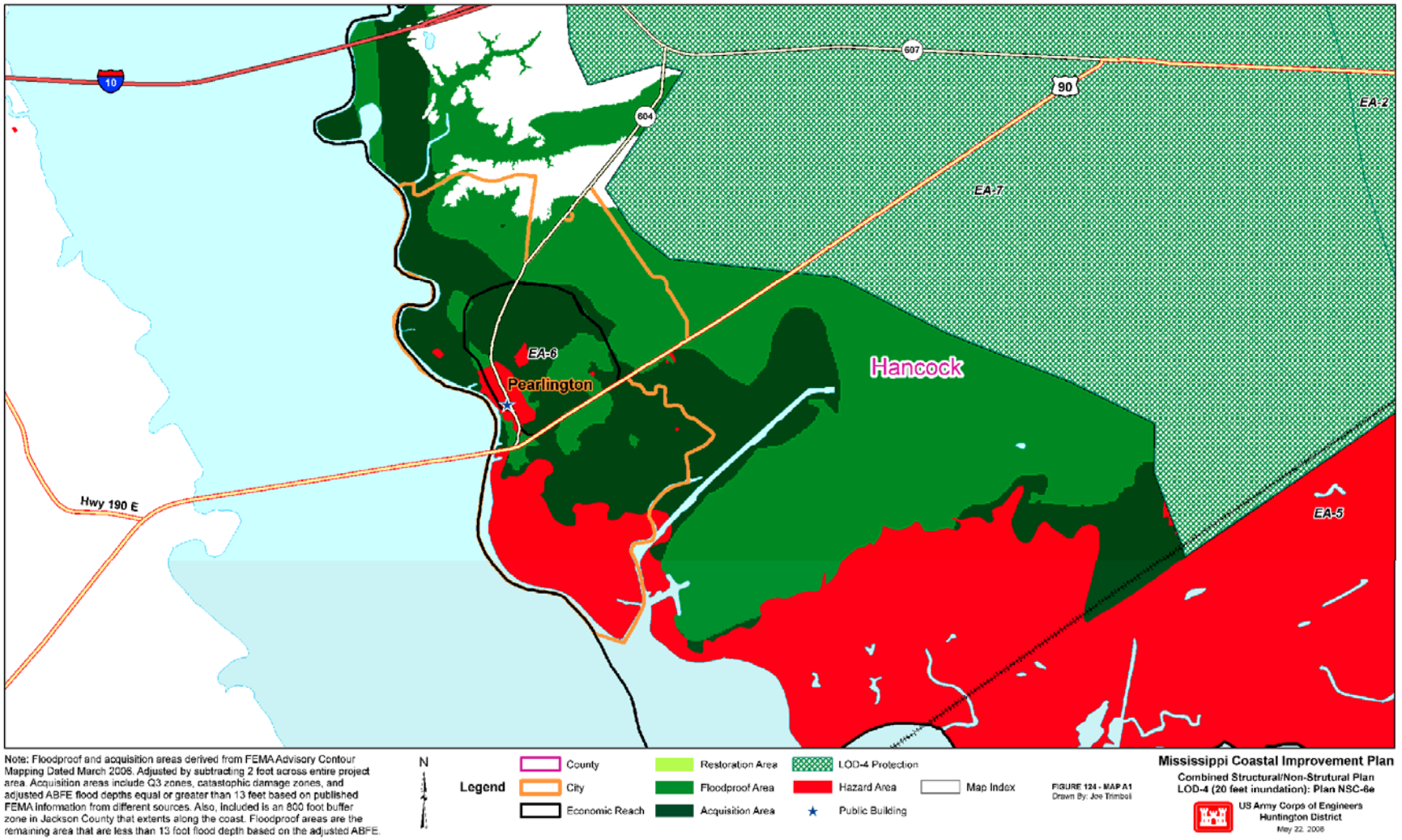


Figure 125 - Plan NSC-6e Combined Nonstructural and Structural Plan (A3)

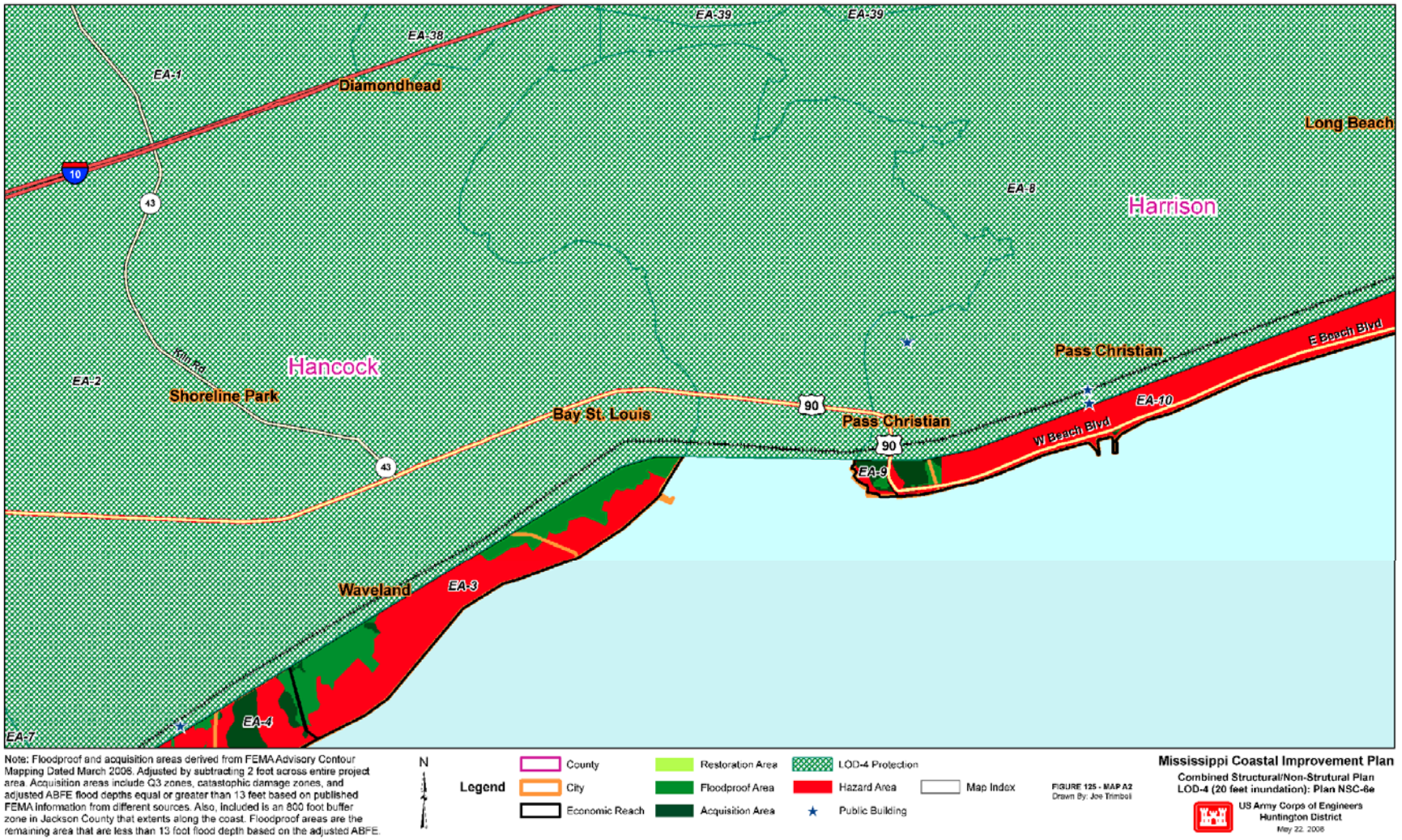


Figure 126 - Plan NSC-6e Combined Nonstructural and Structural Plan (A4)

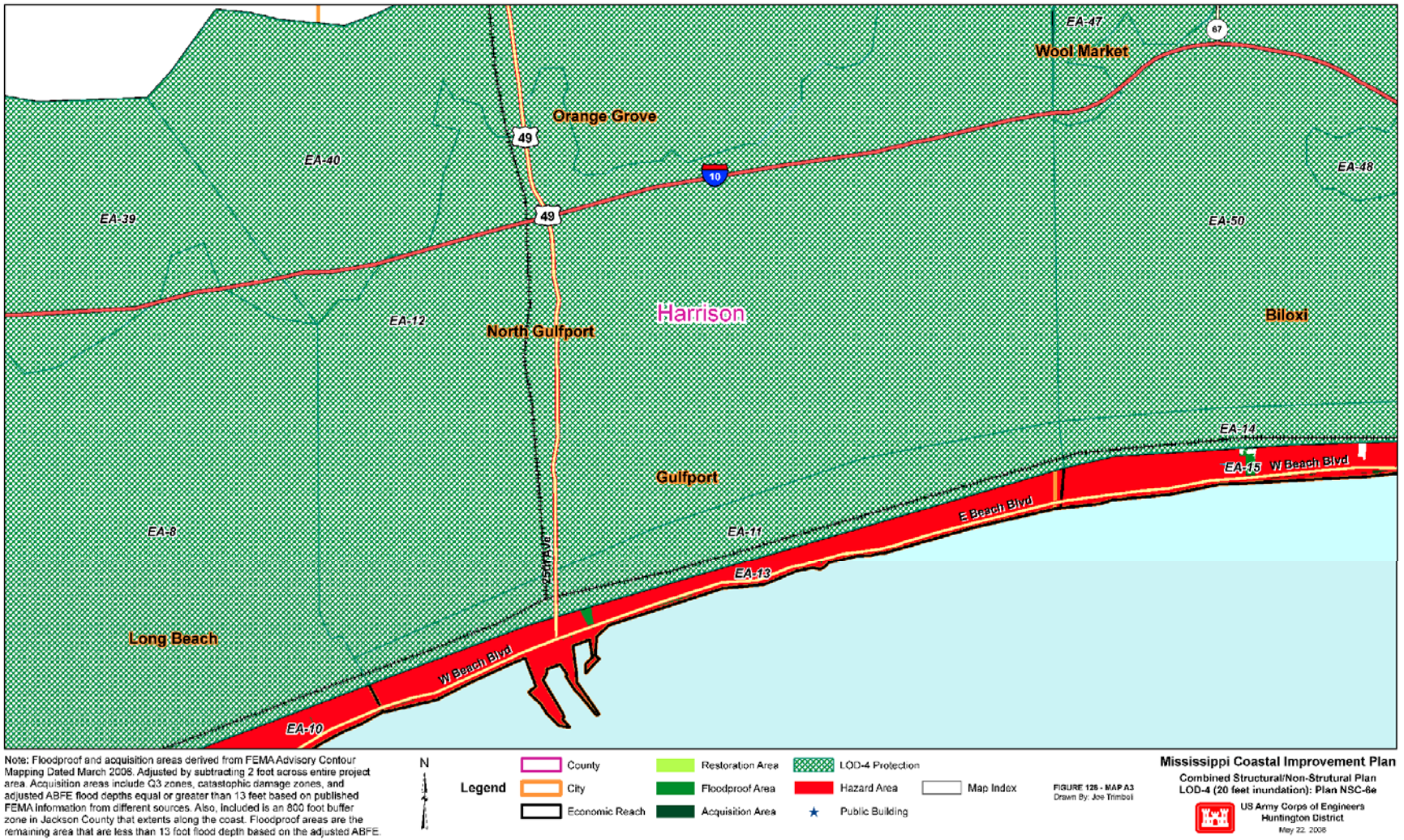


Figure 127 - Plan NSC-6e Combined Nonstructural and Structural Plan (A5)

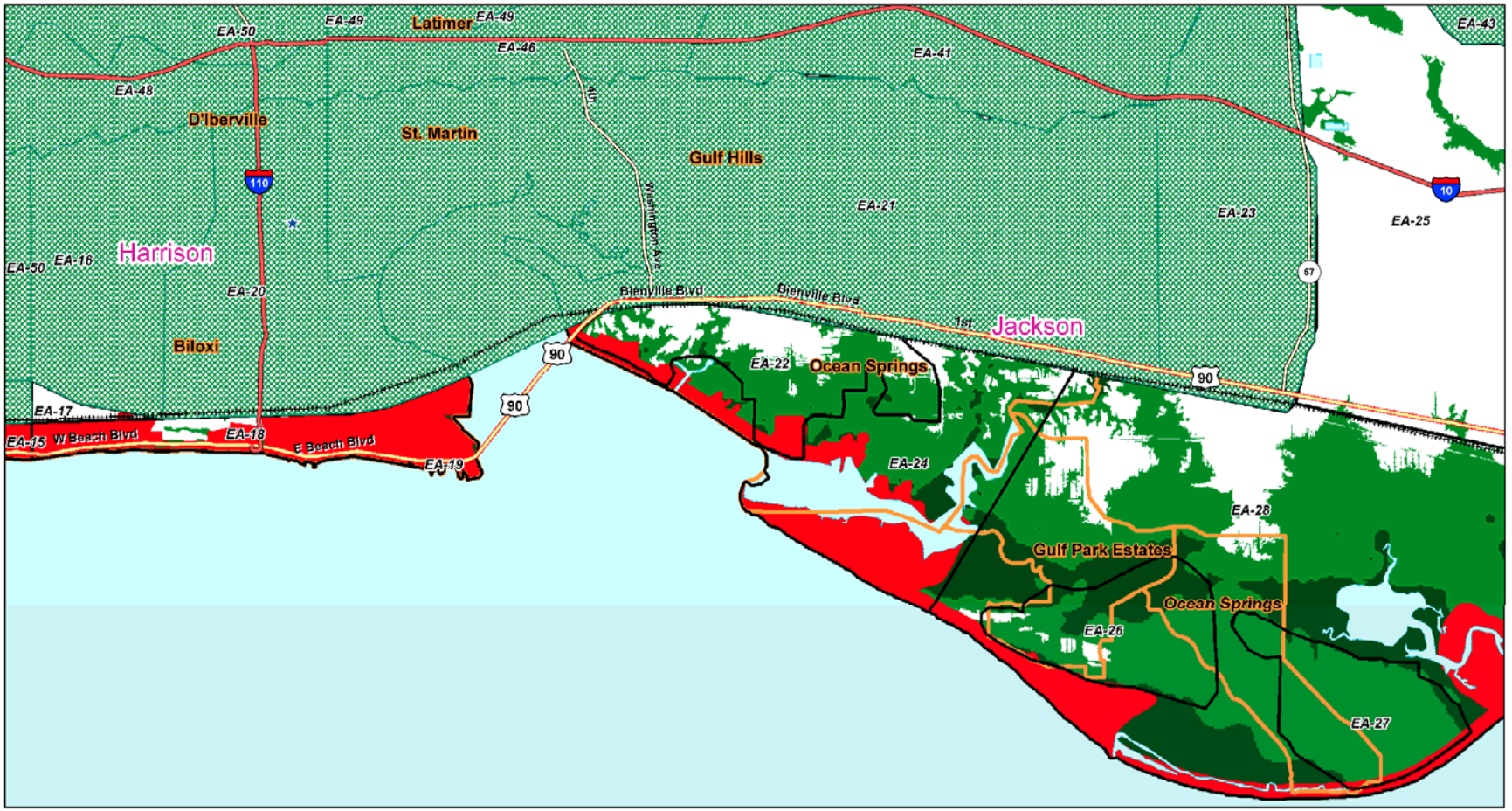


Figure 128 - Plan NSC-6e Combined Nonstructural and Structural Plan (A6)

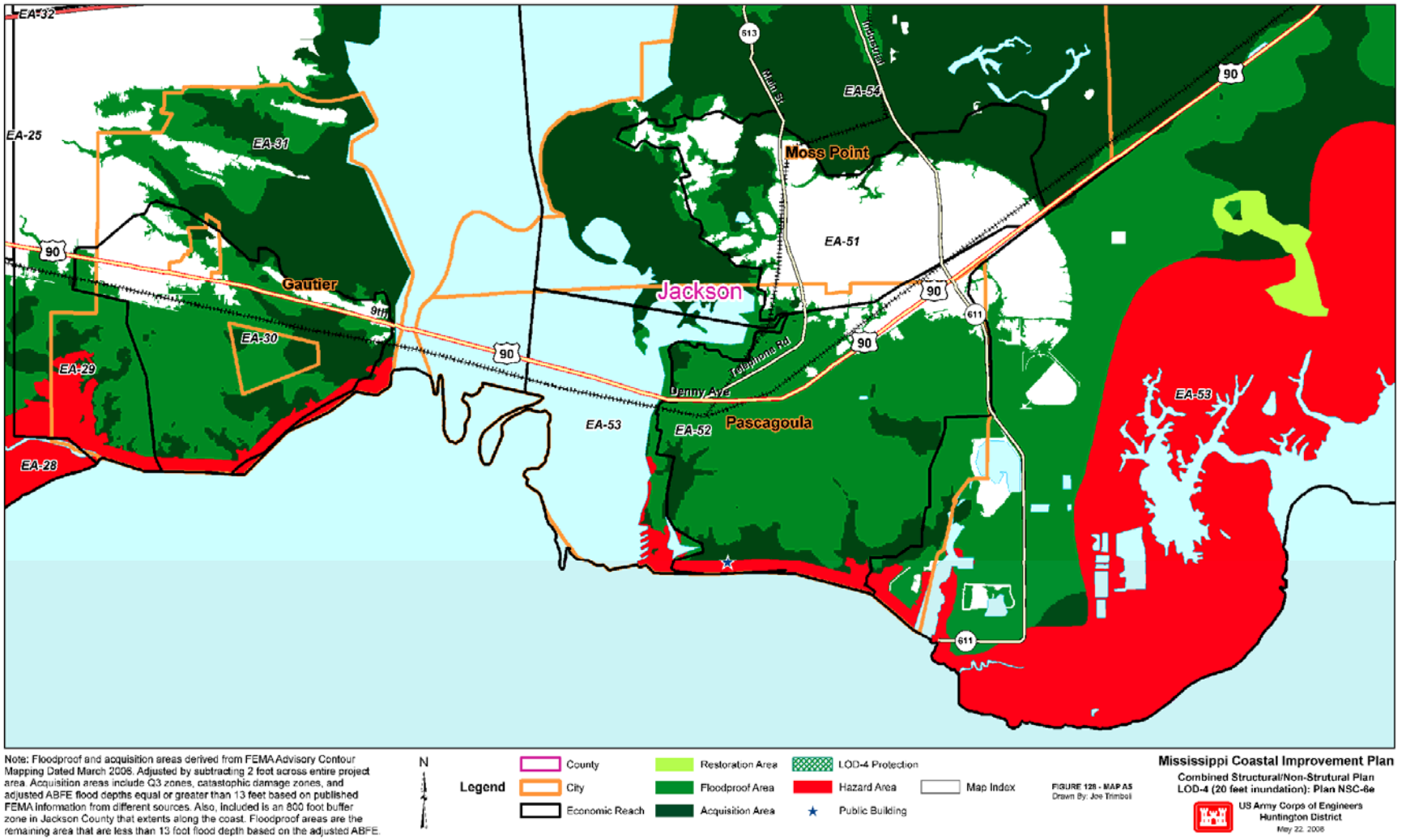


Figure 129 - Plan NSC-6f Combined Nonstructural and Structural Plan (A1)

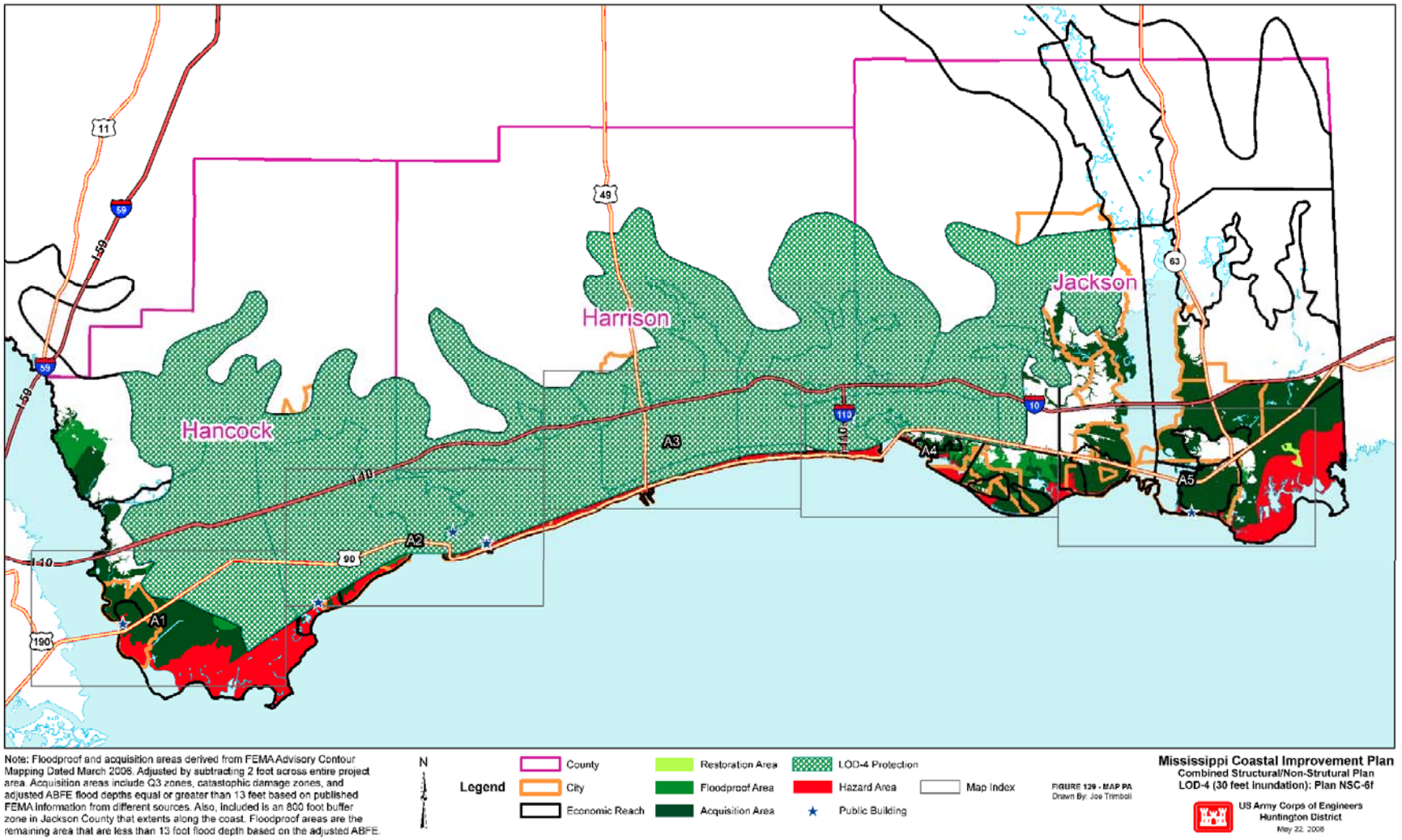


Figure 130 - Plan NSC-6f Combined Nonstructural and Structural Plan (A2)

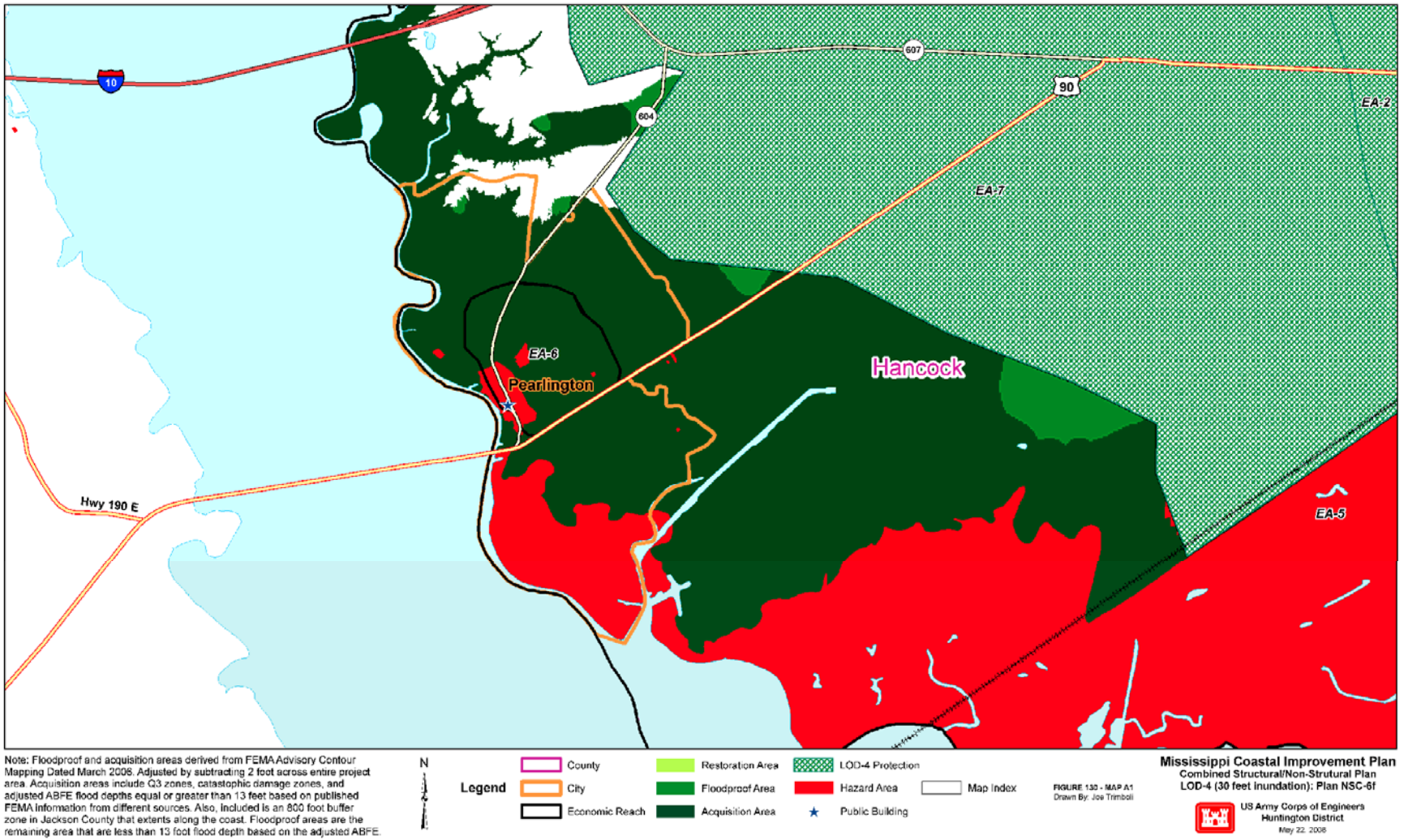


Figure 131 - Plan NSC-6f Combined Nonstructural and Structural Plan (A3)

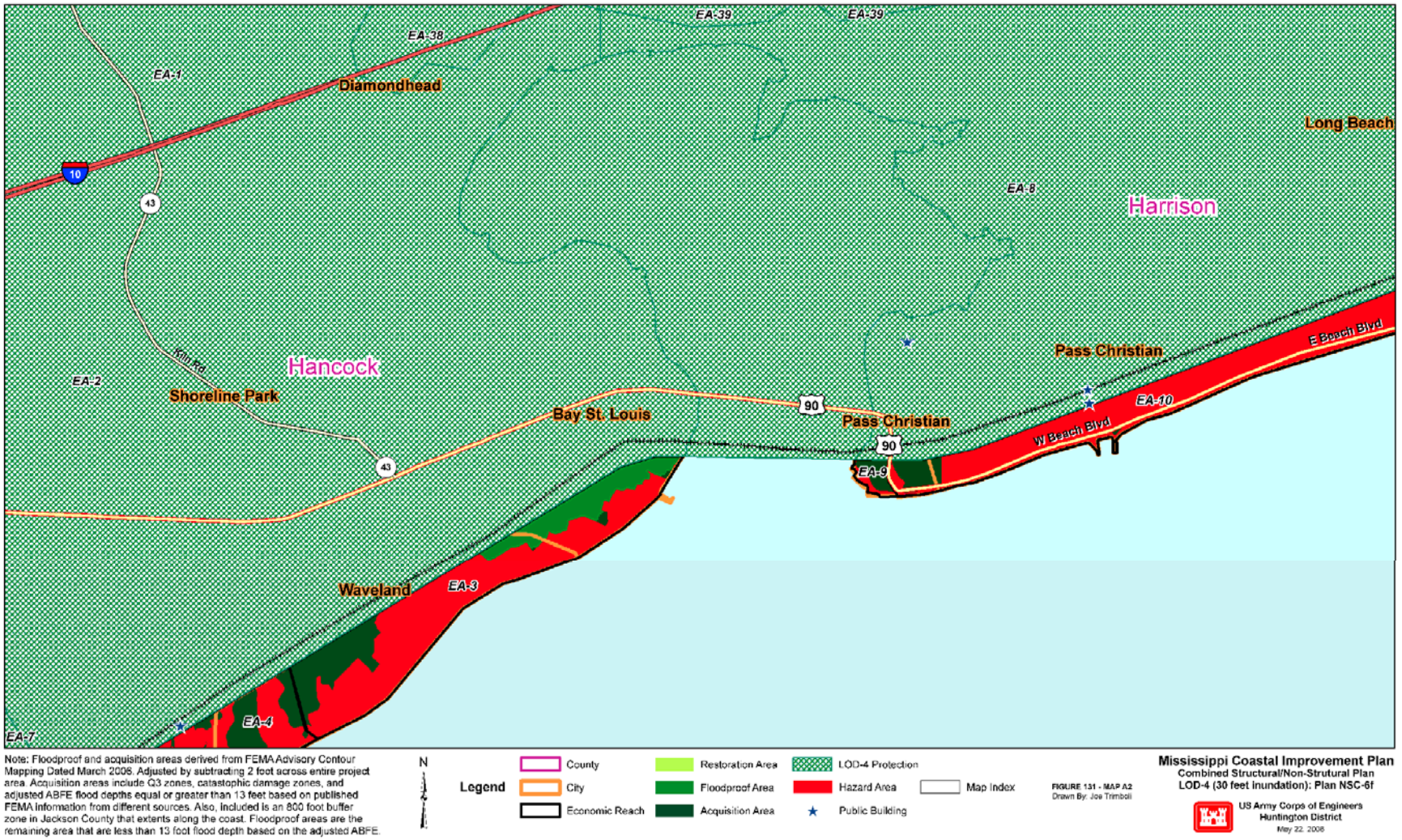


Figure 132 - Plan NSC-6f Combined Nonstructural and Structural Plan (A4)

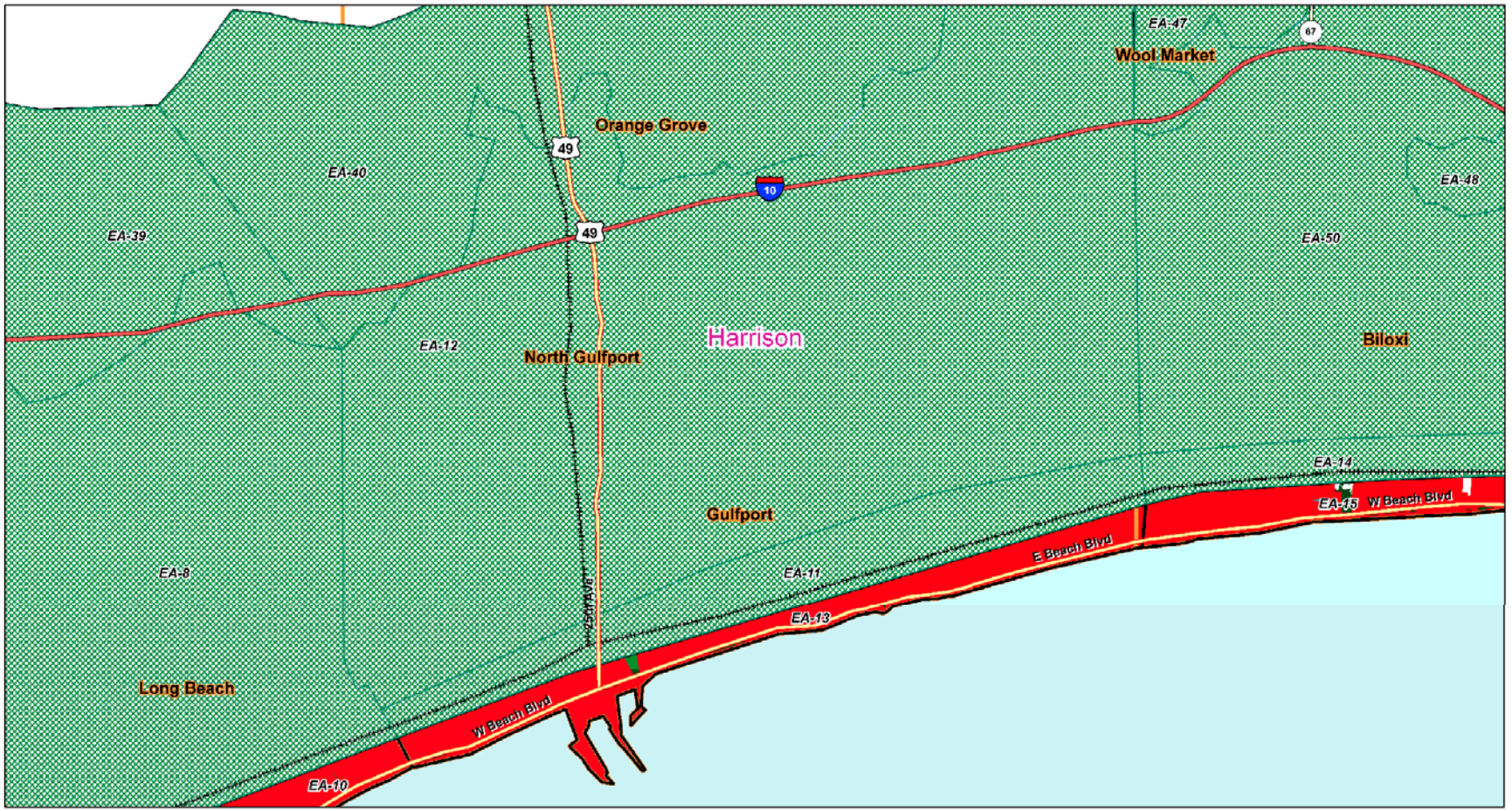


Figure 133 - Plan NSC-6f Combined Nonstructural and Structural Plan (A5)

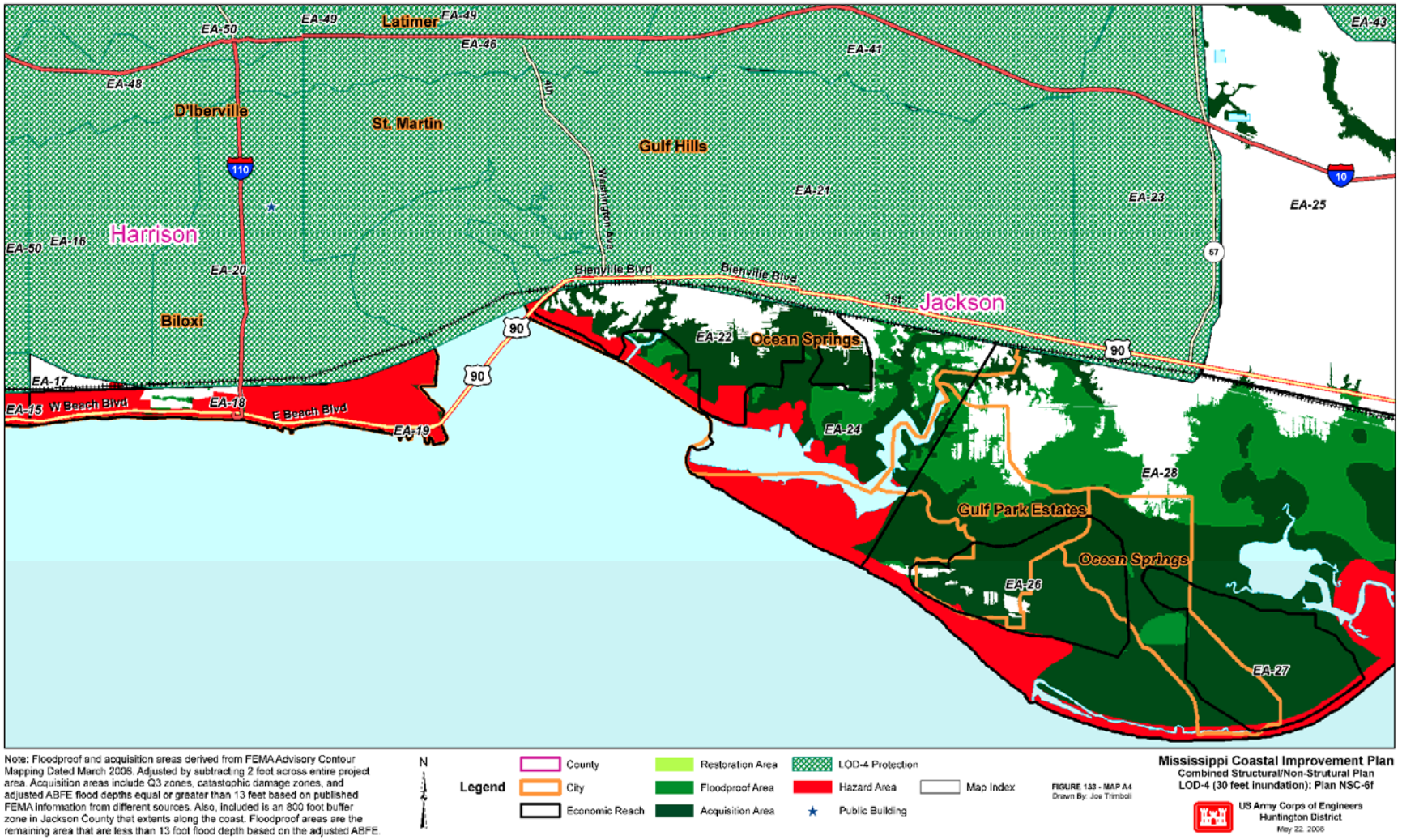


Figure 134- Plan NSC-6f Combined Nonstructural and Structural Plan (A6)

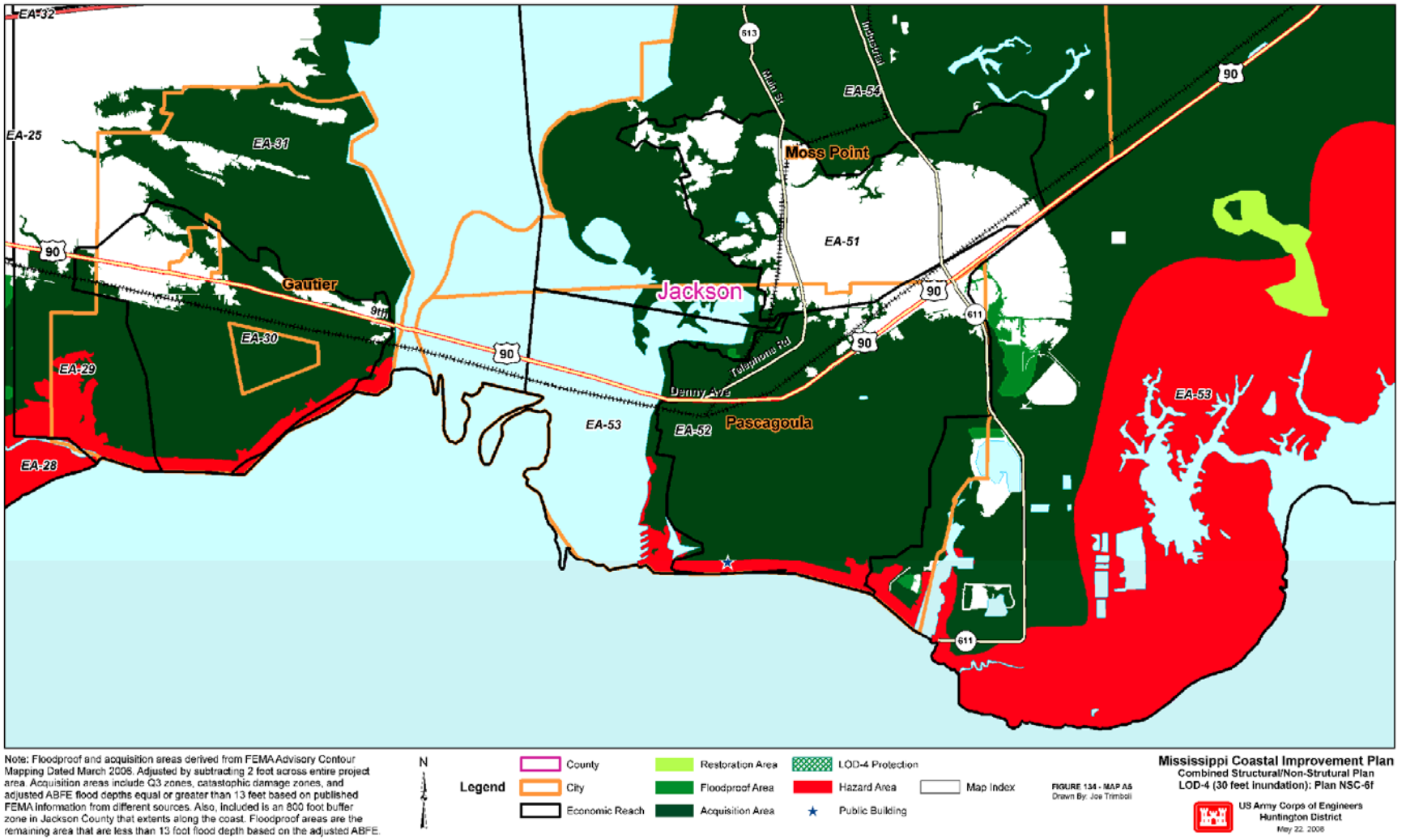


Figure 135 - Plan NSC-6g Combined Nonstructural and Structural Plan (A1)

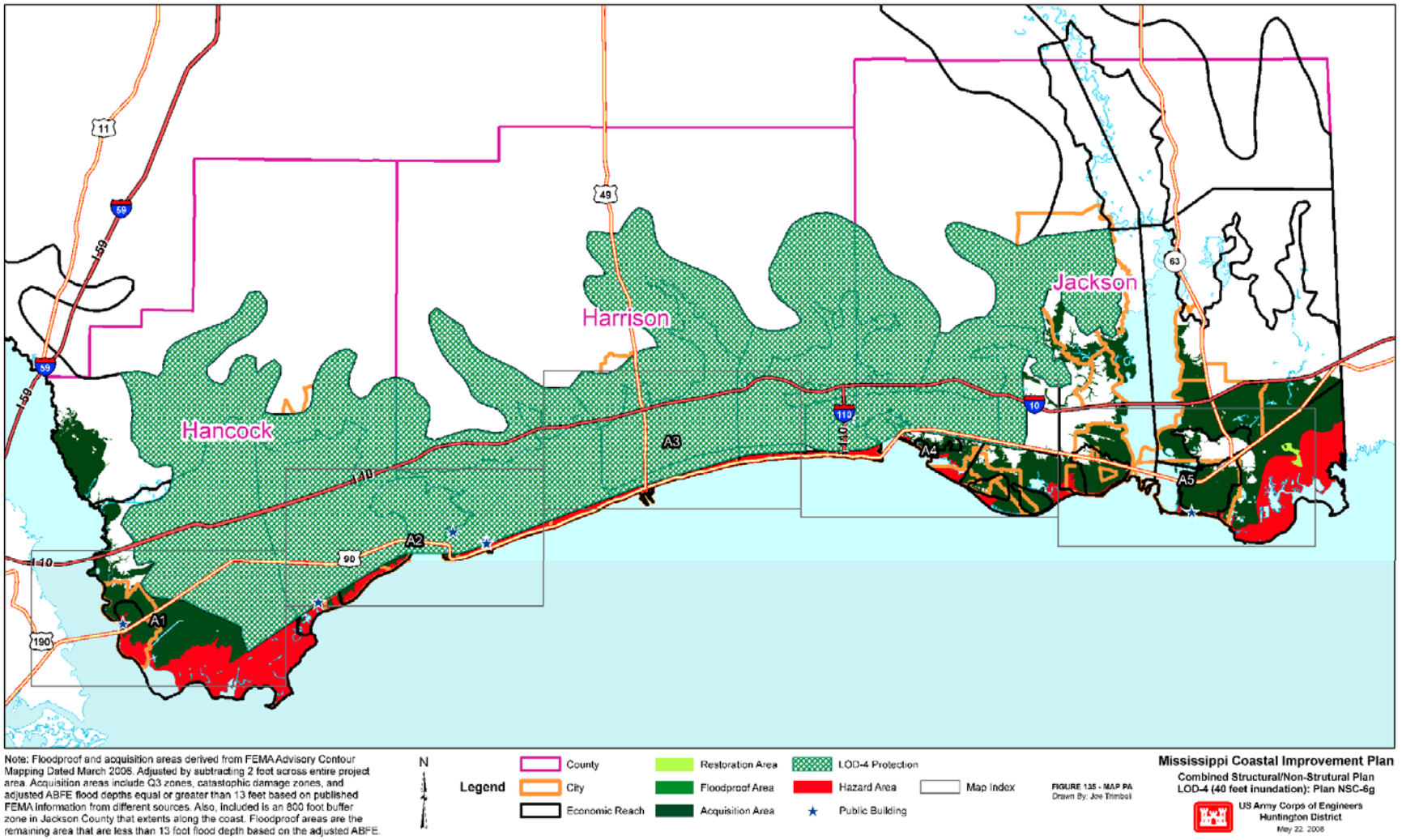


Figure 136 - Plan NSC-6g Combined Nonstructural and Structural Plan (A2)

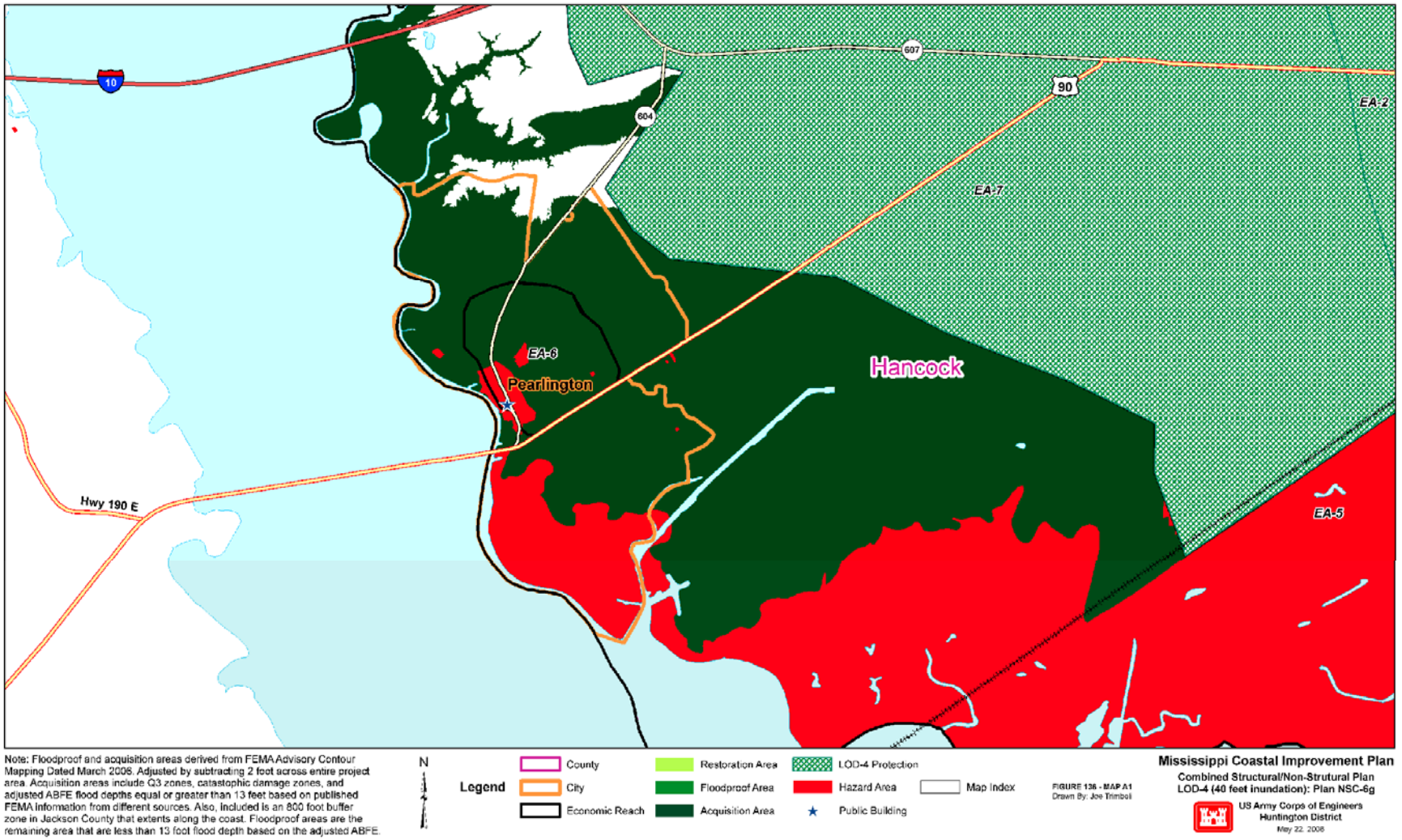


Figure 137 - Plan NSC-6g Combined Nonstructural and Structural Plan (A3)

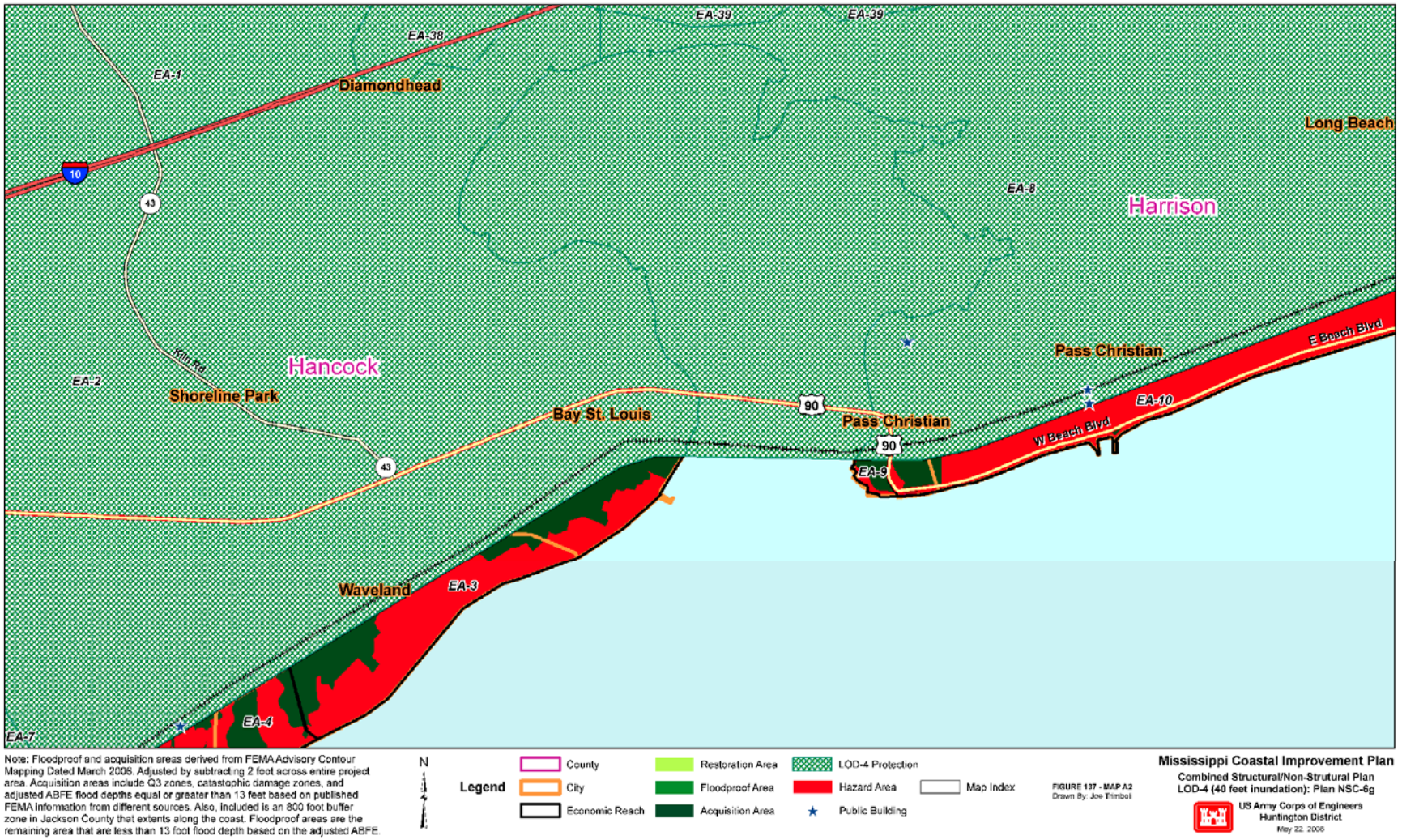


Figure 138 - Plan NSC-6g Combined Nonstructural and Structural Plan (A4)

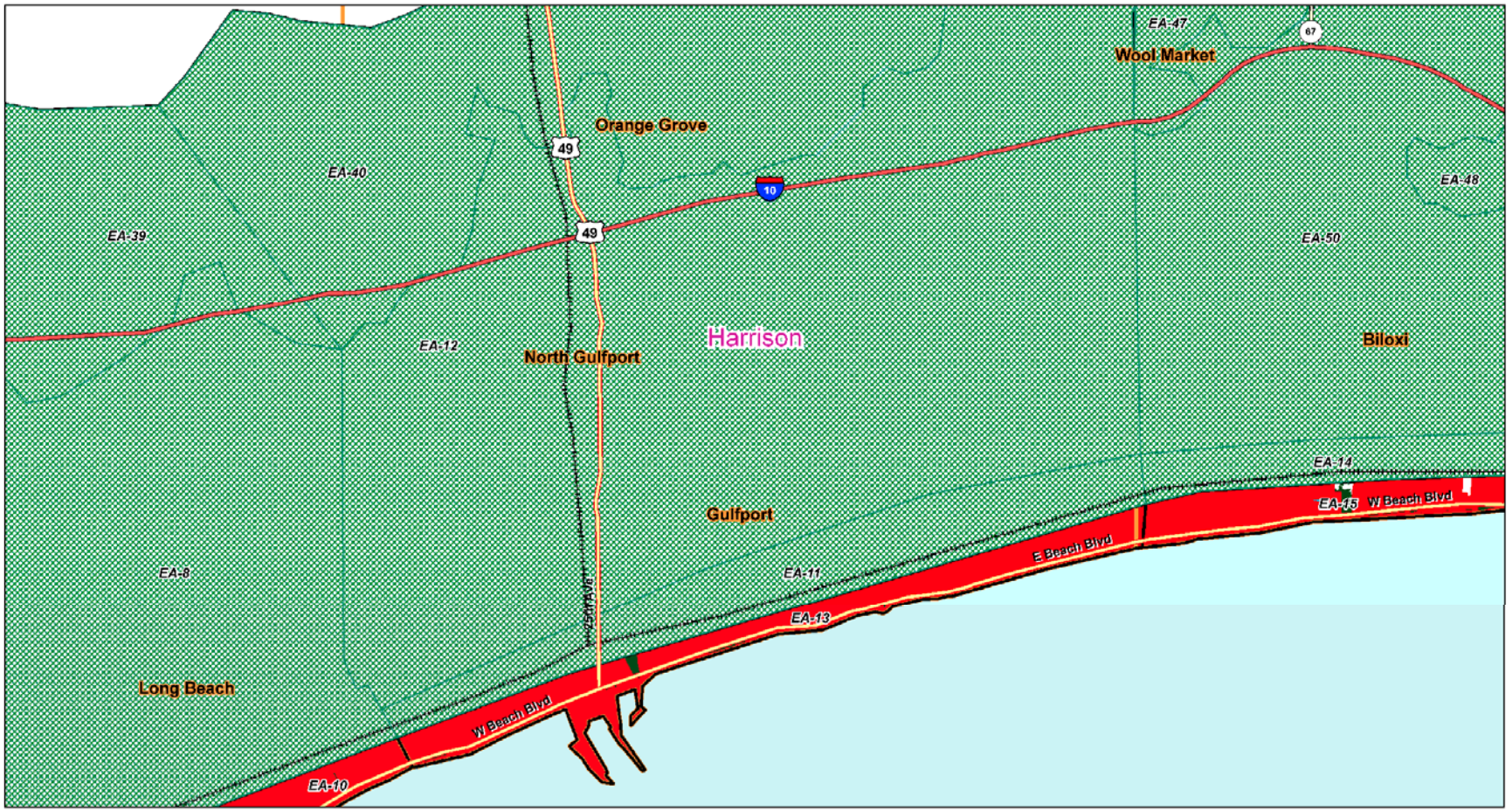


Figure 139 - Plan NSC-6g Combined Nonstructural and Structural Plan (A5)

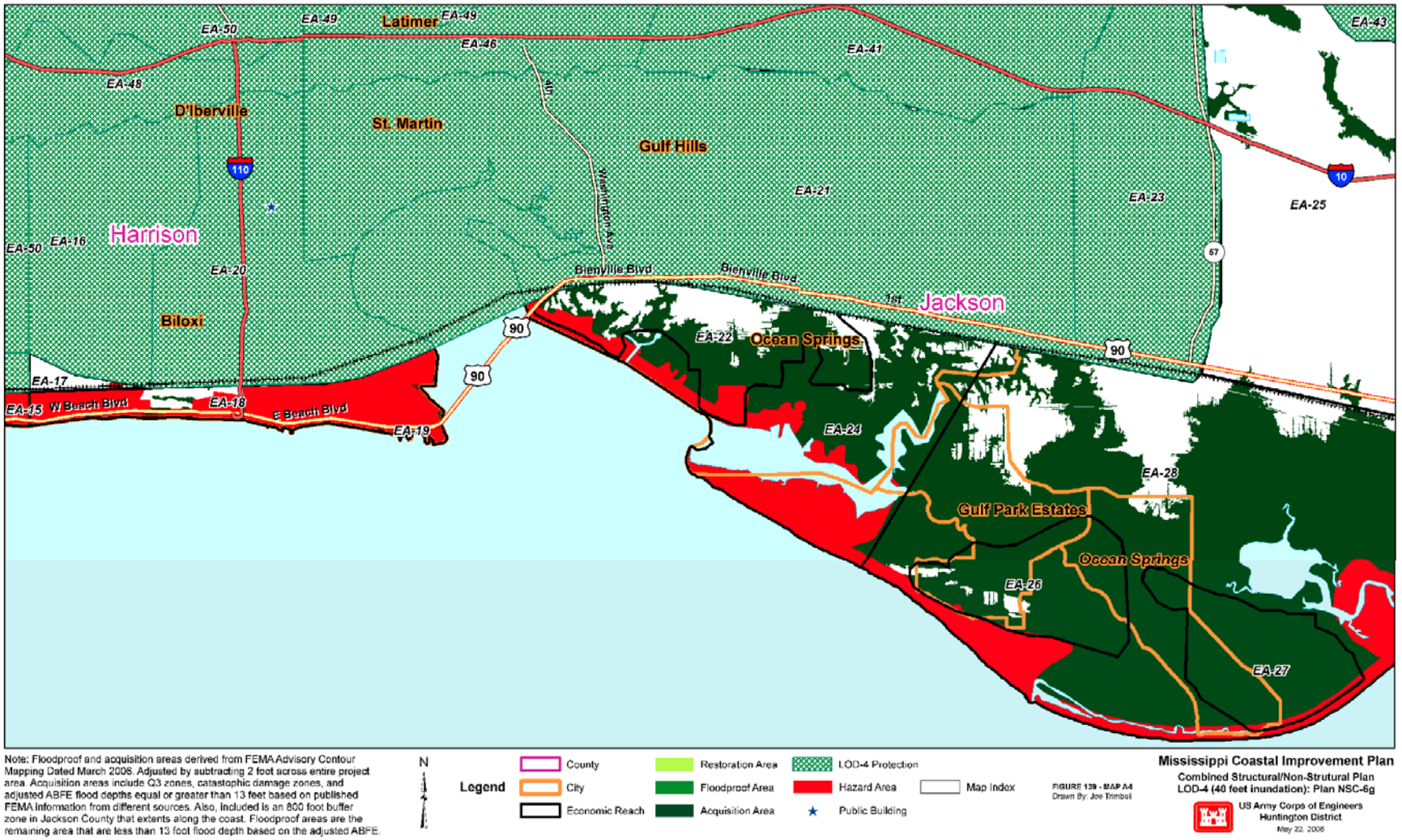
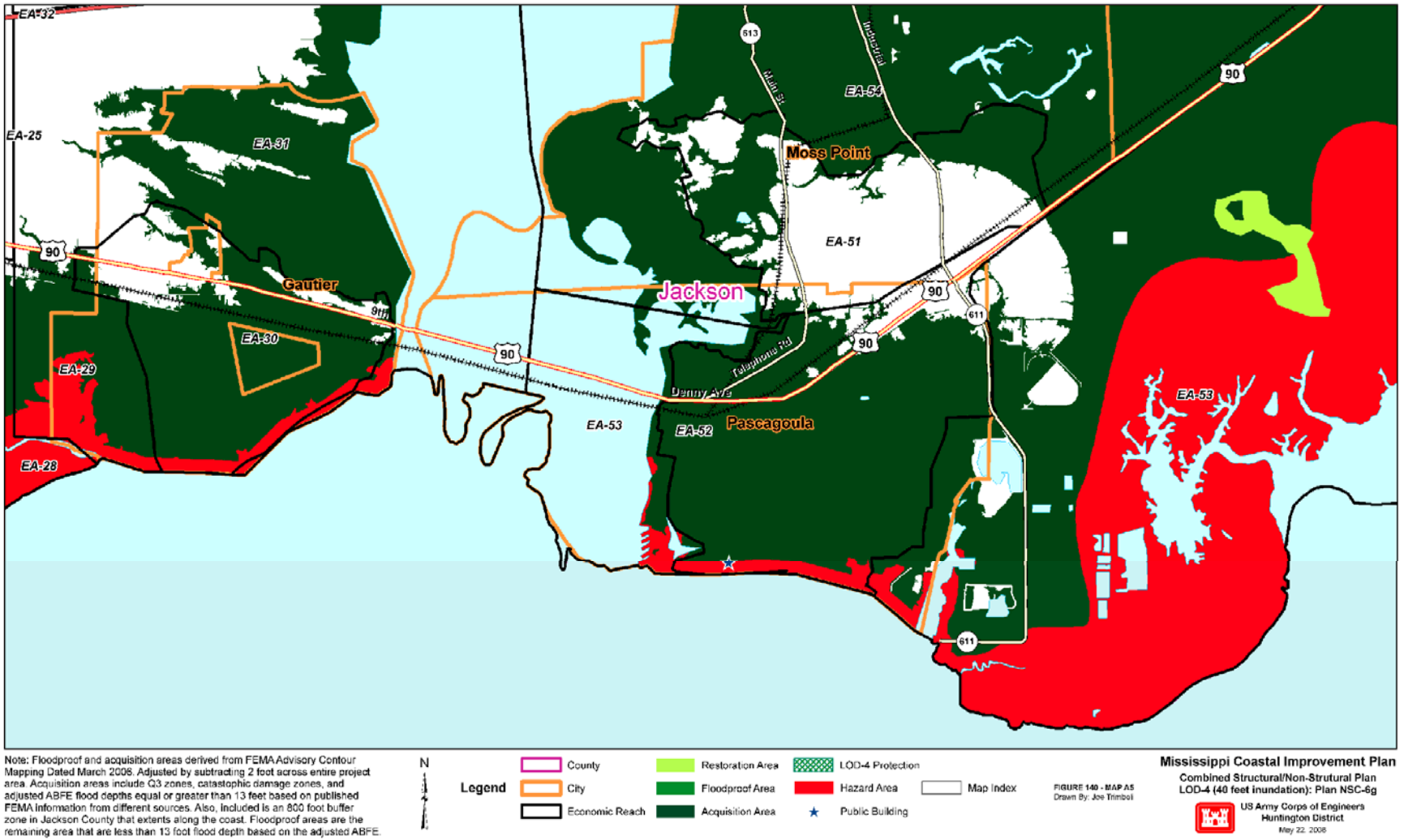


Figure 140 - Plan NSC-6g Combined Nonstructural and Structural Plan (A6)



CHAPTER 7. EVALUATION OF NONSTRUCTURAL PLANS

7.1 General

In Section 4.0 of this Appendix, several nonstructural measures were dropped from further consideration for one or more reasons related to either implementation cost; inability of the measure to meet one or more of the planning objectives, considered to be politically unpalatable, or would result in significant environmental, social or economic impacts to the coastal population. Environmental justice issues were cited several times in the determination to scrub a measure from further consideration. At that initial level of screening, an intuitive evaluation of the outputs of those dropped measures (based largely on experience of the NS PDT, lessons learned from past nonstructural project implementation and research) was sufficient to justify their closure in the process. The remaining measures, although with potential impacts, promise significant benefits or positive outputs if implemented. Having integrated those measures into several plans, identification, quantification and evaluation of their outputs must now be accomplished.

The evaluation process is composed of two steps: 1) assessment or the quantification of the plan affects (may be expressed in relative qualitative as well as quantitative terms) in monetary or numerical terms, and 2) appraisal or the judgment of the worth or significance of the output or improvement. Using these two components of evaluation, each output from each plan can be weighed in relative terms with all other outputs allowing trade-off analysis, sensitivity analysis, and best-deal determinations. At the level of planning detail conducted for the MS Coastal Comprehensive Plan many of the standard metrics used in evaluating plans at a feasibility level are unavailable due to the lack of base data for many of the proposed measures. Collecting and analyzing data for over 70,000 separate parcels of property (some with multiple tracts) requires far more effort in formulating nonstructural measures and plans than time or financial resources allowed in the study. Therefore much more qualitative evaluation is used in the appendix than would normally be used in a standard feasibility study.

In addition, since time and funding constraints did not allow a full economic analysis of each of the several nonstructural plans, only the average annual damages reduced for acquisitions and floodproofing in Plan NSC-1 at the ABFE level were generated in HEC-FDA. This Appendix only identifies, evaluates and compares various nonstructural plans and should not be used as the only document for recommending implementation of any of the plans described herein. Therefore, allowances with the average annual damages figures were taken for comparison of the plans at the ABFE level of inundation. For plans that had either more or less amounts of acquisitions or floodproofing at the ABFE level, the average annual damages were proportionately applied to the various plans (by parcel protected) to compare their outputs.

Subsequent to completion of this evaluation process, the structural alternative labeled “LOD 4” was screened from the list of alternatives due to unsustainable annual O&M costs for the surge gates. Therefore all evaluations involving the structural measure LOD 4 and nonstructural measures shown in plans NSC-6d through NSC-6g are provided for reference only. The combined alternatives that include ringwalls and ring-levees and nonstructural measures (NSC-6 through NSC-6c) are still valid plans for consideration.

The assessment process begins with quantifying and describing the outputs from each formulated plan that would be anticipated to occur in the future with one of the plans (projects) in place. This “future-with project condition” is described below.

7.2 Future With-Project Conditions

7.2.1. General:

The evaluation of nonstructural plans begins with a description of the anticipated future with-project conditions that would emerge if one of the nonstructural plans were to be implemented. The reviewer must remember that the performance of each nonstructural plan is predicated only upon protection to the minimum inundation level of the Advisory Base Flood Elevation. Each of the formulated plans will produce a different future for the project area than would have occurred in the absence of any one of the plans (the future without-project conditions).

The descriptions of these conditions are based upon the stated objectives of the planning process and the metrics determined by the team. Metrics such as reduced flood damages, reduced threats to loss of life, increased wetland acres, reduced emergency costs, and residual damages are all used to define the anticipated future with-project condition. Other benefits of the plans that were not anticipated are likewise noted for each plan. The descriptions of these conditions in whatever metrics may be applicable (monetary flood damage reduction benefits, acres of ecosystem, lives at less risk, improvements to current housing stock, or reductions in emergency costs) are compared with the conditions of the without-project future for the same area to determine whether a plan is worthy of implementation when compared to other alternative plans.

To simplify this process, the various plans are displayed in Table 34 showing the anticipated future with-project conditions in the project area that may occur as a result of their implementation. As the matrix shows, many of the plans generate measurable (quantifiable) outputs such as the reduction of damages, plan and per unit costs for protection and numbers of parcels offered protection to some degree. Several of the plans demonstrate an ability to reduce the potential threats to life and safety due to inundation drowning and still others generate substantial numbers of relocations to flood-safe living units. In many cases, the outputs of each plan are measurable in monetary units, acres protected, structures protected or acres of potential ecosystem restoration land evacuated. In other cases, the plan outputs are either difficult to measure quantitatively or time/funding constraints limited the team's ability to collect the necessary data to support the measurement of the plan outputs and therefore the output is described in qualitative terms.

7.2.2 Plan Outputs:

7.2.2.1 Plan NS-PAHHZ:

This plan provides substantial protection for beachfront structures and their occupants that are at highest risk of severe structural and content damages and loss of life. Field investigations revealed that a substantial number of parcels were made vacant (total structure loss) by Katrina in this zone. Post-Katrina estimates were that at least 30,000 residential structures were destroyed by Katrina and considering the high incidence of structure and content flood related damages in this zone (nearly 90% total loss), reducing damages to residential structures is considered a significant affect.

Composed of one measure, permanent acquisition, this plan affects 14,997 parcels (approximately 7,500 structures) within the three counties. Using a proportionate share of the average annual damages calculated for the ABFE (Plan NSC-1), this plan reduces the without-project average annual damages by approximately $92.0M.

Table 34.
Future With-Project Conditions

PLANS Parameters/Measures	Plan NS-PAHHZ	Plan NS-PA100	Plan NSC-1 – Federal Agencies Action Plan	Plan NSC-2 – Wet and Dry Floodproofing W/FWEE Upgrades	Plan NSC-3 – Joint Federal and Non-Federal Jurisdiction Plan	Plan NSC-4 – Non-Federal Jurisdiction Plan	Plan NSC-5 – Loss of Life Reduction Plan	Plan NSC-6 – Combined Structural and Nonstructural Plan
Flood Damages Reduced Units Protected	14,997 Total Parcels Removed from Future Development $92.0M AAD Prevented	33,191 Total Parcels Removed from Future Development. $210.0M AAD Prevented	58,617 Total Parcels Protected $315.0M AAD Prevented	25,419 Total Units Protected $105.0M AAD Prevented	At least 58,617 Total Parcels Protected , At least $315.0M AAD Prevented	95,000 Total Units Protected 1) AAD reduced are undetermined at this time	14,997 parcels removed from Future Development $92.0M AAD Prevented	Reductions in AAD have not been computed for the scaled plans greater than the ABFE. ABFE reductions are in Plan NSC-1
Total Plan Cost Cost per Unit Protected	$6.1B $404K/parcel	$8.2B $248K/parcel	$18.7B $323K/parcel	$10.8B $425K/parcel	$19.1B $325K/parcel	$5.5M Cost per unit is undetermined at this time.	$6.1B $404K/parcel	Plan costs range from $8.7B to $25.3B with cost per unit of $288K/parcel to $296K/parcel
Permanent Acquisition (including HARP)	14,997 Parcels Removed from Future Development $92.0M AAD Prevented	33,191 Parcels Protected $210.0M AAD Prevented	33,191 Parcels Protected $210.0M AAD Prevented	Although this plan is purely floodproofing, there could be some acquisitions as an option, but the numbers are unknown at this level of planning.	33,191 Parcels Protected $210.0M AAD Prevented	No permanent acquisitions. A TDR or PDR program could purchase development rights at 80% of the total property value for over 27,000 vacant lots	14,997 parcels removed from future redevelopment $92.0M AAD Prevented	Units Protected range from 44,088 to 85,447 Damages prevented are not available.
Total Permanent Acquisition Cost Cost per Unit Protected	$6.1B $404K/parcel	$8.2B $248K/parcel	$7.9B $323K/parcel	Although this plan is purely floodproofing, there could be some acquisitions as an option, but the numbers are unknown at this level of planning.	$7.9B $323K/parcel	No permanent acquisitions. A TDR or PDR program could purchase development rights at 80% of the total property value for over 27,000 vacant lots	$6.1B $404/parcel	Acquisitions costs range from $4.5B to $23.9B with per parcels costs ranging from $225K/parcel to $281K/parcel
Wet and Dry Floodproofing	No Floodproofing	No Floodproofing	25,419 Total Parcels Protected $105.0M Damages Prevented	25,412 Total Parcels Protected $105.0M Damages Prevented	25,419 Total Units Protected $105.0M AAD Prevented	No Floodproofing	No Floodproofing	Ranges from 0 parcels to 40,964 parcels in Floodproofing
Total Floodproofing Costs Cost per unit Protected	No Floodproofing	No Floodproofing	$10.8B $425K/parcel	$10.8B $425K/parcel	$10.8B $425k/parcel	No Floodproofing	No Floodproofing	Ranges from $0.00 to $11.4B and $0/parcel to $278/parcel
By **Elevation**	No Floodproofing	No Floodproofing	$10.8B $425K/parcel	$10.8B $425K/parcel	25,419 Units Protected $210.0M AAD Prevented	No Floodproofing	No Floodproofing	Ranges from 0 parcels to 40,964 parcels in Floodproofing
Total Elevation Costs Cost per unit elevated	No Floodproofing	No Floodproofing	$10.8B $425K/parcel	$10.0B $425K/parcel	$10.8B $425/parcel	No Floodproofing	No Floodproofing	Ranges from $0.00 to $11.4B and $0/parcel to $278/parcel
Other Floodproofing	No Floodproofing	No Floodproofing	Undetermined at this time.	Undetermined at this time	Undetermined at this time	No Floodproofing	No Floodproofing	Undetermined at this time
Total Other Floodproofing Costs Cost per unit floodproofed	No Floodproofing	No Floodproofing	Undetermined at this time	Undetermined at this time	Undetermined at this time	No Floodproofing	No Floodproofing	Undetermined at this time
Relocations of Public Buildings	No Relocations	No Relocations	7 Total Units Protected	No Relocations	7 Total Units Protected	No relocations	7 Total Units Protected	Undetermined at this time
Total Relocations Costs Cost per unit relocated	No Relocations	No Relocations	$51.8M $7.4M per parcel	No Relocations	$51.8M $7.4M per parcel	No Relocations	$51.8M $7.4M	Undetermined at this time.
Reduced Threat to Loss of Life (based upon 2.6 persons per household)	14,997 potential households protected from flooding 38,900 lives protected	33,191 potential households protected from flooding 86,000 lives protected	42,500 Households protected from flooding 152,000 Potential Lives	25,419 Households protected from flooding 66,000 lives protected	58,617 Households protected from flooding 152,000 Potential Lives	Plan affects over 90,000 parcels .Potential for 234,000 lives to be offered some level of protection.	14,997 potential households protected from flooding 38,900 lives protected	Protected Parcels ranges from 30,508 to 85,447 with potential for 79,300 to 222,000 lives to be protected

Table 34.
Future With-Project Conditions

PLANS Parameters/Measures	Plan NS-PAHHZ	Plan NS-PA100	Plan NSC-1 – Federal Agencies Action Plan	Plan NSC-2 – Wet and Dry Floodproofing W/FWEE Upgrades	Plan NSC-3 – Joint Federal and Non-Federal Jurisdiction Plan	Plan NSC-4 – Non-Federal Jurisdiction Plan	Plan NSC-5 – Loss of Life Reduction Plan	Plan NSC-6 – Combined Structural and Nonstructural Plan
Flood Preparedness (Storm Warning and Emergency Evacuation) and Public Education	No FWEE Upgrades	No FWEE Upgrades	95,000 Parcels Covered 247,000 Population Informed	95,000 Structures Covered 247,000 Population Informed	95,000 Parcels Covered 247,000 Population Informed	95,000 Parcels Covered 247,000 Population Informed	95,000 Parcels Covered 247,000 Population Informed	95,000 Parcels Covered 247,000 Population Informed
Floodplain Management Improvements	No NFIP Upgrades	No NFIP Upgrades	No NFIP Upgrades	No NFIP Upgrades	95,000 Parcels Covered by Updated Floodplain Management Ordinances	95,000 Parcels Covered by Updated Floodplain Management Ordinances	No NFIP upgrades	95,000 Parcels Covered by Updated Floodplain Management Ordinances
Building Codes Upgrades	No Building Code Upgrades	No Building Code Upgrades	No Building Code Upgrades	No Building Code Upgrades	95,000 parcels Covered by Updated Codes	95,000 parcels Covered by Updated Codes	No Building Code Upgrades	No Building Code Upgrades
Development **Impact Fees**	No Development Impact Fees	No Development Impact Fees	No Development Impact Fees	No Development Impact Fees	At least 6,000 New Subdivided Lots Covered by Impact Fees and 27,000 vacant lots	At least 27,000 vacant lots Covered by Impact Fees	No Development Impact Fees	No Development Impact Fees
TDR/PDR	May be used to supplement acquisitions of vacant properties in high-hazard zones.	May be used to supplement acquisitions of vacant properties in high-hazard zones and areas deeper than 13 feet of water depth.	May be used to supplement acquisitions of vacant properties in high-hazard zones and areas deeper than 13 feet of water depth.	No TDR or PDR programs	At least 27,000 Vacant Properties Development Rights Transferred or Purchased	At least 27,000 Vacant Properties Development Rights Transferred or Purchased	No TDR or PDR programs	No TDR or PDR programs
Land Use Zoning and Regulations	No changes in land use zoning	No changes in land use zoning	No changes in land use zoning	No changes in zoning or land use regulations	At least 14,997 Parcels with Changed Zoning Designation to Reduce Flood Damages	At least 14,997 Parcels with Changed Zoning Designation to Reduce Flood Damages	No changes in zoning or land use regulations	No changes in zoning or land use regulations
Development Redirection	Approximately 3000 lots would be constructed out of the inundation zones	Approximately 6000 lots would be constructed out of the inundation zones	6,000 New Residential and Commercial lots developed out of the BFE limits	No redirection of development	6,000 New Residential and Commercial lots developed out of the BFE limits	Some redirection by local jurisdiction but numbers of lots undetermined at this time	Approximately 3000 lots would be constructed out of the inundation zones	Between 6,800 lots and 29,900 lots may be developed out of the BFE limits
Residual Damages	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities
Risks and Uncertainty	Risks associated with the acquisition program plus H&H level of protection. Uncertainties center on credibility of the base data supporting acquisition costs.	Risks associated with the acquisition program plus H&H level of protection. Uncertainties center on credibility of the base data supporting acquisition costs.	Risks associated with the acquisition program plus H&H level of protection for floodproofing. Uncertainties center on credibility of the base data supporting acquisition costs.	Risks associated with H&H level of protection for floodproofing.	Risks associated with the acquisition program plus H&H level of protection for floodproofing. Uncertainties center on credibility of the base data supporting acquisition costs.	Uncertainty associated with political willingness to apply nonstructural measures and the TDR or PDR programs.	Risks associated with the acquisition program plus H&H level of protection. Uncertainties center on credibility of the base data supporting acquisition costs.	Risks associated with the acquisition program plus H&H level of protection. Uncertainties center on credibility of the base data supporting acquisition costs.
Potential Upgraded Housing Units	Potential for 7,500 new or upgraded Housing Units	Potential for 17,144 new or upgraded Housing Units	Potential for 17,144 new or upgraded Housing Units. A percentage of floodproofed structures will be upgraded while being elevated.	A percentage of floodproofed structures will be upgraded while being elevated.	Potential for 17,144 new or upgraded Housing Units. A percentage of floodproofed structures will be upgraded while being elevated.	No upgrading of housing expected as a result of project implementation other than through new IBC application.	Potential for 7,500 new or upgraded Housing Units	Potential for a range of 6,800 to 29,900 new housing units to be constructed plus upgrades to over 40,000 floodproofed structures.
Evacuated Acres Available for **Wetlands Restoration**	4,000 Acres	9,300 Acres	9,300 Acres	Undetermined at this time	9,300 Acres	0 acres available for restoration.	4,000 acres	Undetermined at this time

Were the plan to be fully implemented, all 14,997 identified parcels would be acquired and the remaining residents relocated to suitable replacement DSS housing. This massive relocation project may trigger the need for one or more replacement housing sites within the project area to accommodate so many displaced landowners into an anemic housing market. The residential redevelopment sites would be located above the 0.2% annual chance flood elevation either by location or by design and the influx of new DSS housing resources would substantially increase the volume and quality of the region's housing stock from its current state.

Using the average per household size provided in the 2000 US Census figures for this area (2.6 persons per household); approximately 38,900 persons could be removed from these high-hazard zones permanently. Considering that over 250 people lost their lives in MS during Katrina, this reduction in the threat to life and increased safety is a significant affect of the plan.

In addition to the reduction of structural and content damages and reduced threat to life and safety, this plan provides approximately 4,000 acres of land found to be suitable for ecosystem restoration of wetlands many of which are directly connected to the Gulf waters. Considering the importance of estuarine wetland habitats that are directly connected to the Gulf in terms of promoting aquatic diversity, seafood production and shorebird productivity, this product of the plan is considered to be significant.

The cost of implementing Plan NS-PAHHZ is estimated to be $6.1B which translates into $404,000 per unit protected. In addition to the land acquisition, relocations assistance and structure demolition costs reflected in the total cost, the construction of at least 3,000 new housing lots would also be included in that total cost at an average cost of $45,000 per lot.

On the environmental impact side of the ledger, Plan NS-PAHHZ would result in significant migrations of population from the near-shore zone into less flood-prone and less developed areas where good quality habitat may be impacted by new home development (housing redevelopment/subdivision sites). Emphasis on in-fill development in the more urban areas and smaller communities located north of I-10 could reduce those impacts, but the magnitude of the relocations (at least 3,000 new lots) suggests some impacts to natural resources. Suitable redevelopment sites could encompass agricultural land as well as upland forest and grasslands. Wetland areas would be avoided during the redevelopment process.

In addition to the impact on natural resources by this migration, there may be impacts to public services (schools, wastewater collection and treatment systems, police and fire services and water supply systems) as additional users are added to the system. Also, there could be social and economic impacts by the loss of social connections in the affected communities. These impacts would surely be less than the impacts from Katrina itself, but would persist for several years as the program progressed. On the positive side, the Plan would evacuate many acres of high-quality beachfront habitat that would revert to a more natural state in addition to many acres of restored wetland habitat across the region.

Although one-dimensional, Plan NS-PAHHZ does attack the most critical storm damage needs and could significantly reduce threats to loss of life by inundation drowning. Public reaction to this plan would be mixed. Many of those landowners whose homes were destroyed by Katrina and did not have flood insurance would favor an opportunity to be relocated into a new more flood-safe replacement structure with limited personal financial investment. More opposition may be generated by local governments whose loss in tax revenues (already reduced by Katrina) from the relocation of acquired landowners would be hard to replace and whose remaining residents would have to bear the higher costs of remaining public services in those damaged areas.

7.2.2.2 Plan NS-PA100

This plan concentrates on the permanent acquisition of land and structures located in the high-hazard zones (see Plan NS-PAHHZ) and those structures within the FEMA-identified 1% annual chance flood area (as amended by the ABFE) where flood depths from the ABFE are greater than 13 feet above the ground surface. Under a mandatory implementation scheme, this plan would result in the permanent acquisition of an estimated 33,191 parcels of land with attendant structures (estimated 17,144) and families. The reduction in average annual damages due to these acquisitions would be approximately $210.0M. Given the high incidence of total destruction in the high-hazard zone (as much as 90%) and the reduction in annual damages provided by this measure, this would be a significant affect.

Approximately 95,000 acres of land could be acquired through this plan under a mandatory acquisition scheme. The actual number of parcels acquired would be dependent upon the individual landowners' perception of the flood risks and the opportunities for relocation to a flood-safe site. Participation rates could vary substantially depending upon the extent of damages to individuals homes incurred during Katrina and the individual prospects for redevelopment in the current location given higher construction costs and increased FEMA elevation requirements.

As in Plan NS-PAHHZ described above, estimates are that numerous parcels within the boundaries of Plan NS-PA100 were made vacant by Katrina. Early acquisition of a portion of those vacant lots through the initial HARP would potentially save an estimated $270.0 million dollars in structure acquisition and relocations payments. Also like the previous plan, Plan NS-PA100 potentially generates substantial housing relocations (as many as 17,144 at full participation) which would have to be accommodated in a severely under-stocked housing market. Several residential redevelopment sites holding at least 6,000 new residential lots may have to be constructed above the 0.2% annual chance flood limits to accommodate the displaced homeowners.

Using the average per household size provided in the 2000 US Census figures for this area (2.6 persons per household); approximately 44,600 persons could be permanently removed from the combined high-hazard zones and areas of water depth greater than 13 feet. Being relocated to more flood-safe locations, the threats to loss of life due to inundation drowning would be reduced substantially by this plan. This affect would be considered significant.

In addition to the reduction of structural and content damages and reduced threat to life and safety, this plan provides approximately 9,300 acres of land found to be suitable for ecosystem restoration of wetlands many of which are directly connected to the Gulf waters. This acreage is substantially greater (132% greater) than that generated by Plan NS-PAHHZ since many of the original wetland areas located away from the near-shore high-hazard zones and filled for residential development would be purchased as parcels where water depths at the ABFE would exceed 13 feet. This plan affect would be considered significant.

The cost of implementing Plan NS-PA100 is estimated to be $8.2B which translates into $248,000 per unit protected. In addition to the land acquisition, relocations assistance and structure demolition costs reflected in the total cost, the construction of at least 6,000 new housing lots would also be included in that total cost at an average development cost of $45,000 per lot.

Considering the environmental impacts of the plan, Plan NS-PA100 would result in significant migrations of population from the near-shore zone into less flood-prone and less developed areas where good quality habitat may be impacted by new home development (housing redevelopment/subdivision sites). Needing as many as 6,000 new lots to accommodate displaced landowners could impact over 2,000 acres of heretofore undeveloped land above the 0.2% annual chance flood limits. At these higher elevations there are fewer chances that wetland areas would be impacted by redevelopment and efforts would be made during the planning process to delineate all

wetlands and purposefully avoid them during development. Upland forest and grasslands as well as agricultural lands may be most impacted by these redevelopment sites. Emphasis on in-fill development in the more urban areas and smaller communities located north of I-10 could reduce redevelopment impacts, but the magnitude of the relocations suggests some impacts to natural resources.

In addition to the impact on natural resources by this large migration, there could be impacts to public services (schools, wastewater collection and treatment systems, police and fire services and water supply systems) because of lack of capacity as well as social and economic impacts by the loss of social connections in the affected communities. These impacts would surely be less than the impacts from Katrina itself, but the impacts would persist for several years as the programmed acquisition process progressed. Even at a modest rate of participation in the program, many receiving communities would be hard-pressed to accommodate so many new households without substantial investments in new infrastructure and social/public services.

On a more positive environmental side, the permanent acquisition of both the high-hazard zones and areas where water depths at the ABFE exceeded 13 feet would encompass most of the near-shore areas as well as many of the original wetland areas within the inlets where placement of fill over the years had allowed residential and commercial development to occur. Once cleared, this estimated 9,300 acres could be restored to wetland habitat and use for a multitude of public uses including recreation.

As in the case of Plan NS-PAHHZ, Plan NS-PA100 is one dimensional using only permanent acquisition as a method of reducing structure and content damages and risks to life and increasing public safety. This plan does address most directly the highest risk properties that are damaged more frequently due to surge and wave action and does reduce the potential threats to life and public safety in the project area.

The social and economic impacts of this plan would make it unpopular with the local governments and communities unless some form of revenue sharing could be arranged between those communities being evacuated and those receiving new displaced homeowners (read as increased property tax receipts). It is possible that the magnitude of this acquisition program could result in the abandonment of substantial miles of access roads and utilities within heretofore heavily populated neighborhoods thus reducing future damages to these categories of infrastructure as well.

7.2.2.3 Plan NSC-1 Federal Agencies Plan

This plan relies primarily on those actions that could be undertaken by assorted Federal agencies including the Corps of Engineers, FEMA, and NOAA. This plan would feature permanent acquisition of a maximum of 33,191 eligible parcels (approximately 17,100 structures) within the high-hazard zones and areas where water depths would exceed 13 feet at the ABFE (similar to Plan NS-PA100) level. This plan would also feature floodproofing at 25,419 eligible parcels by elevation (meeting current local NFIP requirements) and other means, relocation of 7 public structures to more flood-safe locations and the upgrading of the existing components of the existing flood warning and emergency evacuation system.

This multi-dimensional plan would address several of the planning objectives (reducing flood damages, reducing threats to loss of life and providing opportunities for ecosystem restoration). The plan would provide complete protection through the acquisition of an estimated 33,191 parcels and relocation of at least 17,144 households and businesses and provide a minimum level of protection to the structures of as many as 25,419 landowners through floodproofing in the project area. The total reduction in average annual damages would be approximately $315.0M ($210.0 in acquisitions and $105.0M in floodproofing).

In addition to flood damage reduction, the estimated 33,191 parcel acquisitions represent as many as 86,300 persons residing on those high-risk parcels whose lives would be made safer by relocation to more flood-safe residences through the relocations assistance program. Although the plan would not condone residents remaining in elevated structures during a hurricane event, structures raised above the ABFE would provide protection from drowning due to surge conditions for as many as 63,000 persons. Both of these affects would be considered significant.

As in the case of Plan NS-PA100, this plan could result in the acquisition of up to approximately 95,000 acres of land of which approximately 9,300 acres would be suitable for restoration as wetland ecosystem habitat. This positive affect on the region's ecosystem would be considered significant. The total acres acquired and those suitable for restoration would be contingent upon program participation rates.

By incorporating a multitude of measures, this plan provides a variety of flood damage reduction and public safety measures not found in other plans. The relocation of 7 public structures (some of which are schools) allows not only continuance of essential public services to the population but can provide needed evacuation centers for those fleeing future flooding events. These affects are considered significant as well.

From an environmental standpoint this plan has both positive and negative affects. The potential clearing of over 93,000 acres of residential and commercial land in flood-prone areas that can be converted to wetlands or other quality habitat as well as used for passive recreation uses is a significant positive affect on the region's ecosystems. From a negative viewpoint, relocating all of those households would result in some land and vegetation disturbance either through planned redevelopment sites or through the housing market construction process to meet the new housing needs. Needing at least 6,000 new residential and commercial lots would require an estimated 2,000 acres of subdivision development above the 0.2% annual chance floodplain. In-fill within already disturbed urban areas would siphon off a portion of this needed new development, but some land development disturbance is anticipated. Although identified wetlands could be avoided, agricultural lands and forest and grassland habitat may be impacted by this new development. New private market housing may be more dispersed and potentially less concerned about site development impacts while planned redevelopment sites would be evaluated through the NEPA process.

7.2.2.4 Plan NSC-2 Wet and Dry Floodproofing with FWEE Upgrades

This plan relies primarily on floodproofing, by various methods (wet and dry), structures on at least 25,419 eligible parcels within the ABFE footprint and the implementation of upgrades to the existing flood warning and emergency evacuation (FWEE) system. The upgrades to the existing FWEE would be spearheaded by other Federal (FEMA and NOAA), state and local agencies with support by the Corps of Engineers. Given the potential for thousands of families to be perched in elevated structures along the coast following the implementation of this plan, being able to issue credible and timely storm/flood warnings and efficiently and safely evacuate those people to safe storm shelters would be paramount in assuring that those in elevated residences would wisely choose to evacuate to high-ground.

The level of protection for elevated structures in this plan was based upon the ABFE minus 2 feet which was used as an approximation of the anticipated new FEMA-issued Base Flood Elevations following Katrina. The ABFE elevations or increased freeboard requirements (4 feet of additional freeboard) were adopted by each of the municipal and county governments following Katrina (see Table 8). Average annual flood damages for structures and their contents located on the 25,419 eligible parcels would be reduced by an estimated $105.0M as a result of implementation of this plan at that level of protection. This amount of flood damage reduction would be a significant affect produced by this plan.

[*The new BFE elevations were being issued in draft form by FEMA as this Appendix was being completed, but no attempt was made to recalculate the numbers of eligible parcels for floodproofing or to recalculate floodproofing costs based upon the new revised BFE. Once the new BFE elevations have been reviewed by the 11 municipal areas and 3 counties and have been adopted into the existing floodplain management ordinances, those elevations would form the basis of any subsequent detailed planning and engineering documentation by the Corps of Engineers prior to implementation of an authorized and funded nonstructural project*.]

Although people living within the elevated structures would be strongly encouraged to evacuate their floodproofed homes during a storm surge event, past experience indicates that many would choose to remain sheltered in place. Based upon a household size of 2.6 persons, as many as 65,000 people might be protected by this plan during a storm event that did not exceed the ABFE level. Providing some level of safety to people sheltering in place would be a significant affect. Conversely, promoting elevation of homes in high-hazard zones (potential consequences of other Federal programs) may place many families in extreme peril should hurricane surge and waves exceed the design height of the home's elevation (FEMA BFE).

The floodproofing program would affect approximately 136,000 acres of land within the project area. Of those acres approximately 3,800 acres would be suitable for ecosystem restoration as wetlands. Although the floodproofing program wouldn't be directly involved in purchasing those lands, it is possible that a number of structures would be found to be either structurally unsound and therefore unfit for elevation under the guidelines or that the cost of floodproofing the structure would exceed the appraised value of the structure. In these two cases, the owner may be given the option to sell the property to the Federal government (or project sponsor) for the appraised value, opt for a replacement home on-site at a lesser cost than floodproofing or to buy-up to the floodproofing cost with private funds. In the event that the owner would sell the property to the Federal government, they would be relocated under the provisions of the Uniform Relocations Act and the vacated land could be used for ecosystem restoration as wetlands. This determination would be made at the time of implementation of the floodproofing program on a case-by-case basis.

From an environmental perspective, Plan NSC-2 has very minimal impacts since all of the construction work occurs within the confines of an already disturbed residential, commercial or institutional building lot. In most cases, construction would be confined largely to the existing footprint of the structure foundation and all construction (including storage of building materials) would be confined to the owner's property. Since floodproofing construction is hand-labor intensive, there would be minimal use of heavy construction equipment on site (limited engine exhaust, petroleum or hydraulic fluid leakage, or waste water). Operation and maintenance of the structure elevation by the landowner also is environmentally friendly.

7.2.2.5 Plan NSC-3 Combined Federal and Non-Federal Jurisdiction Plan

This plan combines the best measures and attributes of Plans 1 and 4 into a suite of effective components aimed at all parcels affected by Katrina surge inundation within the ABFE footprint. In addition to the permanent acquisition of up to 33,191 parcels (an estimated 17,144 structures), the floodproofing of up to 25,419 structures and relocations of at least 7 public buildings, this plan includes application of numerous local jurisdiction actions that would affect every parcel (approximately 95,000 parcels) in the project area. Reductions in the average annual damages are estimated to be $315.0M based solely upon the affects of acquisitions of at-risk structures and floodproofing by elevation.

Additional reductions in annual damages would be generated by the application of nonstructural measures by the local jurisdictions such as upgraded floodplain management ordinances (application of the revised FEMA BFE), upgraded building codes, revised land use zoning

ordinances, implementation of either a TDR or PDR program to address vacant properties, and the institution of development impact fees. Although incrementally small in comparison to the damage reductions provided by Federally-funded acquisitions and floodproofing, these local measures, when taken in aggregate, would have a significant affect on future damages.

In addition to flood damage reduction, the 33,191 parcel acquisitions (an estimated 17,144 structures) represent as many as 86,300 persons residing on those high-risk parcels whose lives would be made safer by relocation to more flood-safe residences through the relocations assistance program. Although the plan would not condone residents remaining in elevated structures during a hurricane event, structures raised above the ABFE would provide protection from drowning due to surge conditions for as many as 63,000 persons. Both of these affects would be considered significant.

As in the case of Plans NS-PA100 and Plan NSC-1, this plan could result in the acquisition of up to approximately 95,000 acres of land of which approximately 9,300 acres would be suitable for restoration as wetland ecosystem habitat. This positive affect on the region's ecosystem would be considered significant. The total acres acquired and those suitable for restoration would be contingent upon program participation rates.

From an environmental standpoint this plan has both positive and negative affects. The potential clearing of over 93,000 acres of residential and commercial land in flood-prone areas that can be converted to wetlands or other quality habitat as well as used for passive recreation uses is a significant positive affect on the region's ecosystems. Clearing the beachfront properties of residential and commercial development and the pavements and weekly maintenance of lawns and ornamentals (as well as extracting invasive plant species) would release the indigenous vegetation communities to flourish and provide additional storm protection (primarily wave and wind) through dense tree and shrub growth.

From a negative viewpoint, relocating all of those households would result in some land and vegetation disturbance either through planned redevelopment sites or through the housing market construction process to meet the new housing needs. Needing at least 6,000 new residential and commercial lots would require an estimated 2,000 acres of subdivision development above the 0.2% annual chance floodplain. In-fill within already disturbed urban areas would siphon off a portion of this needed new development, but some land development disturbance above the 0.2% annual chance elevation is probable. Planned development sites would avoid identified wetlands, but agricultural lands (especially vacated agricultural lands) and forest and grasslands may be impacted by new housing development. New private market housing may be more dispersed and potentially less concerned about site development impacts while planned redevelopment sites would be evaluated through the NEPA process.

In addition to the impact on natural resources by this large migration, there could be impacts to public services (schools, wastewater collection and treatment systems, police and fire services and water supply systems) because of lack of capacity as well as social and economic impacts by the loss of social connections in the affected communities. These impacts would surely be less than the impacts from Katrina itself, but the impacts would endure for several years as the programmed acquisition process progressed. Even at a modest rate of participation in the program, many receiving communities would be hard-pressed to accommodate so many new households without substantial investments in new infrastructure and social/public services.

The social and economic impacts of this plan would make it unpopular with the local governments and communities unless some form of revenue sharing could be arranged between those communities being evacuated (taxable property lost) and those receiving new displaced homeowners (read as increased property tax receipts). It is also possible that the magnitude of this acquisition program could result in the abandonment of substantial miles of access roads and

utilities within heretofore heavily populated neighborhoods thus reducing future damages to these categories of infrastructure as well.

7.2.2.6 Plan NSC-4 Non-Federal Jurisdiction Plan

This plan contains the full palette of flood damage reduction measures that can be implemented through the local jurisdictions' (counties and municipalities). These individual measures affect essentially each and every parcel and structure located with the footprint of the Katrina surgeplain. Most of the measures are regulatory in nature (upgrading and enforcement of building codes, NFIP, and land use zoning), but a few are more proactive in their application such as a TDR/PDR program that would actively acquire or transfer development rights from at-risk properties or the development impact fees that would increase the costs of development in the at-risk zones (hopefully discouraging further development in high-risk zones) as well as generating funds for emergency management purposes.

Unlike the measures listed under Plan NSC-1 Federal Agencies Plan, the measures contained in NSC-4 do not lend themselves to easily quantifying benefits in terms of flood damages reduced or reductions in threats to loss of life. In addition, the application of these regulatory and land use measures do not directly generate additional lands for ecosystem restoration although the TDR/PDR programs could both be used to accomplish the same objectives in that regard as does permanent acquisition and relocations. In most cases, the counties and municipalities have the regulatory measures (land use zoning, NFIP, and building codes) in place to some degree and the incremental differences in reduced damages and loss of life to be gained by upgrading these components would be largely unnoticeable on an individual parcel basis. Only at the aggregate level would the differences be evident following a hurricane event. Intuitively, positive changes in the building codes and increases in the level of the Base Flood Elevation (should that be adopted by the communities) should reduce damages from future events. The presence of such a large number of vacant parcels (developed under previous codes/regulations) following Katrina indicates that updated regulatory codes and floodplain ordinances should generate positive benefits when the rebuilding occurs.

In the absence of a Federal program for storm protection in the project area (known as the No Federal Action Plan in NEPA terminology), these measures could be instituted at the local level to reduce future damages to those types of land uses contemplated in the future without-project condition described in the comprehensive plan and below. With the institution of these local measures and enforcement of upgraded building codes, floodplain management ordinances and land use zoning, future storm-related damages could be significantly reduced. The initiation of a TDR or PDR program that would transfer or purchase development rights on high-risk parcels (up to 33,191 parcels within the 100-year surge inundation footprint) would generate significant damage reduction benefits while potentially increasing development in less flood-prone areas north of I-10. Such limitations on development rights negotiated through the market system or by direct purchase would allow continued maintenance of the coastline properties by private landowners while maintaining some proportion of the original tax revenues to local jurisdictions.

7.2.2.7 Plan NSC-5 Loss of Life Reduction Plan

This plan relies primarily on permanent acquisitions in the high-hazard zone, relocations of public structures and upgrades to the flood warning and emergency evacuation (FWEE) systems. The permanent acquisitions would address 14,997 parcels located in the most dangerous coastal properties where the potential for loss of life due to drowning would be greatest in many categories of hurricanes and tropical storms. This area is subject to surge inundation and high waves, both factors in drowning deaths. The reduction in average annual damages amounts to approximately $92.0M. The potential reduction in threats to life by surge inundation drowning is approximately

39,000 persons. Considering that over 200 people lost their lives in MS during Katrina, this reduction in the threat to life and safety is a significant affect of the plan. The effectiveness of this plan in reducing the threats to life would be dependent upon the attitudes of the landowners and their perception of the risks of redevelopment in the high-hazard zone.

Were the plan to be implemented in a mandatory fashion, all 14,997 identified properties would be acquired and the remaining residents relocated to suitable replacement DSS housing. This massive relocation project may trigger the need for one or more replacement housing sites within the project area to accommodate so many displaced landowners in an anemic housing market. The residential redevelopment sites would be located above the 0.2% annual chance flood elevation either by location or by design and the influx of new DSS housing resources would substantially increase the volume and quality of the region's housing stock from its current state.

In addition to the reduction of structural and content damages and reduced threat to life and safety, this plan provides approximately 4,000 acres of land found to be suitable for ecosystem restoration of wetlands many of which are directly connected to the Gulf waters. Considering the importance of estuarine wetland habitats that are directly connected to the Gulf in terms of promoting aquatic diversity, seafood production and shorebird productivity, this product of the plan is considered to be significant.

On the environmental impact side of the ledger, Plan NS-PAHHZ would result in significant migrations of population from the near-shore zone into less flood-prone and less developed areas where good quality habitat may be impacted by new home development (housing redevelopment sites). Emphasis on in-fill development in the more urban areas could reduce those impacts, but the magnitude of the relocation effort suggests some impacts to natural resources.

In addition to the impact on natural resources by this migration, there could be impacts to public services (schools, wastewater collection and treatment systems, police and fire services and water supply systems) because of lack of capacity as well as social and economic impacts by the loss of social connections in the affected communities. These impacts would surely be less than the impacts from Katrina itself, but would persist for several years as the program progressed. On the positive side, the Plan would evacuate many acres of high-quality near-shore habitat that would revert to a more natural state in addition to many acres of restored wetland habitat across the region.

In addition, this plan address relocation of public structures including 7 identified public buildings including schools and fire stations. These structures would contain children (one of the segments of the population more susceptible to drowning in surge situations) and first responders during and immediately following a storm event. Their relocation would reduce the potential for loss of life and would provide flood-safe emergency shelters for evacuees.

Upgrades to the flood warning and emergency evacuation system would assure that credible and timely warnings could be issued to a larger segment of the at-risk population so that evacuations could be conducted in a safe and orderly manner encouraging more people to participate in both voluntary and mandatory evacuations. The upgrades to signage and highway routing and emphasis on an ongoing education and awareness program would assure that both residents and visitors would be knowledgeable about evacuation routes and locations for emergency shelters.

7.2.2.8 Plan NSC-6 Combined Structural/Nonstructural Plan

Plan NSC-6 envisions combining several structural projects that either protect individual municipal areas with ring-levees or, as in the case of LOD-4, protect all of those parcels located roughly north of the CSX railway line with a levee and surge gates with nonstructural measures that would address all of those parcels not protected by these projects. Protecting large municipal areas in place with structural projects does eliminate many of the social and economic impacts of full-scale relocations

or the visual and access impacts of elevating so vast a number of tightly confined structures. The benefits of LOD-4 when combined with nonstructural measures (primarily permanent acquisitions) is the generation of many acres of land suitable for ecosystem restoration as wetlands between the levee alignment and the Gulf.

This basic NSC-6 plan (combinations of nonstructural measures and structural projects) and its several scales (ABFE, 20 foot, 30 foot and 40 foot inundation) were formulated using just the measures described in Plan NSC-1 set in combination with various ring-levees and the Line of Defense 4 (LOD-4). Other measures described in the local jurisdiction plan (Plan NSC-4) could be applied in the nonstructural areas in NSC-6, but issues of combinability would emerge as shown in Plan NSC-3. Specific data on the numbers and costs of relocations of public buildings was eliminated for the 20 foot, 30 foot and 40 foot levels of inundation since data on the specific locations of these critical facilities at these increased flooding depths was not available from local, Corps or FEMA sources.

In addition, since only the annual flood damage reductions were calculated for the nonstructural measures at the ABFE level, specific reductions in average annual damages for the higher level of inundation were not available for this Appendix. What is known are the numbers of structures that would be included in the various scales of the nonstructural plan and estimates of the plan cost shown in Tables 25 through 33. Also, based upon the structures being afforded protection by each scale of the alternative, the approximate number of persons afforded protection from loss of life by nonstructural measures in the several scales of this plan can be estimated. These figures are shown in Table 25.

In addition to the numbers of parcels that would be eligible for acquisitions and floodproofing in the scales of NSC-6, there may be a need for several redevelopment sites located above the 0.2% annual chance floodplain (north of I-10). Numbers of needed relocation lots range from 6,800 to 29,000 to accommodate the numbers of structures that would be displaced by the nonstructural acquisitions in inundation depths from the ABFE to the 40 foot level. This need would require between 2,200 acres and 9,600 acres of land to address this number of displaced persons. Careful planning of these new subdivision sites could reduce significant environmental impacts normally associated with land development on this scale, but impacts to upland grasslands and forested sites may be unavoidable.

Specific data on the number of acres that would be acquired by permanent acquisition in the 20 foot, 30 foot and 40 foot levels of inundation was not available for this appendix, but in the options that involved the ring-levee alignments, the number of acres that would be purchased and suitable for ecosystem restoration would approximate those displayed for the single-measure permanent acquisition plans NS-PAHHZ and NS-PA100.

In comparison with the nonstructural plans, the combined structural nonstructural plan would open up the potential for more in-fill redevelopment in protected urban areas so that the relocation of displaced households could occur in areas with in-place infrastructure and public services rather than more rural areas without infrastructure. The combined plan featuring LOD-4 with nonstructural measures would accomplish the objective of moving most development away from the beachfront north towards the I-10 corridor. This movement, part of the “tiering” concept, would accomplish significant reductions in flood damages while spurring significant growth along that highway corridor.

7.3 Comparison with Future Without-Project Conditions

7.3.1. General

Following the description and display of the future with project outputs from each of the plans, those plan outputs are then compared to the anticipated future without-project conditions to determine to what extent the plans affect or improve the anticipated future condition. The MsCIP PDT formulated a series of future without-project scenarios based upon different mixes of land uses re-occupying the high-hazard zones and the possible effects of various sea-level rise amounts that may occur along the project area during the planning period (100 years). The two primary land use types were residential (single-family homes) and a mixed-use redevelopment featuring residential and commercial uses. Sea-level rise was divided into no relative rise, an expected relative sea level rise and a high relative sea level rise. In all, six scenarios were developed by the team including:

1) Residential redevelopment with no relative sea-level rise,
2) Residential redevelopment with an expected relative sea-level rise,
3) Residential redevelopment with a high relative sea-level rise,
4) Mixed use (residential/commercial) with no relative sea-level rise,
5) Mixed use (residential/commercial) with an expected relative sea-level rise, and
6) Mixed use (residential/commercial) with a high relative sea-level rise.

In each case the rate of redevelopment demonstrates an expected vigorous rebuilding program that would result in most of the previous development being back in place within 10 years. This growth rate is not unusual given the rates of growth that were common within the project area prior to Katrina. The combination of revised FEMA floodplain mapping and ordinances to guide redevelopment and the resurgence of various sectors of the economy in the region, rebuilding of the coast, barring a recurrence of Katrina-like events, could be swift and sustained.

In this re-building environment, the nonstructural plans would produce, in varying amounts, an array of storm damage reduction benefits, reductions in potential losses of life and opportunities for substantially increasing the acres of high-quality wetland and other ecosystem habitats in the region. The affects of the various amounts of anticipated relative sea level rise could be compensated for in the nonstructural measures by adjusting the geographical limits of permanent acquisition (to account for greater depths of inundation or expansions of the V zone) and floodproofing by elevation. Since both of these nonstructural measures are applied on a structure-by-structure basis, program adjustments accounting for changes in inundation depths are relatively simple and incrementally inexpensive on a per structure basis. The performance of each nonstructural plan with respect to the various future without-project condition scenarios is discussed below.

7.3.2. Comparisons with Future Without-Project Conditions

7.3.2.1. Plan NS-PAHHZ

This plan addresses a geographic area of the coast (approximately 57,000 acres) that is defined not by elevation above the gulf, but by lateral extent from the waterline based on the presence of velocity waters (V Zone) and the damages observed after Katrina. In this regard, all of the changes in sea level contemplated by the scenarios have little affect on the effectiveness of this plan unless

the changes in sea level were to translate into a regulatory modification of the V Zone and other damage zones that comprise this area in the Plan.

This plan addresses those parcels (14,997) and attendant structures (7,510) residing in the high-hazard zones of the project area. Since a number of structures were totally destroyed during Katrina, this plan is particularly effective in reducing damages and threats to life and public safety since all of the scenarios described above would see this area completely repopulated with new structures within 4 years. Even elevated to the revised BFE's published by FEMA and adopted by the local jurisdictions, the new structures may still be highly susceptible to massive damages by any storm surge level and waves that would exceed the revised BFE level in this zone.

Residential construction was observed to be highly susceptible to the battering affects of surge and waves in this zone. Therefore, the scenarios featuring residential growth (scenarios 1-3) in this high-hazard zone would be most susceptible to heavy damages which would be completely eliminated by mandatory application of this Plan. The eventual effectiveness of this plan would be contingent upon a high rate of participation in a non-mandatory plan. Plan NS-PAHHZ would also be effective under scenarios 4-6 featuring a mix of residential and commercial growth. It is anticipated that any land use development including commercial that is rebuilt in this zone to the revised BFE's would remain susceptible to heavy damages by storm surge and waves that exceeded the BFE elevation. Given the risks that commercial uses (especially retail uses) would assume in rebuilding in this high-hazard zone, their flood insurance burden may demand greater elevation of first floors and greater use of building materials and construction practices that would reduce damages. In any case, this plan would significantly reduce those damages through permanent acquisition and relocation of commercial uses as well as residential uses.

Continued threats to life and public safety under any of the 6 scenarios would be significantly reduced by this plan through permanent acquisition and relocation of the at-risk households. Were the high-hazard zone to be rebuilt within a 10 year period under any of the scenarios, the potential losses of life by surge inundation may be substantial and potentially greater than that experienced in Katrina. New development in the high-hazard zone under revised NFIP guidelines may encourage elevation of homes and businesses thus instilling a false sense of security and tendency for homeowners to seek shelter in elevated structures during larger storms. Permanent acquisition and relocation of these at-risk properties removes the risk to life and public safety.

More importantly, the proposed initial High Hazard Area Risk Reduction (HARP) would be most effective in reducing future damages and loss of life in this zone under any of the 6 scenarios of redevelopment. By purchasing vacant properties in the high-hazard zone prior to the initiation of any of the 6 scenarios of the future without-project condition, the potential damages that could occur with new growth would be eliminated.

7.3.2.2. Plan NS-PA100

This plan addresses only permanent acquisitions in the high-hazard zone and the area affected by the 1% annual chance flood event where water depths would exceed 13 feet at the ABFE. As such, the effectiveness of this plan in the high-hazard zone under each of the 6 scenarios is the same as described above in Plan NS-PAHHZ. According to field observations and the structure databases, the incidence of structure loss in the area inundated by the 1% annual chance flood where water depths would exceed 13 feet at the ABFE was much less than observed in the high-hazard zone. Although there are vacant acres of land in this deep water zone that could be affected by any one of the 6 scenarios of the future without-project condition, the anticipated increase in placement of damageable property is much less than would be expected in the largely decimated high-hazard zone. There are approximately 95,000 acres of land included within this plan area (an additional 37,000 more than Plan NS-PAHHZ).

Conversely, there remain a significant number of structures still susceptible to flood damages in this deep-water zone that would continue to suffer future damages in spite of any substantial redevelopment in the zones covered by this plan. Permanent acquisition of these remaining structures would significantly reduce damages under any of the 6 scenarios and especially in the scenarios that contemplate rises in sea level (scenarios 2, 3, 5 & 6) for those remaining structures. As such, Plan NS-PA100 would show incremental storm damage reduction benefits in excess of Plan NS-PAHHZ just based upon the substantial number of additional parcels (structures) included in this plan (approximately 10,000 additional parcels affected) over Plan NS-PAHHZ.

Threats to loss of life would be substantially lessened by this plan through at least 4 of the 6 scenarios since any sea level rise would result in an increase in the numbers of structures that would be acquired in lieu of elevation in place (floodproofing) in the deep water area. Although this area is not subject to the wave action encountered in the high-hazard zone, inundation of homes by deeper water would place more persons in jeopardy of drowning before evacuation would be possible. Acquisition of these structures through this plan would remove this threat.

7.3.2.3. Plan NSC-1

This plan not only addresses both permanent acquisition of the high-hazard zone and areas where water depths would be in excess of 13 feet at the ABFE but also elevates additional structures and their contents above the ABFE. This plan generates substantial storm damage benefits under any of the 6 scenarios as described in the above two plans (Plan NS-PAHHZ and Plan NS-PA100) and additionally generates storm damage benefits through elevation of structures on an additional 25,419 parcels. Compared to the zones described in the two plans above where wave action and deep water may have resulted in substantial numbers of destroyed structures, the geographic area comprising the 25,419 parcels eligible for floodproofing by elevation (about 136,000 acres) is mainly susceptible to inundation damages with substantially fewer losses of structures.

This plan is effective under any of the 6 scenarios since the elements of the plan associated with permanent acquisitions eliminate many of the potential future damages that would occur by either residential or mixed-use redevelopment of the high-hazard zone and areas where water depths would exceed 13 feet. The balance of structures covered by this plan through floodproofing and any additional vacant acres of land within the total 136,000 acres of this zone that may be redeveloped under one of the 6 scenarios would be protected by elevating the first floor of new structures above the design flood elevation. Since the plan is implemented on a structure-by-structure basis, adjustments to the design flood height (0-3 feet) to account for any anticipated sea level rise would not increase costs substantially on an individual structure. Storm damage reduction benefits and reduced threats to loss of life could be maintained by slight adjustments in design criteria for elevating structures or increasing the number of acquired structures.

An added feature of this plan is the relocations of public buildings to flood-safe areas. Under any of the 6 future without-project scenarios, relocations will be effective in both reducing damages to these critical facilities as well as maintaining essential services both during and immediately after a storm event. Given the increased regulatory requirements for locating critical facilities (usually above the 0.2% annual chance flood zone) under the NFIP, it is improbable that many of these types of structures would populate the high-hazard zones in future redevelopment scenarios. Since the flood frequency elevations that govern location of these structures would be sensitive to sea level rise, the relocations component of Plan NSC-1 could be easily adjusted during implementation to account for anticipated sea level rise at either an expected relative level or relative high level.

Threats to life and public safety under this plan are substantially reduced under any of the 6 scenarios. With permanent acquisition of the high-hazard zone and areas where water depths exceed 13 feet, most of the threat is substantially reduced. Since the program does not recommend

that people remain in elevated structures during a storm surge event and would be evacuated to high-ground, the threats to that population would be substantially reduced under all of the scenarios.

7.3.2.4. Plan NSC-2

This plan relies mainly on floodproofing by elevation and upgrades to the flood warning and emergency evacuation system (FWEE) to reduce storm surge related damages and threats to life and public safety. The upgrades to the FWEE will be spearheaded by NOAA and FEMA in cooperation with state and local emergency management offices with support and coordination from the Corps.

Since this plan does not include permanent acquisition of the high-hazard zone or areas where water depths at the ABFE would exceed 13 feet, its ability to reduce damages as a result of the 6 redevelopment scenarios is substantially less that other plans. This plan can be effective in reducing damages despite sea level rise for structures on the 25,419 parcels included in the floodproofing component because the heights of elevation can be easily adjusted during implementation of the program at minimal cost per structure lifted. The only impact that sea level rise anticipated in 4 of the 6 scenarios would have on this plan is the transfer of some structures to the permanent acquisition component of the project due to water depths in excess of 13 feet at the structure. The mix of new development considered in the 6 scenarios would not impact the effectiveness of this plan since either residential or commercial structures can be elevated to reduce flood damages.

However, since most of the redevelopment would occur in those areas where the majority of vacant land is now located (notably the high-hazard zone), this plan is largely ineffective in reducing storm surge damages or threats to life and public safety for upwards of 33,191 parcels and attendant structures (an estimated 17,144). Given an average of 2.6 persons per household in the region, this leaves potentially 86,300 persons unprotected by this plan under the 6 redevelopment scenarios.

7.3.2.5. Plan NSC-3

This plan combines the best nonstructural measures (9 total measures) that can be jointly implemented by Federal agencies and local jurisdictions to reduce storm-related damages, reduce threats to life and public safety and increase the acreage of wetland ecosystems in the project area. With such a broad array of effective measures available, this plan can be adjusted on a parcel-by-parcel basis to meet any of the new conditions or threats that would be generated by the 6 future without project condition scenarios.

In addition to the nonstructural components included in Plan NS-PA100 and Plan NSC-2 above that would address future damages in the high-hazard zones by acquisition, this plan features the application of local jurisdictional measures such as upgraded NFIP requirements, upgraded building codes, a TDR or PDR program for acquiring development rights on at-risk parcels, development impact fees, and modifications of existing land use zoning codes. In terms of the redevelopment scenarios that feature either residential or a mix of residential and commercial land uses, the application of a voluntary TDR or PDR program would significantly limit redevelopment of these damageable structures in the high-risk areas of the coast by securing the development rights of each parcel in perpetuity. In addition, development rights could be purchased on parcels that possessed existing wetland thereby restricting further development of these sensitive ecosystems in the future scenarios.

Upgrading the existing floodplain management ordinances according to new FEMA floodplain mapping and the FEMA 550 guidelines would significantly reduce damages to the redeveloped land uses anticipated in the 6 scenarios. As these ordinances can be easily adjusted to account for any sea level rise, storm-related damages to new development would be reduced through enforcement

of the floodplain management ordinances and revised building codes. Upgrading and enforcing the existing International Building Codes and International Residential Codes in each county and municipal jurisdiction would assure that any new construction anticipated in the 6 scenarios would be able to withstand hurricane force wind loads as well as wind-driven rain penetration and the corrosive effects of a saltwater environment.

This plan performs very well under any of the future without-project conditions described in the 6 scenarios through reduction of storm-related damages, reduced threats to life and public safety and opportunities for increasing the acres of ecosystem restoration for wetlands and other sensitive habitat types.

7.3.2.6. Plan NSC-4

This plan emphasizes those nonstructural measures that can be implemented by local jurisdictions such as the 3 counties and 11 municipalities in the project area. These measures are primarily regulatory in nature and would be easily applied to all of the parcels that were affected by Katrina's surge floodplain. Any redevelopment of the project area under the 6 scenarios would be subject to the upgraded floodplain management ordinances, building codes, land use zoning ordinances and development impact fees all capable of reducing storm-related damages and threats to loss of life and public safety through application and enforcement. Generally these regulatory measures are mandatory in nature and therefore do not depend upon individual parcel owner's voluntary participation to be effective. Changes in sea level could be accommodated by the various regulations through modification of the ordinances.

Of the local jurisdictional measures, the application of either a voluntary TDR or PDR program in the project area could have the most impact under all 6 scenarios of redevelopment. By securing the development rights of a substantial number of high-risk parcels, the anticipated placement of damageable assets under the scenarios would not take place thereby significantly reducing storm-related damages and threats to life and public safety for the occupants. Although the development rights would be secured in perpetuity, the landowner would still retain the property and be able to enjoy whatever use of the property the purchase agreements allowed. In addition to maintaining the property according to municipal or county requirements, the landowner would still be paying property taxes (a minimal amount) that would support a minimal level of public services (vacant land).

Despite the ability of the local jurisdictional measures in this plan to have an effect on the redevelopment of the coast anticipated in the 6 scenarios, these measures do little to reduce further damages to existing structures that survived Katrina. Structures remaining in the high-hazard zone and those that could be elevated or purchased and relocated in other risk zones would not be addressed by this plan.

7.3.2.7. Plan NSC-5

This plan emphasizes reductions in loss of life and treats to public safety through permanent acquisitions of parcels in the high-hazard zone, relocations of critical public facilities in flood-hazard areas and upgrades to the FWEE. Upgrades to the FWEE would be led by NOAA, FEMA and state and local emergency management departments with support and cooperation from the Corps. These upgrades to the existing system would make early warning of approaching storms and hurricanes more credible and timely allowing the at-risk population more time to safely evacuate the potential surge inundation areas and seek shelter in safe evacuation centers. Under any of the 6 scenarios the upgraded FWEE would be able to provide credible and timely warnings to the anticipated additional occupants of the high-risk parcels.

The permanent acquisition component of the plan would purchase (on a volunteer basis) parcels within the high-hazard zone where much of the development anticipated in the 6 scenarios would occur. Therefore under any scenario, this plan removes a portion of the future damages that may occur in future storm events. The effectiveness of the plan under any of the scenarios would be based upon the participation rate of the individual landowners in the high-hazard zone. Potential sea level rises would not affect this component of the plan since the delineation of the high-hazard zone for permanent acquisition is not sensitive to elevation, but lateral extent of the V zone and post-Katrina damage documentation by FEMA. This component would also reduce threats to life and public safety by removing potential occupants from the high-hazard parcels.

The relocation of public structures from hazard areas would significantly reduce storm-related damages and threats to life and public safety by relocating these critical facilities to higher elevations and away from hazard areas. During relocations planning, the affects of potential future placement of either residential or mixed use development back into the hazard zones (minus those parcels acquired through this plan) that could affect the service areas of relocated structures would be taken into account. Only the effects of sea level rise in the scenarios would affect the relocations portion of this plan. However, under any of the sea level rise scenarios, the locations or construction of the relocated structures (elevated first floors) could be modified to accommodate the anticipated rises in sea level described in the 4 scenarios.

7.3.2.8. Plan NSC-6

This nonstructural plan is a modification of Plan NSC-1 with three scales of surge inundation above the base ABFE level of protection that would be applied to all of those areas not protected by either a series of ring-levees or by LOD-4. Since the ring-levee alignments protect most of the high-density urban development, the nonstructural measures would address the less densely developed areas and some displaced households or businesses through the permanent acquisition component may relocate into the urban areas protected by structural projects. This “in-fill” opportunity for displaced households and businesses would reduce program costs and impacts to the tax base.

As described above for Plan NSC-1, this plan features permanent acquisition in the high-hazard zones and non-floodproofing areas where water depths would exceed 13 feet. This plan also uses floodproofing by elevation as a means of reducing storm inundation damages to structures and their contents and the relocations of critical public facilities to further reduce storm-related damages and threats to life and public safety.

As described in Plan NSC-1 above, the use of permanent acquisition in the high-hazard zone, where much of the redevelopment contemplated in the 6 scenarios could occur, would reduce future damages by a significant amount (the percent reduction would be contingent upon the program participation rate). This reduction in damages would also hold true for any sea level rise scenario since the high-hazard zone is not sensitive to water elevation but lateral extent of the V Zone and the damage zone observed in Katrina.

The floodproofing component of the plan, depending upon the determination of the final level of protection for each structure would be sensitive to sea level rise although being implemented on a structure-by- structure basis, this measure can be easily adjusted to account for changes in the Gulf’s water level and the freeboard included in the floodproofing design gives some increment of protection against future rises in the Gulf levels. Under any of the redevelopment scenarios, floodproofing by elevation would be applicable through the current NFIP requirements by setting first floors above the BFE. Since this regulatory requirement is mandatory in the flood hazard areas defined in the local ordinances, each new building constructed would be subject to this requirement in order to obtain a building permit.

The relocation of public structures from hazard areas would significantly reduce storm-related damages and threats to life and public safety by relocating these critical facilities to higher elevations and away from hazard areas. During relocations planning, the affects of potential future placement of either residential or mixed use development back into the hazard zones (minus those parcels acquired through this plan) that could affect the service areas of relocated structures would be taken into account. Only the effects of sea level rise in the scenarios would affect the relocations portion of this plan. However, under any of the sea level rise scenarios, the locations or construction of the relocated structures (elevated first floors) could be modified to accommodate the anticipated rises in sea level described in the 4 scenarios.

7.4 Plan Comparisons With Planning Objectives

7.4.1 Planning Objectives

The MsCIP team developed a series of planning objectives for the Comprehensive Study in concert with project stakeholders and cooperating agencies. In total, 29 separate and distinct planning objectives were formulated for the study. Among those objectives were 10 objectives that could be specifically addressed through nonstructural measures. Other objectives being pursued by the study such as protection against saltwater intrusion and restoration of the barrier islands are not consistent with the nonstructural measures identified and evaluated in this appendix. The plans are also evaluated with the 4 primary civil works project objectives prescribed in the P&G. Those planning objectives that can be addressed by nonstructural measures are:

1) Reduction of the potential for future storm created flood damages,

2) Reduction of the potential for future storm related threats to life and safety,

3) Reduce costs for storm related emergency services,

4) Provide environmental justice in recommended solutions,

5) Provide complete solutions (in accordance with the P&G),

6) Provide solutions “acceptable” to communities & resource agencies,

7) Provide environmentally sound solutions,

8) Provide solutions that fit within existing laws, policies, regulations, and the general plans of local governments and communities,

9) Minimize impacts to the environment, and

10) Generate opportunities for ecosystem restoration of wetland habitat.

7.4.2. Comparisons with Planning Objectives

It is against this abridged listing of planning objectives, objectives that can be reasonably addressed by nonstructural measures, that the various plans have been evaluated. Table 35 shows the comparisons of the various plans with respect to the planning objectives and indicates whether or not and to what extent the plans accomplish one or more of the stated objectives.

Table 35
Comparison of Plans with Study and Principles and Guidelines (P&G) Objectives

Plans	NS-PAHHZ	NS-PA100	NSC-1	NSC-2	NSC-3	NSC-4	NSC-5	NSC-6
Objectives								
Reduce Storm Damages	Partially meets objective - $92.0M in AAD prevented	Partially meets objective - $210.0M in AAD prevented	Meets objective - $315.0M in AAD prevented	Partially meets objective - $105.0M in AAD prevented	Meets objective - $315.0M in AAD prevented	Partially meets objective – but AAD prevented would be minimal	Partially meets objective - $92.0M in AAD prevented	Meets objective – AAD prevented is undetermined
Reduce threats to life and public safety	Partially meets objective – 38,900 lives potentially given protection	Partially meets objective – 86,300 lives potentially given protection	Meets objective – 152,000 lives potentially given protection	Partially meets objective – 65,900 lives potentially given protection	Meets objective – 152,000 lives potentially given protection	Partially meets objective - lives given protection is undetermined	Partially meets objective – 38,900 lives potentially given protection	Meets objective – 222,000 lives potentially given protection
Reduce storm related emergency costs	Partially meets objective – reduces emergency costs for at least 14,997 parcels	Partially meets objective - reduces emergency costs for at least 33,100 parcels	Meets objective - reduces emergency costs for at least 42,513 parcels	Partially meets objective - reduces emergency costs for at least 25,419 parcels	Meets objective - reduces emergency costs for at least 42,513 parcels	Partially meets objective - potentially reduces emergency costs for at least 27,000 parcels	Partially meets objective – reduces emergency costs for at least 14,997 parcels	Meets objective - reduces emergency costs for at least 42,513 parcels
Provide environmental justice in recommended solutions	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population
Provide complete solutions (in accordance with the P&G	Provides complete solution for specific geographic zone of the project area	Provides complete solution for specific geographic zones of the project area.	Provides complete solution for the project area.	Provides complete solution for specific geographic zones of the project area.	Provides complete solution for the project area.	Does not meet the objective for the project area – is incomplete	Provides complete solution for specific geographic zone of the project area	Provides complete solution for the project area.
Provide solutions “acceptable” to communities & resource agencies	Does not meet objective with respect to community acceptance in target area. Meets the objective from resources agencies viewpoint.	Does not meet objective with respect to community acceptance in target area. Meets the objective from resources agencies viewpoint.	Does not meet objective with respect to community acceptance in target areas. Meets the objective from resources agencies viewpoint.	Does meet objective with respect to community acceptance in target area. Meets the objective from resources agencies viewpoint.	Does not meet objective with respect to community acceptance in target areas. Meets the objective from resources agencies viewpoint.	Does meet objective with respect to community acceptance in target areas. Meets the objective from resources agencies viewpoint.	Does not meet objective with respect to community acceptance in target areas. Meets the objective from resources agencies viewpoint	Does meet objective with respect to community acceptance in target areas. Partially meets the objective from resources agencies viewpoint
Provide environmentally sound solutions	Meets the objective	Meets the objective	Meets the objective	Meets the objective	Meets the objective	Meets the objective	Meets the objective	Partially meets the objective
Provide solutions that fit within existing laws, policies, regulations, and the general plans of local governments and communities	Partially meets objective – relocation of structures from the HHZ may not meet current community plans	Partially meets objective – significant relocation of structures may not meet current community plans	Partially meets objective – significant relocation of structures may not meet current community plans	Meets objective	Partially meets objective – significant relocation of structures may not meet current community plans	Meets objective	Partially meets objective – significant relocation of structures may not meet current community plans	Meets objective
Minimize impacts to the environment	Meets the objective – only impacts are through redevelopment sites	Meets the objective – only impacts are through redevelopment sites	Meets the objective – only impacts are through redevelopment sites	Meets the objective	Meets the objective – only impacts are through redevelopment sites	Meets the objective	Meets the objective – only impacts are through redevelopment sites	Partially meets the objective

Plans	NS-PAHHZ	NS-PA100	NSC-1	NSC-2	NSC-3	NSC-4	NSC-5	NSC-6
Objectives								
Generate opportunities for ecosystem restoration of wetland habitat	Meets the objective – 4,000 acres made available for ER	Meets the objective – 9,200 acres made available for ER	Meets the objective – 9,200 acres made available for ER	Does not meet the objective – no acres would be available for ER	Meets the objective – 9,200 acres made available for ER	Does not meet the objective – no acres would be available for ER	Meets the objective – 4,000 acres made available for ER	Meets the objective – 9,200 acres made available for ER
Completeness	Partially meets the objective – complete for the identified zone being targeted	Partially meets the objective – complete for the identified zone being targeted	Meets the objective	Partially meets the objective – complete for the identified zone being targeted	Meets the objective	Does not meet the objective	Partially meets the objective – complete for the identified zone being targeted	
Effectiveness	Effectiveness is contingent upon landowner participation rates; thus meeting the objective is uncertain at this time.	Effectiveness is contingent upon landowner participation rates; thus meeting the objective is uncertain at this time.	Effectiveness is contingent upon landowner participation rates; thus meeting the objective is uncertain at this time.	Partially meets the objective	Effectiveness is contingent upon landowner participation rates; thus meeting the objective is uncertain at this time.	Partially meets the objective	Partially meets the objective	Effectiveness is contingent upon landowner participation rates; thus meeting the objective is uncertain at this time.
Efficiency	Does not meet the objective with respect to other plans	Does not meet the objective with respect to other plans	Meets the objective with respect to other plans	Does not meet the objective with respect to other plans	Meets the objective with respect to other plans	Meets the objective with respect to other plans	Does not meet the objective with respect to other plans	Meets the objective with respect to other plans
Acceptability	Meets the objective from the standpoint of feasibility of implementation, but would not be acceptable to local communities affected.	Meets the objective from the standpoint of feasibility of implementation, but would not be acceptable to local communities affected.	Meets the objective from the standpoint of feasibility of implementation, but would not be acceptable to local communities affected.	Meets the objective from the standpoint of feasibility of implementation and acceptability to local communities affected.	Meets the objective from the standpoint of feasibility of implementation, but would not be acceptable to local communities affected.	Meets the objective from the standpoint of feasibility of implementation and acceptability to local communities affected.	Meets the objective from the standpoint of feasibility of implementation, but would not be acceptable to local communities affected.	Meets the objective from the standpoint of feasibility of implementation and acceptability to local communities affected.
Sustainability	Meets the objective since acquired lands would have minimal O&M requirements	Meets the objective since acquired lands would have minimal O&M requirements	Meets the objective since acquired lands would have minimal O&M requirements	Meets the objective since floodproofed structures would have minimal O&M requirements	Meets the objective since acquired lands and floodproofed structures would have minimal O&M requirements	Meets the objectives since local measures are sustainable with local revenues	Meets the objective since acquired lands would have minimal O&M requirements	Meets the objective since acquired lands and floodproofed structures would have minimal O&M requirements

As the table shows, several of the plans perform very well with respect to the planning objectives and 4 primary civil works project objectives in the P&G. In general, those plans including significant amounts of permanent acquisitions meet the objectives of storm damage reduction and reduced threats to life and public safety while providing substantial amounts of land for ecosystem restoration as wetlands and other sensitive habitat. Generally speaking these plans also are environmentally friendly having only minimal impacts (construction impacts at redevelopment sites) that can be mitigated and do not disproportionately affect low income or minority populations. Conversely, plans featuring substantial displacement of households may not be well accepted by the communities or local governments due to potential social and economic impacts (lost tax revenues).

Although effective in reducing damages throughout the project area (approximately $105M AAD) and reducing threats to loss of life and public safety for numerous parcels (25,419), Plan NSC-2 – Floodproofing with FWEE upgrades does not produce significant acres of land for ER and does not address those high-hazard parcels so susceptible to destruction and loss of life.

The Non-Federal Jurisdiction Plan (Plan NSC-4) does address several of the planning objectives and because of its mandatory regulatory nature, can assure compliance with upgraded ordinances and codes that would reduce damages for new growth in the future without-project conditions. However, the plan with the exception of a possible TDR or PDR program in place does little to address objectives for reducing damages to existing structures and providing acres for ecosystem restoration.

Plans NS-PAHHZ and NS-PA100 meet the objectives regarding reduction of damages and threats to life and public safety as well as providing lands suitable for ER and are environmentally friendly, but they are confined to smaller geographic zones and would not be well received by local governments or communities due to their potential social and economic impacts.

Plan NSC-6 which combines the nonstructural measures in Plan NSDC-1 with structural components at several communities or a single line of defense (LOD-4) meets or partially meets several objectives while having few instances where the nonstructural plan portion of the combined project would not meet an objective. Among the plans, Plan NSC-6 (with ring-levees) at the ABFE level of protection would meet most objectives while partially meeting many others.

Plan NSC-1 meets several of the objectives (damage reduction, loss of life and ER opportunities) but like the other plans including permanent acquisitions as a component of the plan, the plan may not be popular and perhaps unacceptable to local governments and communities due to the number of displaced landowners.

Plan NSC-3 provides the widest array of measures that can be applied to the various planning objectives and generally fully meets or partially meets most of the planning objectives with the one exception of the issue of local acceptability. The large number of permanent acquisitions that would result in displaced landowners would be a concern for the local governments and communities. The anticipated social and economic impacts that could accompany this plan when implemented make this plan less popular than some of the other plans that do not include large numbers of displaced landowners. There are a number of mitigative actions that be taken that would lessen the anticipated social and economic impacts of large migrations away from the coast to safer areas, all of which are discussed in this Appendix.

CHAPTER 8. COMPARISON OF ALTERNATIVE PLANS

8.1 General

Having displayed and discussed the various outputs of the plans and evaluated the plans with respect to the future without-project conditions and with respect to the planning objectives and P&G objectives, the plans can now be compared against one another for the purpose of indentifying major differences between them and ranking the plans based upon their attributes. Table 36 displays the plans and compares them through their contributions to 9 individual output categories.

Although this Appendix does not conclude with selection of a best or optimal nonstructural plan, this comparison does show which plans perform the best with respect to one another in certain categories of relative outputs and impacts. An objective ranking of the plans would depend upon a consensus agreement by the stakeholders of what constituted the most important category of plan outputs or most insidious impacts.

Since the MsCIP Main Report addresses many other alternatives (i.e. structural plans) in addition to the nonstructural plans, the identification of an optimal or best plan is relegated to that document. Regrettably, not all of the output categories discussed below involve metrics expressed in dollars or numbers of structures protected, lives protected or acres of ecosystem restoration land provided. Many comparison categories are not commensurable or the plan outputs are not measurable at this level of study. Where possible, comparisons are provided in like units of measurement.

8.2 Plan Comparisons

8.2.1. Plan NSC-3

Among the various plans being compared, Plan NSC-3 provides the widest array of nonstructural measures available. There are 9 measures provided that include the best practices for reducing storm-related damages in a joint effort by Federal agencies and state and local governments. Although the complete metrics that would show the full benefits of this plan are not available at this level of study, the nonstructural measures included are proven in other Corps projects to be cost effective compared to other alternatives and can be modified to adjust to a multitude of changing conditions as have been anticipated in the future without-project conditions. The local jurisdiction measures have been proven to reduce flood damages in other coastal areas and would be largely regulatory and administrative in nature.

This plan is the most expensive plan of those considered ($19.1B) since it includes administrative costs necessary to accomplish the non-Federal jurisdiction actions as well and its cost per parcel protected is relatively high at $325K per parcel. In most respects, this plan is very similar to Plan NSC-1 from a Federal perspective with similar damage reduction and reductions to loss of life (reducing the threat to as many as 152,000 people) characteristics. Plan NSC-3 at least partially addresses many of the planning objectives and performs well through all of the 6 future without project scenarios. The only concern for this plan is the potentially large number of displaced households (33,191) which would be a concern for the local communities. Other mitigative actions through the Uniform Relocations Act and various revenue sharing processes could address these relocation and public revenue concerns.

From an environmental standpoint, Plan NSC-3 could provide over 9,200 acres of land suitable for restoration as wetlands through the acquisition program. Additional land for wetland restoration could be provided through the floodproofing program as well during implementation. The only environmental impacts generated by this plan are those associated with construction of redevelopment sites for displaced households and businesses. If constructed through a Corps program under the last report housing provisions of the Uniform Relocations Act, these sites would be subject to scrutiny through an EA or EIS process and the impacts mitigated in collaboration with Federal and state resource agencies.

8.2.2. Plan NSC-1.

Similar to Plan NSC-3 is Plan NSC-1 which provides substantial AAD reductions ($315.0M) and reduces threats to loss of life for at least 152,000 people living in the storm surge zones through a combination of acquisitions and floodproofing. Compared to the other plans for which AAD figures are available this plan produces the most FDR benefits and has a low per parcel cost ($323K/parcel) compared to other nonstructural plans evaluated. Plan NSC-1 is expensive at $18.7B, but it is effective in reducing damages and does reduce the threat of massive property damage and possible loss of life in another hurricane event.

NSC-1 does not include the array of local jurisdiction measures that could be applied (in particular the TDR and PDR programs) to the many parcels within the ABFE footprint, but even without additional upgrades to existing regulations and ordinances, the ability of local jurisdictions to police coastal development and redevelopment activities is potent and effective. When new FEMA BFE mapping is adopted by the counties and municipalities, any development activities that occur within the defined flood hazard areas will be provided some level of protection through existing ordinances.

As with Plan NSC-3 this plan could provide a substantial number of acres of land (9,200 acres) suitable for wetlands restoration and with the exception of potential impacts caused by the redevelopment sites, is environmentally friendly to natural resources. Like plan NSC-3 this plan does acquire a large number of parcels and that potential displacement of households and businesses is a concern for local governments and communities regarding social and public services and property tax revenue issues. Were a local TDR or PDR program to be established in conjunction with Plan NSC-1, the costs of securing the vacant parcels in the high-hazard zone would be reduced by 20-30 percent as only the development rights of the property would be purchased.

8.2.3. Plan NSC-6

Plan NSC-6 includes all of the nonstructural measures of Plan NSC-1 and when combined with LOD 4 at the 20 feet inundation level has the lowest per parcel protected cost of $210K for all nonstructural plans. With costs between $8.0B and $25.0B, these plans are more expensive that several other plans (Plan NS-PAHHZ, Plan NS-PA100 and Plan NSC-5) considered. Other variants of Plan NSC-6 that combine nonstructural measures with structural components at varying levels of inundation may provide substantial reductions in AAD (not determined at this phase of the study) and may provide protection for many people located outside of the lines of protection. Estimates of the numbers of people whose threat of drowning by surge inundation would be lessened by Plan NSC-6 variants range from 79,000 to 222,000. Combined with those protected by the structural measures, the variants of Plan NSC-6 are very effective in protecting at-risk residents.

Each of the scaled plans developed as a part of Plan NSC-6 will produce substantial acres of ecosystem restoration for wetlands (specific acreages not yet determined) and other sensitive habitat. Like Plan NSC-1 the permanent acquisition component of the NSC-6 variants will result in displacement of many thousands of households and businesses. The acquisitions range from

19,556 to 85,447 parcels across the 8 variants and required redevelopment lots range from 6,800 to 29,900 lots. This large number of displaced persons would be a concern for local governments and communities. These numbers clearly exceed anything found in the other plans and would have devastating effects on the social and economic systems of the project area.

The one benefit that Plan NSC-6, in its several scales, provides that is slightly different than other plans is its ability to protect, by use of structural means, the major commercial centers within the project area thus reducing the social and economic impacts associated with acquisitions within the urban centers that power the coastal economy. Either by means of the several ring-levees or the LOD 4 protection system, many of the major centers could be protected from surge flooding without resorting to high levels of population relocation.

8.2.4. Plan NS-PA100

This plan compares favorably with other plans at the ABFE level of protection in damages reduced ($210.0M) and lives protected (86,000) from surge inundation drowning. The plan has a lower per parcel protected cost at $248K/parcel and does produce 9,200 acres of land suitable for ecosystem restoration as wetlands. Among the plans considered this plan is very efficient on a per parcel protected basis, but is geographically limited to the 100-year surge floodplain in its effect and may not be acceptable to local governments and communities due to the displacement issues.

8.2.5. Plan NSC-2

This plan has a high project cost at $10.8B and is not efficient (compared to other alternatives) at $425K/parcel protected. The plan would reduce average annual flood damages by $105.0M. This plan does not provide many acres of land suitable for ecosystem restoration as wetlands and although it provides some potential increment of protection for as many as 69,900 lives, the inhabitants of floodproofed structures would be encouraged to seek shelter outside of the elevated structure.

This plan would be technically feasible and probably acceptable to the local communities and local governments compared to other plans that have large permanent acquisition components. The plan would have limited environmental impacts except perhaps for historic structures that may not be able to be elevated in place and maintain their significance. The plan would be applicable at several levels of protection although due to the depth restrictions for elevating structures at higher level of inundation (30 feet and 40 feet) floodproofing is not an option for most of the parcels in the project area.

8.2.6. Plan NS-PAHHZ

This plan in comparison to other nonstructural plans is relatively efficient at $404K/parcel protected. Its project cost is relatively high given the limited geographical extent of its coverage (high-hazard zone) and the number of displacements although lower than other plans still would be a concern for local governments and communities. The plan offers the least amount of reduction in average annual damages ($92.0M) but is relatively effective in reducing threats to life and public safety (38,900 lives) compared to the other plans.

The plan does provide 4,000 acres of land suitable for ecosystem restoration as wetlands and its environmental impacts would be relatively insignificant compared to the other plans since it has a limited geographical impact.

8.2.7. Plan NSC-5

This plan is dedicated to reducing loss of life and increasing public safety. At a cost comparable to Plan NS-PAHHZ ($6.1B) the plan is relatively inexpensive compared to other plans but at a per parcel cost of $404/parcel) this plan is relatively inefficient compared to all the other plans (i.e. NS-PA100 and NSC-1). The plan is comparable to Plan NS-PAHHZ in geographic extent and community impacts and therefore may not the best nonstructural plan.

The plan does create 4,000 acres of land suitable for ecosystem restoration as wetlands and its public buildings relocation component would enable these critical facilities to be relocated to higher ground, but its per parcel cost is much higher than other plans also featuring relocations as well.

8.2.8. Plan NSC-4

This plan is unique in that all of the measures within it are non-Federal and implemented by local jurisdictions. It has a relatively low cost (estimated to be $5.5M) compared to the other more robust plans since the majority of the costs are administrative and enforcement related and some like building codes are actually reimbursed through the building construction permit process. Although the plan is simple in its delivery and its effectiveness is not contingent upon a participation rate since the regulatory ordinances are mandatory in nature, the plan does not address damages for existing structures and is contingent upon the political will of the local leadership to upgrade and enforce the necessary ordinances and codes to control new development.

Since the plan is locally based and does not have a permanent acquisition component that would generate opposition, this plan can be effective in reducing future damages. Since there are so many vacant parcels in the project area that would be rebuilt upon (all 6 scenarios suggest a rebuilt environment in 10-12 years) and since the ordinances and codes that control such redevelopment rest in the hands of the local jurisdictions, this plan has merit.

In order to address the future damages on the vacant parcels and protect sensitive environmental areas, the initiation of either a TDR or PDR program by the three counties would allow securing the development rights of many parcels and accomplishing the same flood damage reduction objectives as can be met by the permanent acquisition components of several of the plans. At a much reduced cost for acquisition (just the development rights) or in the case of a TDR program where all transactions are within the land market, using these programs to forestall redevelopment and new development in perpetuity would increase the completeness of the plans and make them more efficient on a per parcel cost basis.

Table 36
Comparison of Plans

Plans / Metrics	Plan NS-PAHHZ	Plan NS-PA100	Plan NSC-1	Plan NSC-2	Plan NSC-3	Plan NSC-4	Plan NSC-5	Plan NSC-6
Reduction of Average Annual Damages and Parcels protected	$92.0M in AAD prevented and 14,997 parcels removed from future development	$210.0M in AAD prevented and 33,191 parcels removed from future development	$315.0M in AAD prevented and 58,617 parcels protected.	$105.0M in AAD prevented and 25,419 parcels protected – some additional protection offered by the FWEE.	$315.0M in AAD prevented and 58,617 parcels protected	AAD prevented have not been determined for this Plan at this time.	$92.0M in AAD prevented and 14,997 parcels removed from future development	AAD have not been determined for this plan at this time.
Plan Costs and Cost per parcel protected	$6.1B $404K/parcel	$8.2B $248K/parcel	$18.7B $323K/parcel	$10.8B $425K/parcel	$19.1B $325K/parcel	$5.5M No per parcel cost has been determined at this time	$6.1B $404K/parcel	Costs range from $8.8B to $25.3B and per parcel cost range from $221K/parcel to $306K/parcel
Completeness	Plan complete in addressing damages in geographical target area.	Plan complete in addressing damages in geographical target area.	Plan complete in addressing damages	Plan not complete in addressing damages in project area	Plan Complete in addressing damages	Plan not complete in addressing damages to existing structures	Plan complete in addressing loss of life issues in project area.	Various plan variants complete for those areas located outside lines of structural protection.
Efficiency	Less efficient plan based upon per parcel cost to protect $404K/parcel	Very high efficiency at $248K/parcel protected	Medium level of efficiency compared to other plans at $323K/parcel protected	Very low efficiency at $425K/parcel protected	Medium level of efficiency at $325K/parcel protected	Efficiency yet to be determined based upon application of local regulatory codes and ordinances	Less efficient plan based upon per parcel cost to protect - $404/parcel	Plan NSC-6 at 20 feet inundation with LOD-4 is most cost efficient plan at $221K/parcel protected
Effectiveness	Plan is effective in addressing damages in geographic target area. Effectiveness will be contingent upon participation rate	Plan is effective in addressing damages in geographic target area. Effectiveness will be contingent upon participation rate	Plan is effective in addressing damages and threats to life in project area.	Plan not effective in addressing damages in geographic target area. Effectiveness will be contingent upon participation rate.	Plan is effective in addressing damages and threats to life in project area.	Plan is not effective in reducing damages to existing structures but would reduce damages for structures built upon approx. 27,000 vacant acres in flood zones.	Plan is effective in addressing damages in geographic target area. Effectiveness will be contingent upon participation rate	Plan is effective in addressing damages and threats to life in project areas located outside of structural protection.
Acceptability	Plan is technically feasible but may be unacceptable to local communities	Plan is technically feasible but may be unacceptable to local communities	Plan is technically feasible but permanent acquisitions may be unacceptable to local communities	Plan is technically feasible and may be acceptable to local communities	Plan is technically feasible but permanent acquisitions may be unacceptable to local communities	Plan is technically feasible and may be acceptable to local communities	Plan is technically feasible but permanent acquisitions may be unacceptable to local communities	Plan is technically feasible but permanent acquisitions may be unacceptable to local communities
Sustainability	Plan is sustainable in long term since evacuated parcels have minimal O&M requirements	Plan is sustainable in long term since evacuated parcels have minimal O&M requirements	Plan is sustainable in long term since evacuated parcels and floodproofed structures have minimal O&M requirements	Plan is sustainable in long term since floodproofed structures have minimal O&M requirements	Plan is sustainable in long term since evacuated parcels and floodproofed structures have minimal O&M requirements	Plan is sustainable since costs are primarily administrative in nature and supported by existing taxes and assessments which are anticipated to grow.	Plan is sustainable in long term since evacuated parcels have minimal O&M requirements	Plan is sustainable in long term since evacuated parcels and floodproofed structures have minimal O&M requirements
Public Safety	Plan potentially protects at least 38,900 lives	Plan potentially protects at least 86,000 lives	Plan potentially protects at least 152,000 lives	Plan potentially protects at least 60,000 lives	Plan potentially protects at least 152,000 lives	Plan potentially protects at least 220,000 lives	Plan potentially protects at least 38,900 lives	Plan potentially protects between 69,000 and 220,000 lives depending upon the level of protection selected.

Plans	Plan NS-PAHHZ	Plan NS-PA100	Plan NSC-1	Plan NSC-2	Plan NSC-3	Plan NSC-4	Plan NSC-5	Plan NSC-6
Metrics								
Environmental Impacts	Plan is environmentally acceptable and creates 4,000 acres of potential wetlands creation. Potential impacts to social and economic systems that can be mitigated.	Plan is environmentally acceptable and creates 9,200 acres of potential wetlands creation. Potential impacts to social and economic systems that can be mitigated.	Plan is environmentally acceptable and creates 9,200 acres of potential wetlands creation. Potential impacts to social and economic systems that can be mitigated.	Plan is environmentally acceptable but does not create many acres of potential wetlands creation. No significant displacements of landowners through acquisition.	Plan is environmentally acceptable and creates 9,200 acres of potential wetlands creation. Potential impacts to social and economic systems that can be mitigated.	Plan is environmentally acceptable but does create any acres potential wetlands creation	Plan is environmentally acceptable and creates 4,000 acres of potential wetlands creation. Potential impacts to social and economic systems that can be mitigated.	Plan is environmentally acceptable but acres of potential wetlands created are unknown at this time. Potential impacts to social and economic systems that can be mitigated.

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Table 37.
National Register of Historic Buildings and Sites

	City	Date
Hancock County		
Beach Blvd. Historic District (Bay St. Louis MRA)	Bay St. Louis	25 Nov 1980
Building at 242 St. Charles (Bay St. Louis MRA)	Bay St. Louis	25 Nov 1980
Claiborne Site (22-Ha-501) (A)	Pearlington	12 Nov 1982
Glen Oaks/Kimbrough House (Bay St. Louis MRA Amdmt)	Bay St. Louis	21 Nov 1986
Jackson Landing Site (22-Ha-504) (A)	Pearlington Vicinity	27 Jul 1973
Main St. Historic District (Bay St. Louis MRA)	Bay St. Louis	25 Nov 1980
Nugent Site (22-Ha-592) (A)	Kiln Vicinity	13 Apr 1988
Onward Oaks	Bay St. Louis	1 Nov 1996
Rocket Propulsion Test Complex (NHL)(F)	Bay St. Louis	3 Oct 1985
SJ Mound (22-Ha-594) (A)	Pearlington Vicinity	13 Apr 1988
Sycamore St. Historic District (Bay St. Louis MRA)	Bay St. Louis	25 Nov 1980
Taylor House (Bay St. Louis MRA Amdmt)	Bay St. Louis	21 Nov 1986
Taylor School (Bay St. Louis MRA Amdmt)	Bay St. Louis	15 Jan 1987
Three Sisters Shell Midden (22-Ha-596) (A)	Pearlington Vicinity	28 Jul 1988
Up the Tree Shell Midden (22-Ha-595) (A)	Pearlington Vicinity	13 Apr 1988
Washington St. Historic District (Bay St. Louis MRA)	Bay St. Louis	25 Nov 1980
Webb School (Bay St. Louis MRA Amdmt)	Bay St. Louis	21 Nov 1986
Williams Site (22-Ha-585) (A)	Pearlington Vicinity	28 Jul 1988
Harrison County		
Bailey House (Holy Angels Nursery) (Biloxi MRA)	Biloxi	18 May 1984
Barq, E., Pop Factory (Biloxi MRA)	Biloxi	18 May 1984
Bass, Raymond Site (22-Hr-636) (A)	Biloxi	26 Feb 1987
Beauvoir (NHL)	Biloxi	3 Sep 1971
Benton, Thomas & Melinda, House	Gulfport	9 Aug 2002
Biloxi Downtown Historic District	Biloxi	3 Sep 1998
Biloxi Garden Center (see Old Brick House)		
Biloxi Lighthouse	Biloxi	3 Oct 1973
Biloxi's Tivoli Hotel (Trade Winds) (Biloxi MRA)	Biloxi	18 May 1984
Biloxi Veterans Administration Medical Center (F)	Biloxi	14 Feb 2002
Bond House (Biloxi MRA)	Biloxi	18 May 1984
Brielmaier House (Biloxi MRA)	Biloxi	18 May 1984
Brunet-Fourchy House (Mary Mahoney's) (Biloxi MRA)	Biloxi	18 May 1984
Church of the Redeemer (Biloxi MRA)	Biloxi	18 May 1984
Clemens House (Biloxi MRA)	Biloxi	18 May 1984
Dantzler, G.B., House	Gulfport	1 Dec 1989
Fisherman's Cottage (Biloxi MRA)	Biloxi	9 Mar 1990
Fort Massachusetts (Ship Island) (F)	Gulfport Vicinity	21 Jun 1971
French Warehouse (Gulf Islands NTL SS) (22-Hr-638) (A) (F)	Biloxi	13 Dec 1991
Gillis House [Relisted – 1978]	Biloxi	7 Jul 1978
Grass Lawn (see Milner House)		
Gulf Coast Ctr for the Arts (Old Library) (Biloxi MRA)	Biloxi	8 May 1984
Harbor Square Historic District	Gulfport	13 Aug 1985
Hermann House (Biloxi MRA)	Biloxi	18 May 1984

	City	Date
Hewes Building	Gulfport	7 Oct 1982
Hewes, Finley B., House	Gulfport	15 Aug 2002
Holy Angels Nursery (see Bailey House)		
House at 121 West Water Street (Biloxi MRA)	Biloxi	18 May 1984
House at 407 E. Howard Ave	Biloxi	17 Jul 1986
Josephine (shipwreck) (22-Hr-843)	Biloxi Vicinity	22 Nov 2000
Magnolia Hotel	Biloxi	14 Mar 1973
Harrison County		
Bailey House (Holy Angels Nursery) (Biloxi MRA)	Biloxi	18 May 1984
Barq, E., Pop Factory (Biloxi MRA)	Biloxi	18 May 1984
Bass, Raymond Site (22-Hr-636) (A)	Biloxi	26 Feb 1987
Beauvoir (NHL)	Biloxi	3 Sep 1971
Benton, Thomas & Melinda, House	Gulfport	9 Aug 2002
Biloxi Downtown Historic District	Biloxi	3 Sep 1998
***Margaret Emillie (schooner) (Delisted 1989)*	*Biloxi*	*1973*
Mary Mahoney's (see Brunet-Fourchey House)		
Milner House (Grass Lawn)	Gulfport	31 Jul 1972
Nativity B. V. M. Cathedral (Biloxi MRA)	Biloxi	18 May 1984
Old Brick House (Biloxi Garden Center)	Biloxi	3 Oct 1973
Peoples Bank of Biloxi (Biloxi MRA)	Biloxi	18 May 1984
Quarles, W. J., House	Long Beach	16 Oct 1980
Redding House (Biloxi MRA)	Biloxi	18 May 1984
Reed, Pleasant, House (Reed House)	Biloxi	11 Jan 1979
Saenger Theater (Biloxi MRA)	Biloxi	18 May 1984
Scenic Drive Historic District	Pass Christian	7 May 1979
Scherer House (Spanish House) (Biloxi MRA)	Biloxi	18 May 1984
Seashore Campground School (Biloxi MRA)	Biloxi	18 May 1984
Spanish House (see Scherer House)		
Suter House (Biloxi MRA)	Biloxi	18 May 1984
Swetman, Glenn, House (Biloxi MRA)	Biloxi	18 May 1984
Tivoli Hotel (see Biloxi's Tivoli Hotel)		
Toledano/Philbrick/Tullis House	Biloxi	5 Nov 1976
Trade Winds (see Biloxi's Tivoli Hotel)		
U.S. Post Office & Customhouse (F)	Gulfport	19 Mar 1984
U.S. Post Office, Courthse & Customhse/Biloxi City Hall	Biloxi	30 Jan 1978
West Beach Historic District (Biloxi MRA)	Biloxi	18 May 1984
West Central Historic District (Biloxi MRA)	Biloxi	18 May 1984
West Central Historic District (Addl Documentation)		1997
Jackson County		
Applestreet Site (22-Ja-530) (A)	Gautier Vicinity	12 Sep 1985
Back Bay of Biloxi Shipwreck Site (22-Ja-542)	Ocean Springs Vic	22 Apr 1999
"Bellevue" ("Longfellow House")	Pascagoula	12 Dec 2002
Bertuccine House & Barbershop (Ocean Springs MRA)	Ocean Springs	9 Jun 1987
Bodden, Capt. Willie, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Brash, Anna C., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Carter-Callaway House (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Clark, Clare T., House (Pascagoula MPS)	Pascagoula	20 Dec 1991

	City	Date
Clinton, Capt. F. L., House	Pascagoula	20 Dec 1991
Cochran-Cassanova House (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Colle Company Housing (Pascagoula MPS)	Pascagoula	20 Dec 1991
Colle, Capt. Herman H. Sr., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Cottage by the Sea Tavern (Pascagoula MPS)	Pascagoula	20 Dec 1991
Cudabac-Gantt House	Moss Point	24 Jul 1990
Dantzler, A. F., House	Moss Point	26 Mar 1987
Degroote Folk House	Hurley Vicinity	4 May 1982
Dejean House	Pascagoula	25 Feb 1993
Farnsworth R. A. Summer House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Ford, Mayor EBB, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Frentz, George, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Front Street Historic District	Pascagoula	17 May 1984
Gautier, Adam, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Gautier, Eugene, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Gautier, Walter, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Graveline Mound Site (22-Ja-503) (A)	Gautier Vicinity	2 Jul 1987
Griffin House	Moss Point	7 Jul 1983
Halstead Place (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Hansen-Dickey House (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Herrick, Lemuel D., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
House at 1112 Bowen Ave (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
House at 1410 Bowen Ave (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Hughes, William, House (Pascagoula MPS)	Pascagoula	21 Oct 1993
Hull, Edgar W., (Pascagoula MPS)	Pascagoula	20 Dec 1991
Indian Springs Historic District (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Keys, Thomas Isaac, House (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Kinne, Georgia P., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Krebs, Agnes V., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Krebs, James, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Krebsville Historic District (Pascagoula MPS)	Pascagoula	20 Dec 1991
Levin, Leonard, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Lewis, Col. Alfred E., House (Oldfields)	Gautier	16 Oct 1980
Louisville & Nashville Railroad Depot	Pascagoula	27 Aug 1974
Louisville & Nashville Railroad Depot	Ocean Springs	31 Dec 1979
Lover's Lane Historic District (Ocean Springs MRA)	Ocean Springs	9 Jun 1987
Marble Springs Historic District (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Nelson Tenement (Pascagoula MPS)	Pascagoula	20 Dec 1991
Nelson, John C., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
O'Keefe-Clark Boarding House (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Ocean Springs Comm Center (Walter Anderson thematic)	Ocean Springs	24 Aug 1989
Oldfields (see Col. Alfred E. Lewis House)		
Old Farmers & Merchants State Bank (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Old Ocean Springs Historic Dist (Ocean Springs MRA)	Ocean Springs	7 Oct 1987
Old Ocean Springs High School	Ocean Springs	2 Aug 1990
Old Spanish Fort	Pascagoula	3 Sep 1971
Olsen, Lena, House (Pascagoula MPS)	Pascagoula	20 Dec 1991

	City	Date
Orange Avenue Historic District	Pascagoula	14 Aug 2001
Pascagoula Central Fire Station #1	Pascagoula	8 Dec 1978
(Old) Pascagoula High School	Pascagoula	6 Apr 2000
Pascagoula St. Railroad & Power Co (Pascagoula MPS)	Pascagoula	20 Dec 1991
Randall's Tavern (Pascagoula MPS)	Pascagoula	20 Dec 1991
Round Island Lighthouse	Pascagoula Vicinity	9 Oct 1986
Shearwater Historic District (Walter Anderson thematic)	Ocean Springs	24 Aug 1989
St. John's Episcopal Church (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
St. Mary's by the River	Moss Point	2 May 1991
Sullivan-Charnley Historic Dist (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Tabor, Dr. Joseph A., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Thompson, George, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Vancleave Cottage (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Westphal, Laura, House (Pascagoula MPS)	Pascagoula	20 Dec 1991

Figure 141 – Land Surface Elevations of Economic Reaches w/Respect to the Gulf (A1)

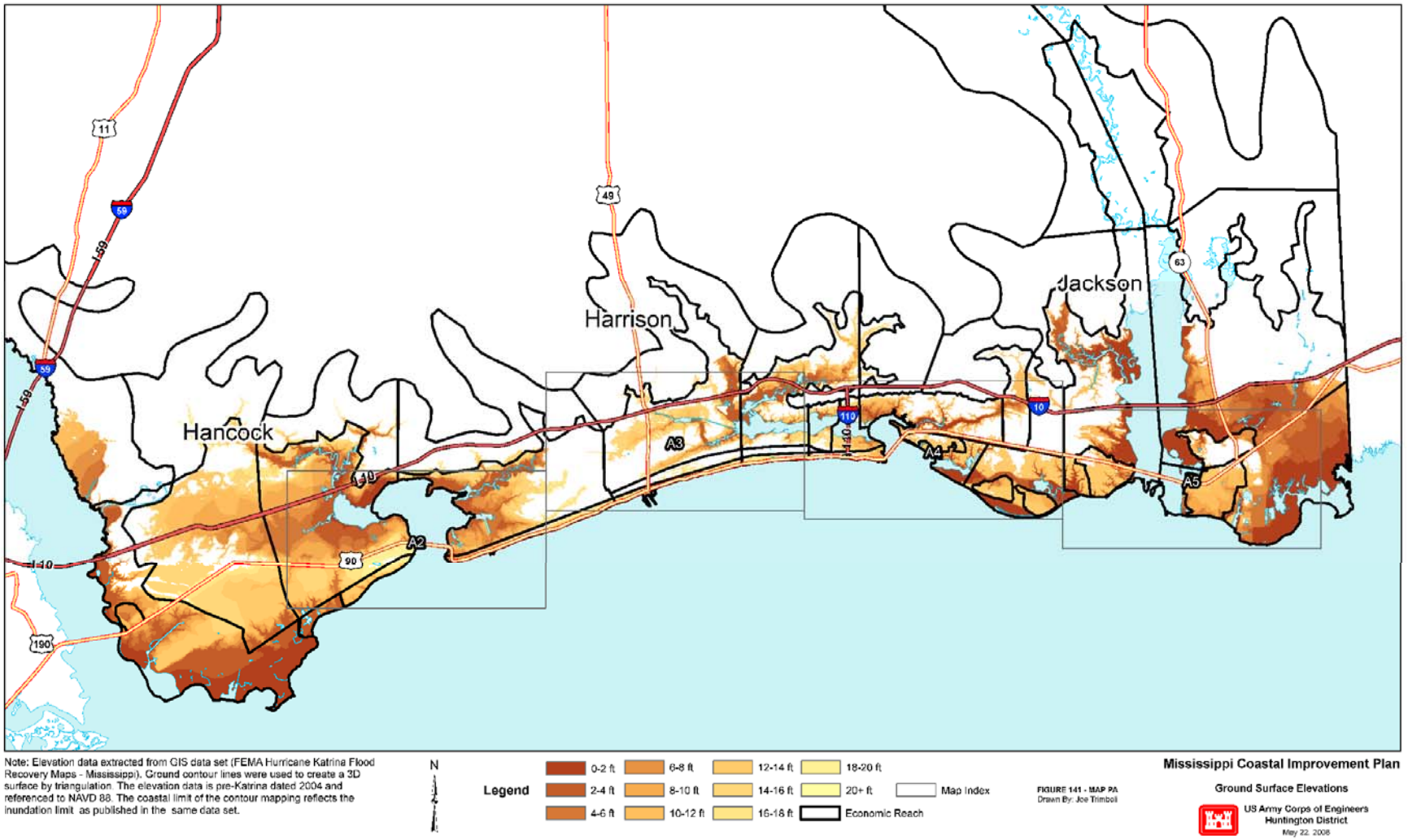


Figure 142- Land Surface Elevations of Economic Reaches w/Respect to the Gulf (A2)

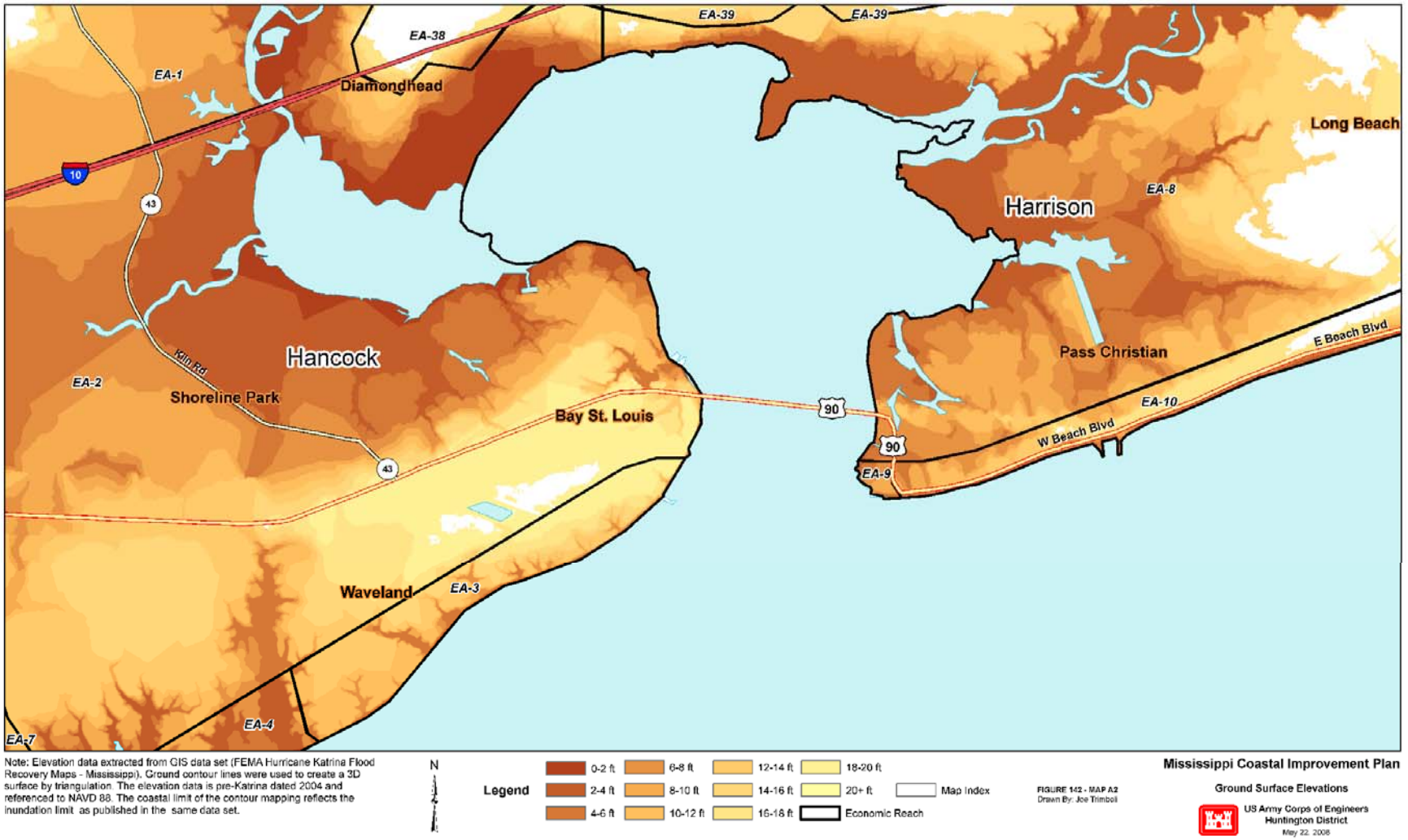


Figure 143 - Land Surface Elevations of Economic Reaches w/Respect to the Gulf (A3)

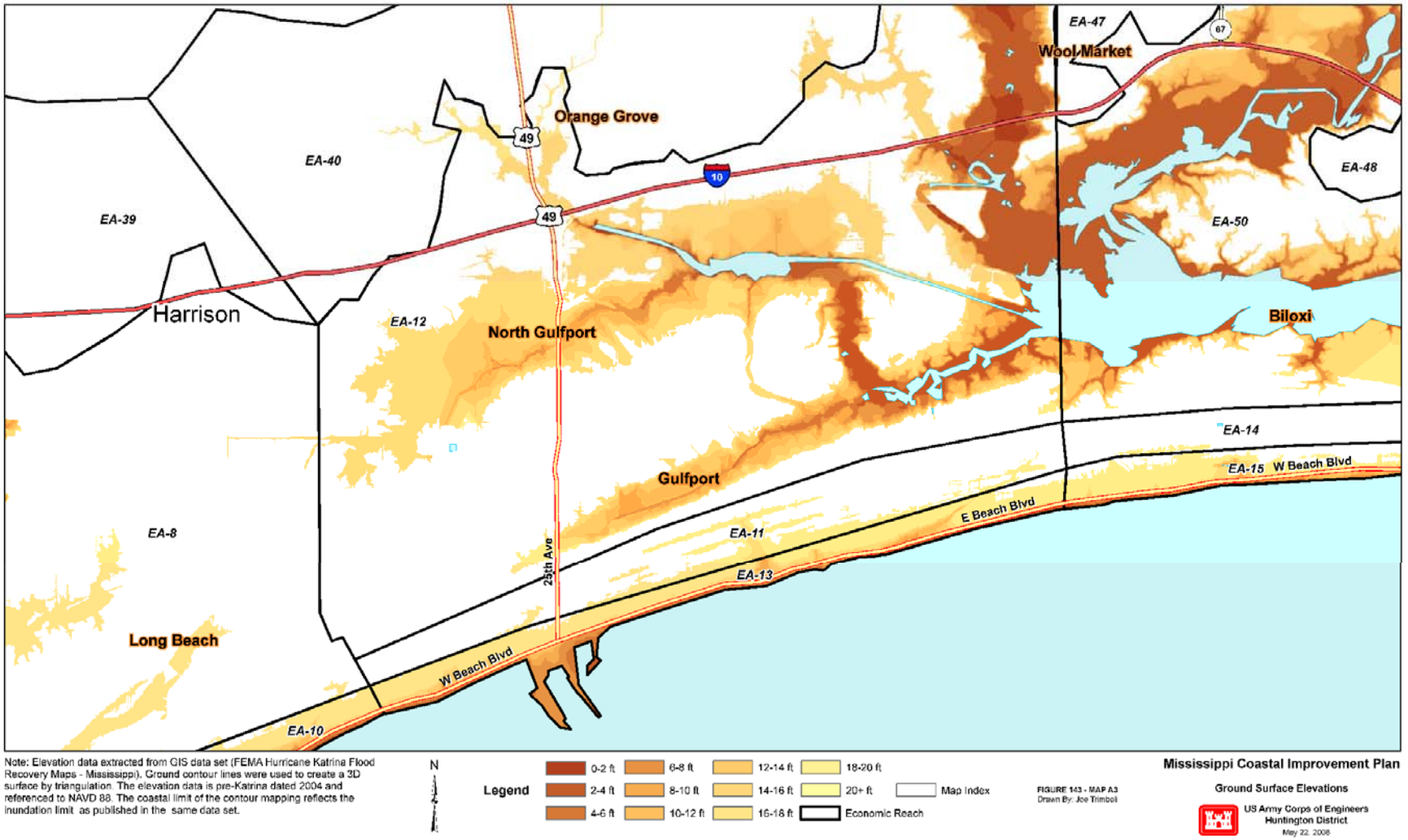


Figure 144 - Land Surface Elevations of Economic Reaches w/Respect to the Gulf (A4)

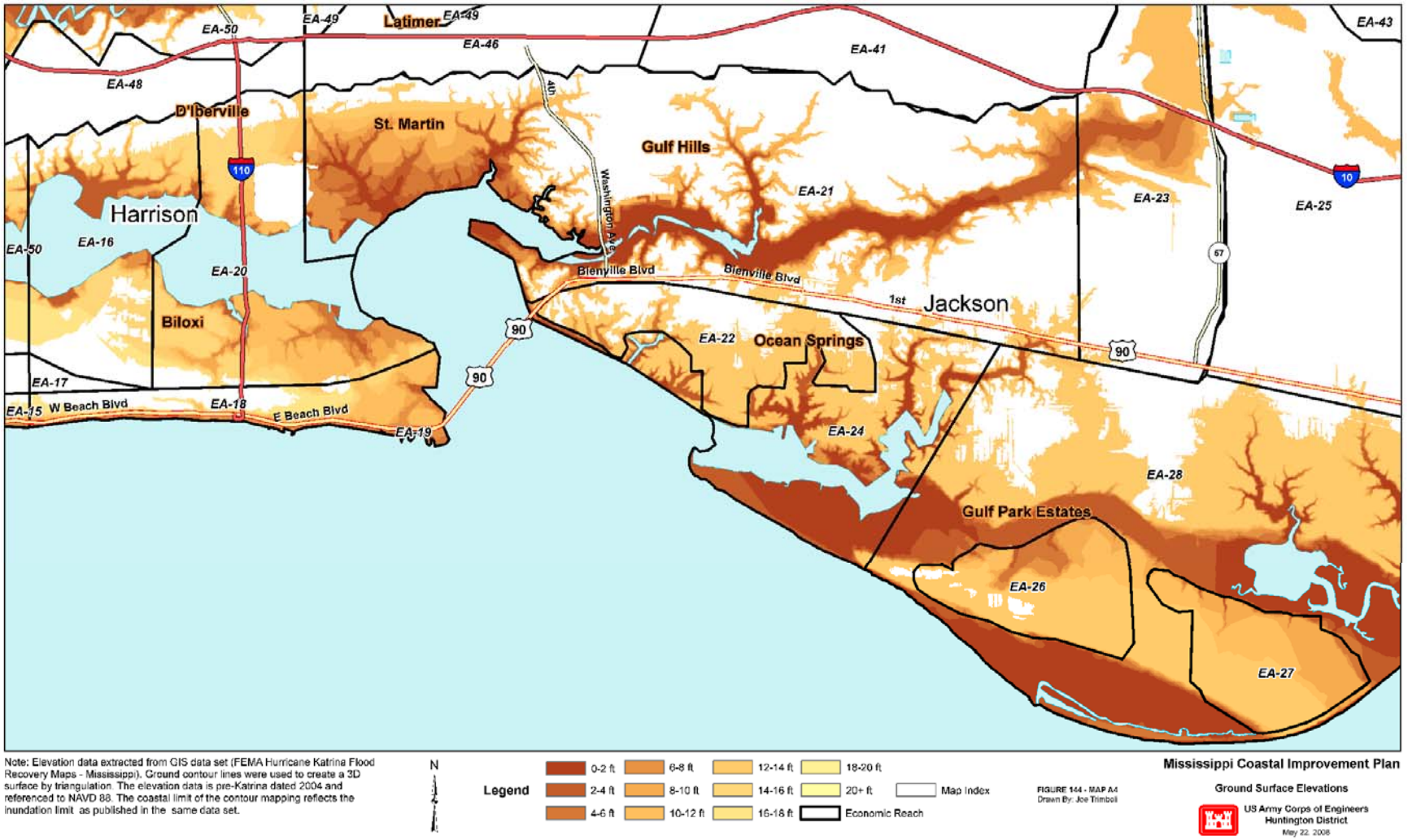
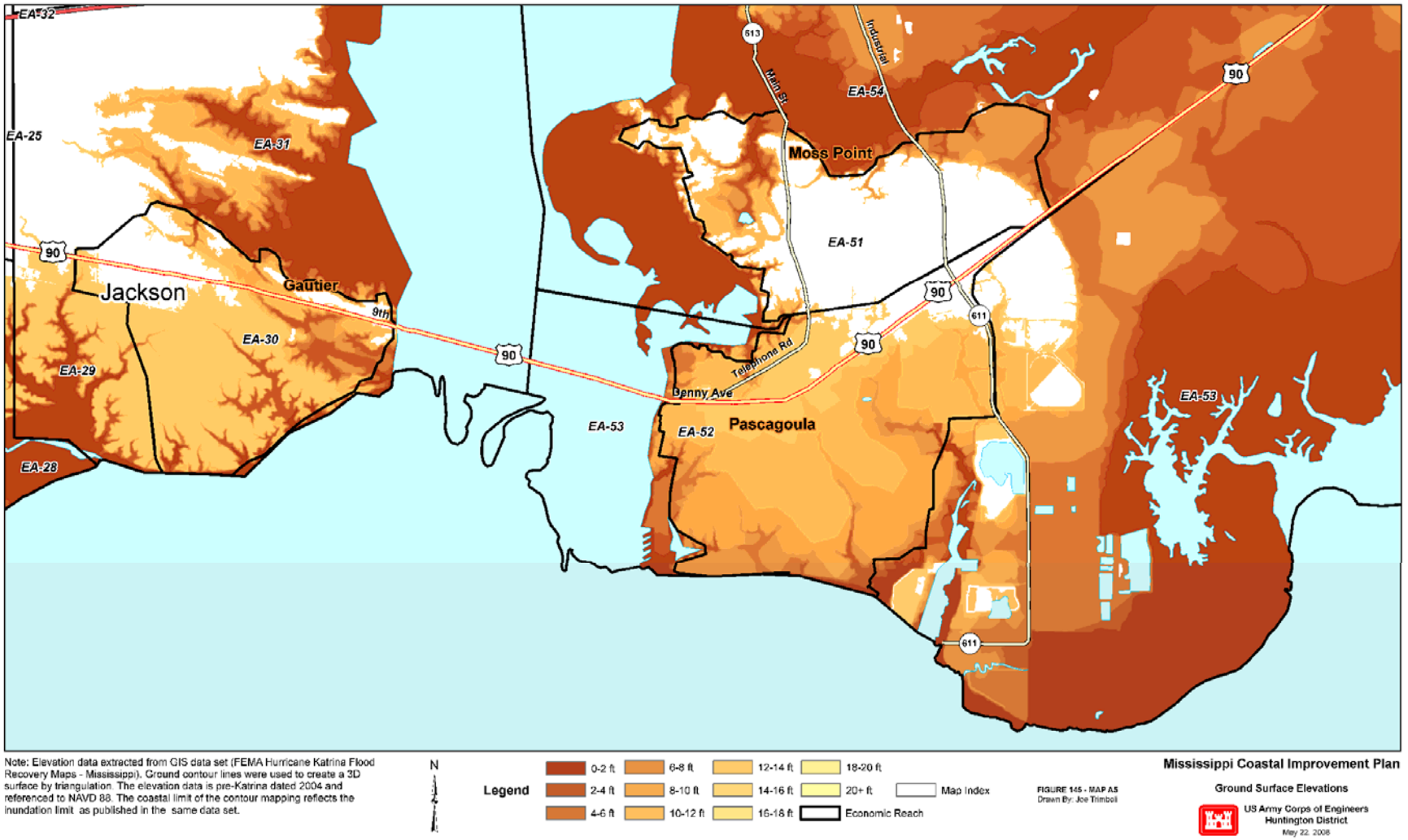


Figure 145 - Land Surface Elevations of Economic Reaches w/Respect to the Gulf (A5)



AFTERWORD

Rather than abruptly conclude this Appendix with the text in Chapter 8 on page 288, the team decided to prepare this short Afterword. Many of the concepts within this document are captured within the Main Report of the MsCIP and will hopefully be the focus of future, more detailed planning and implementation plans.

Much thought, analysis and teamwork went into the plan formulation and preparation of this document, but the plan is not the end of the process in and of itself. The proof of the pudding as many say is in the successful implementation of the plan itself. An old planning cliché states that "Action without planning can be fatal, but planning without action is futile." It would be sad indeed were this current planning effort to end in futility.

All of the thought processes that supported the formulation of the nonstructural measures and alternatives displayed in text and graphics in this document must be reaffirmed on the ground with the various neighborhood and community residents and local officials before the efficacy of the plans can be proven. As those collaborative workshops, charrettes, community meetings and small-group gatherings take place, a vision of a future disaster-resilient community needs to be formed through consensus-building – a vision that all can support to some degree and that all can participate in as citizens of the coast.

The Nonstructural PDT encourages all those who will participate in the coastal visioning efforts to be open-minded, future-oriented and committed to a coastal community that is sensitive to the productive natural resources of the region, individual citizen rights and the rich culture and history of the Gulf Coast.

Essayons

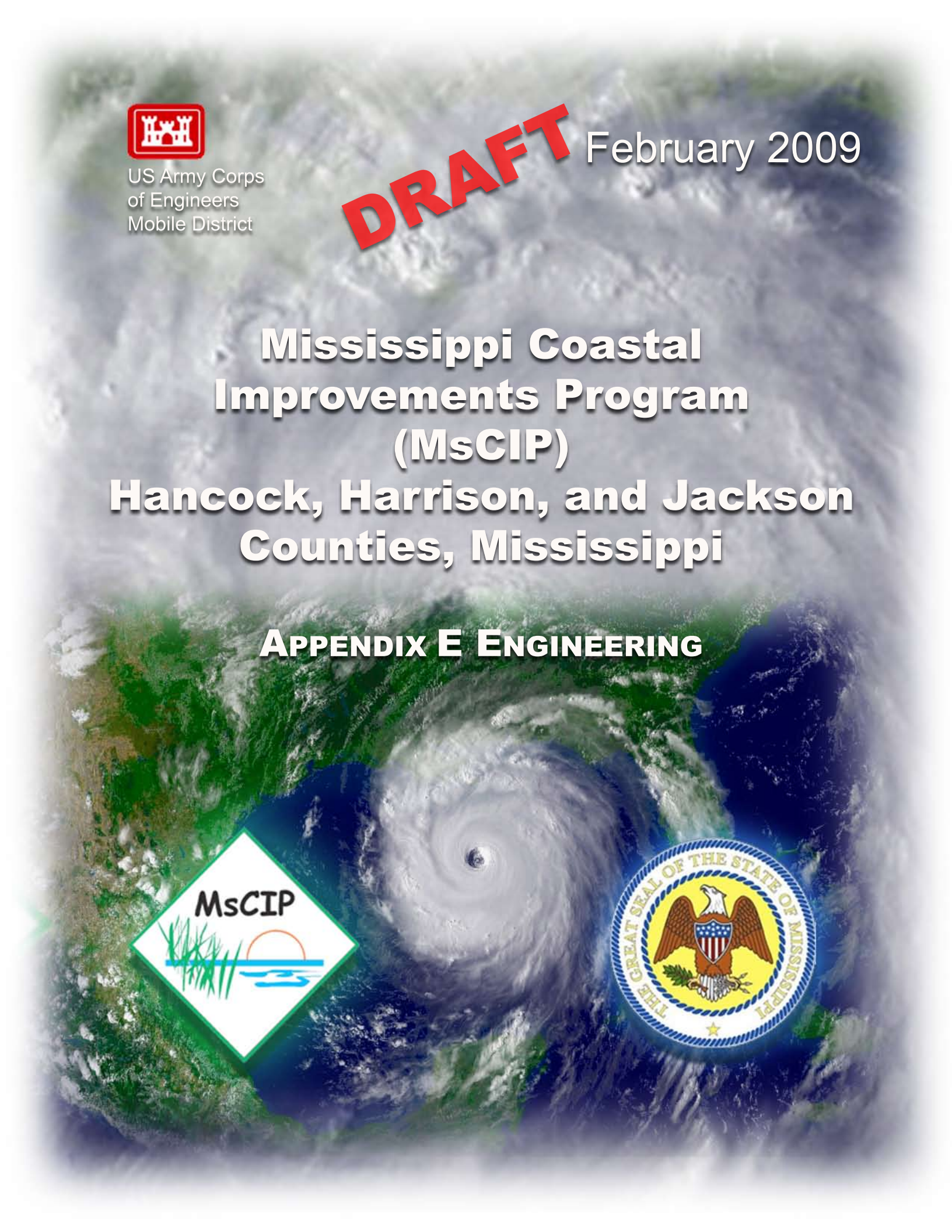
US Army Corps
of Engineers
Mobile District

DRAFT

February 2009

Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

Appendix E Engineering



FOREWORD

This document is one of a number of technical appendices to the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Feasibility Report and Environmental Impact Statement.

The Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Integrated Feasibility Report and Environmental Impact Statement provides systems-based solutions and recommendations that address: hurricane and storm damage reduction, ecosystem restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion. The recommendations contained in the Main Report/EIS also provide measures that aid in: greater coastal environmental and societal resiliency, regional economic re-development, and measures to reduce long-term risk to the public and property, as a consequence of hurricanes and coastal storms. The recommendations cover a comprehensive package of projects and activities, that treat the environment, wildlife, and people, as an integrated system that requires a multi-tiered and phased approach to recovery and risk reduction, irrespective of implementation authority or agency.



The MsCIP Study Area

The purpose of the Comprehensive Plan Report is to present, to the Congress of the United States, the second of two packages of recommendations (i.e., the first being the “interim” recommendations funded in May 2007, and this “final” response, as directed by the Congress), directed at recovery of vital water and related land resources damaged by the hurricanes of 2005, and development of recommendations for long-term risk reduction and community and environmental resiliency, within the three-county, approximately 70 mile-long coastal zone, including Mississippi Sound and its barrier islands, of the State of Mississippi.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and an External Peer Review (EPR). Both review processes will have been conducted in accordance with the Corps "Peer Review of Decision Documents" process, has been reviewed by Corps staff outside the originating office, conducted by a Regional and national team of experts in the field, and coordinated by the National Center of Expertise in Hurricane and Storm Damage Protection, North Atlantic Division, U.S. Army Corps of Engineers.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing recommendations directed at assisting the people of the State of Mississippi in recovery, recommended actions and projects that would assist in the recovery of the physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

This appendix contains detailed technical information used in the analysis of existing and future without-project conditions, in the development of problem-solving measures, and in the analysis, evaluation, comparison, screening, and selection of alternative plans, currently presented as tentatively-selected recommendations contained in the Main Report/EIS.

Each appendix functions as a complete technical document, but is meant to support one particular aspect of the feasibility study process. However, because of the complexity of the plan formulation process used in this planning study, the information contained herein should not be used without parallel consideration and integration of all other appendices, and the Main Report/EIS that summarizes all findings and recommendations.

This appendix, The Engineering Appendix, contains detailed supporting data and technical information on the many engineering options that were considered as possible measures that could be used in the Comprehensive Plan. Each option can be used as a stand-alone measure or in combination with other engineering options, environmental measures or non-structural programs in the development of alternatives for the Comprehensive Plan.

EXECUTIVE SUMMARY

Hurricanes are commonly recurring hazards for coastal Mississippi. Climatologically, the central Gulf coast region has one of the highest rates of occurrence in the United States. The Atlantic tropical cyclone database since 1886 indicates significant tropical storm impacts on the region occurring about every 2-3 years, and at least category 1 hurricane impact about every 8-9 years. Development along the Mississippi coastline with relatively low elevations in many areas has created a landscape that is highly susceptible to storm damage. Two bays that divide the coastlines of the three counties also aggravate the potential for inland flooding due to storm surge. The influence that landfall location for hurricanes may impart on storm surge is based on physical reasons and dictates why western Mississippi might register higher stages for a given hurricane than elsewhere along the Mississippi Coast. While the central coast of Mississippi has the highest topography, major hurricanes such as Camille in 1969 and Katrina in 2005 still produced surges that devastated this highly developed area. The area that was completely inundated due the storm surge associated with Hurricane Katrina is shown in Figure ES-1. Approximately half of the coast of Mississippi including all of Harrison County has man-made beaches with high-value real estate immediately landward of the beaches. Essentially all of the structures facing the Mississippi Sound were completely destroyed in Katrina.

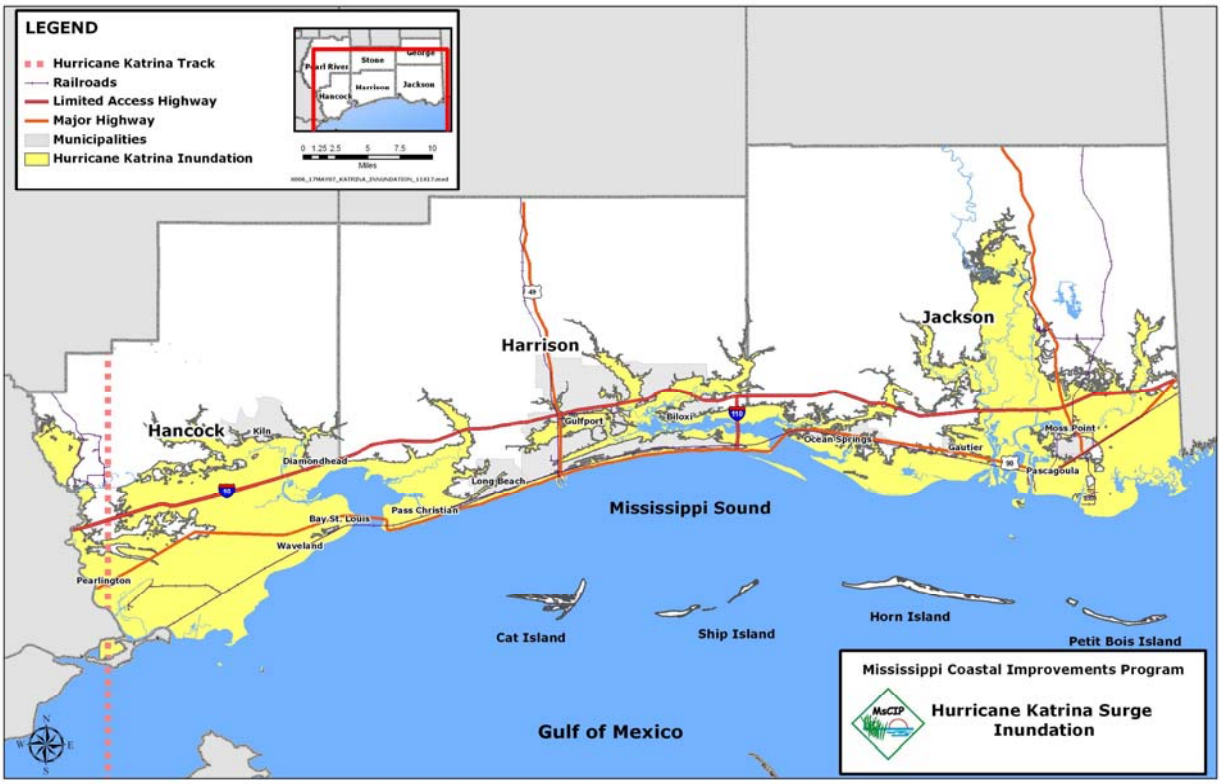


Figure ES-1. Inundated Areas of Coastal Mississippi from Hurricane Katrina Storm Surge

The Mississippi coast and its offshore chain of barrier islands is a wave-dominated coastline. Because prevailing wind in the Mississippi barrier island and mainland areas is from the eastern quadrants, most waves approach the shoreline at an angle and induce longshore currents that move sediment to the west. The islands migrate west due to littoral drift at approximately 50 ft/yr. Studies

also show that all of the barrier islands are losing surface area due to erosion caused by a number of factors including the impacts of major storms.

Sea level rise and land surface subsidence have been taken into account as part of this study and is reported as “relative sea level rise” which accounts for both as a single value. The Intergovernmental Panel for Climate Change (IPCC) ‘high’ values were selected for evaluating project performance as the ‘higher than observed rate’ versus those predicted using EPA and NRC methods because the IPCC values are more recent and more widely (globally) used. In a subtle departure from USACE guidance, relative sea level rise values based on IPCC ‘expected’ (also referred to as ‘medium’ and ‘central value’) eustatic sea level rise predictions were adopted in lieu of rise computed using extrapolated historic rates because most experts believe that the rate of sea level rise will increase in this century and extrapolated historic rise assumes past relative sea level rise rates will persist.

With the task of developing a comprehensive hurricane damage reduction plan for the coast of Mississippi, several issues had to be considered. First, it had to be technically feasible. The storm damage reduction system must be designed such that it would be effective and at the same time not destroy what it was supposed to help protect? It had to be reliable so when needed, it would do the job it was designed for. It also needed to be cost effective. This system also had to be integrated into other storm reduction concepts such as non-structural solutions and buy-out programs. It must also include re-establishing some wetland areas as environmental components of the plan. The development along the coast had some areas that were not contiguous to highly developed areas like found in Harrison County where the entire coastline is densely developed. These outlying areas will require individual means for any storm damage reduction. Almost any project along a coastline has environmental concerns and this is true in Mississippi. In Jackson County, the Pascagoula River system separates the city of Pascagoula from most of the coast to the west. This river system with its vast marshes areas is one of the last major free-flowing rivers in the southeast and is home to an endangered fish species. In the western portion of the state, extensive marshes create other concerns along with the Pearl River that separates Mississippi from Louisiana. Other technical issues also made working in this river problematic.

Review of the coastline in Mississippi using aerial photographs, topographic maps, LIDAR surveys, and storm inundation data revealed that natural topography could play a major role in forming storm barriers. Other features such as the offshore barrier islands, extensive beaches in many areas, and existing beach-front roadways were also realized as having a role in formulating a storm defense system. An existing railway track crosses the entire state near the coast and in the typical fashion of railways, these tracks follow high ground. This same general alignment was judged to be favorable for any type of inland barrier.

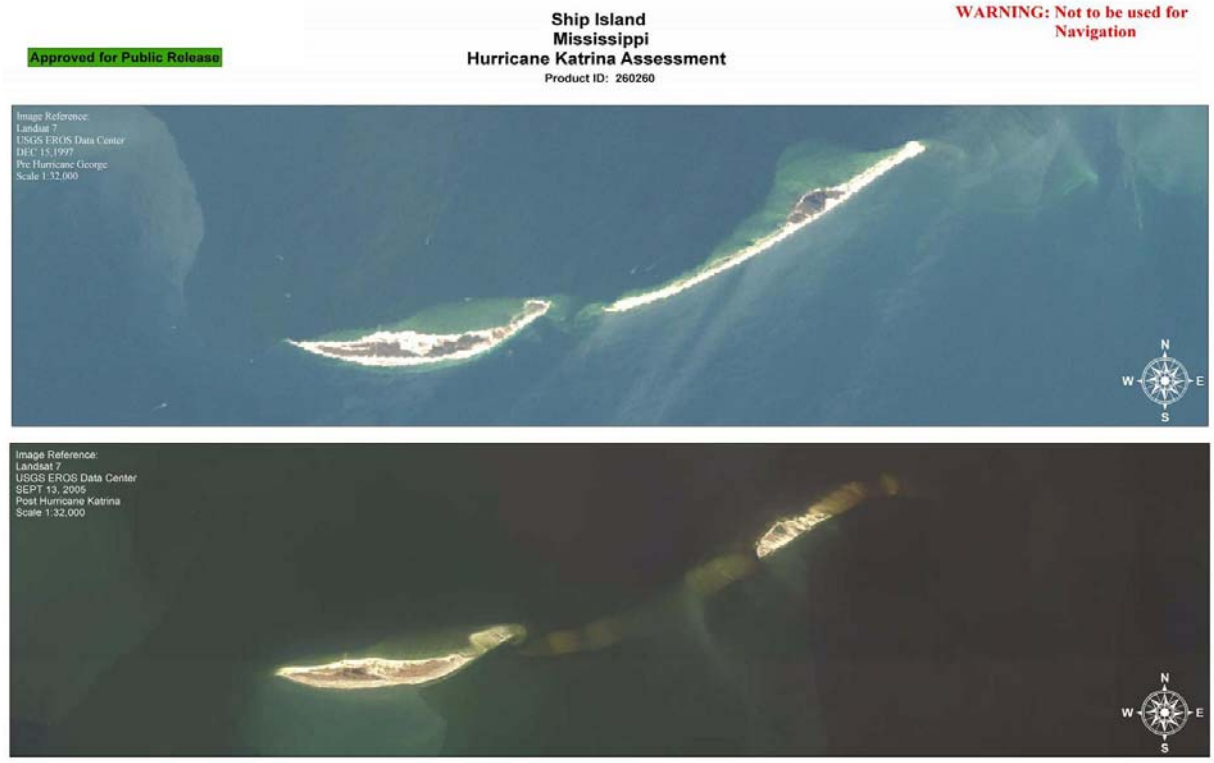
Review of the inundation maps from Katrina also revealed the extensive low-lying areas associated with two bays that extend inland from the coast. It was apparent that any storm protection systems would have to consider these as breaks in the line. Closing off rivers and bays with surge gates have been used in Europe to protect inland areas and these type structures have been considered for Mississippi.

During planning sessions with the project delivery team, a structural “Lines of Defense” concept was drafted that started with the offshore barrier islands and progressed inland to what could be considered the worst possible scenario with a extremely large hurricane, even worse than Katrina. Research identified numerous methods that have been developed to provide protection from storm surge. Along with the traditional methods of levee or structural seawall construction, many other types of protection were reviewed. These included inflatable barriers, concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall, sliding panel gates, offshore breakwaters, and many types of surge barriers to close off the bays. The lines would also provide increasing levels of protection as you transgressed inland. It was understood that some lines would

not provide protection from large storms. It was also evident that several areas of the coast could not be included in continuous line of defense and would be either placed in a ring levee system or designated to a non-structural solution.

From the planning session came five conceptual lines of defense. The general concept for this plan was made in a project team meeting that included engineers, environmentalists, planners, and geologists. Information from along the coastline was gathered that included large scale aerial photography, topographic maps, navigation maps, and a large collection of pre and post-Katrina photographs.

The first apparent feature to be considered was the offshore barrier islands that had been included in the Mississippi Governor's Hurricane Recovery Plan. Designated as Line of Defense (LOD) 1, the barrier islands have been eroded by numerous storms. In 1969, Hurricane Camille caused extensive erosion on the islands and created a large breach in Ship Island, (see Figure ES-2). This breach began to heal from the east as the littoral drift of sand added land mass to the west end of East Ship Island. This large scale breaching occurred again during Katrina, eroding away all the sand that had collected over the previous 35 years since Hurricane Camille. The post-Camille shoreline of Ship Island was documented by the Mississippi Department of Environmental Quality. After Katrina, it was widely expressed that if the islands had been in a pre-Camille condition, the storm surge would have been much less along the mainland coast. This scenario was modeled to help predict what effects the islands play in storm reduction. There are a total of seven different options included in this report covering a wide range of possible ways to mitigate erosion of the islands.



Source – United States Geological Survey

Figure ES-2. Before and After. The aerial photograph on top shows the islands in 1997 prior to Hurricane George in 1998. The bottom photograph shows the same view of the eroded condition of East and West Ship Island after Hurricane Katrina. Prior to a breach during Hurricane Camille, Ship Island was a single island, although the island has been breached prior to Camille.

The beaches (manmade in the 1950s) that extend along much of the coast were also considered as a feature that could be modified to provide some level of protection by construction of dunes on the beaches. Other projects are underway to improve some of the beaches and proposed projects would construct small dunes on most of the beaches. Improving on these features by adding higher dunes and/or dune vegetation was designated as LOD-2. These would not provide protection from large storms, but would be beneficial for smaller storms and would provide recreational and environmental benefits. Each of the three counties has beaches that fit this scenario for adding dunes. For each county, 11 options were considered for adding some measure of dune creation. Most of the options have versions that included adding vegetation and sand fencing as well as dunes without these features. Eight of the options in each county have the dune placed against roadways that parallel the beaches with the assumption that these roadways would be elevated as a separate measure. Each of these options have a dune crest elevation less than the adjacent roadway (possibly raised in the future under LOD-3 options) to prevent sand from constantly being blown onto the road. A photo of the existing condition of the beaches and roads in Harrison County is shown in figure ES-3. These options have some value as protection for the road, but more value as an ecological benefit. Two other options include a stand-alone dune out on the beach that could provide some level of surge defense along with ecological benefits. Each county also has an option with a wide sand berm fully planted with sea oats, the preferred vegetation to help stabilize dunes. This option will allow the sea oats to trap wind-blown sand and naturally build a dune with time. The dune options in all three counties total 33 different measures that could be considered.



Figure ES-3. 2007 photograph of Biloxi Beach showing the existing beach berm and the adjacent seawall and roadway.

As mentioned above, another existing condition along much of the coast is roadways that coincide with the beaches. It was envisioned that raising these roadways would have minimal environmental impact and provide the first hardened barrier to surge damage. These roadways, while not

continuous along the coast, were designated as LOD-3. The new road elevations would not be as high as to act as a seawall for very large storms, but like LOD-2, they would be beneficial for smaller, more frequent storms. While different elevations were initially considered for the roadways, the technical difficulty of raising the roads over six feet was realized. This is due to the numerous intersecting roads, driveways, and parking areas that could not be constructed without extreme grades. The existing beachfront roads in Hancock and Jackson have a typical grade elevation of 5.0 (NGVD88) and the general grade elevation for US 90 in Harrison County is 10.0 (NGVD88) although it varies from elevation 7.0 to 16.0 (NGVD88) depending on the exact location. With the existing road elevations, a top elevation of 11.0 (NGVD88) was selected for study in Hancock and Jackson County and a top elevation of 16.0 (NGVD88) was selected for study in Harrison County for a total of three options. It was also recognized that LOD-3 would require that a barrier be placed at the mouths of the bays to be effective against back-flooding.

Some areas of the coast were not associated with beaches or existing roadways that allowed for a continuous defense line. When including environmental and/or technical reasons, these areas could only be viewed as stand-alone projects such as ring levees. These areas included five communities in Jackson County and one in Hancock County. For discussion purposes, these were also included in LOD-3. Each of the conceptual ring levees have been evaluated for construction at two elevations, 20.0 and 30.0 (NGVD88). The costs also included interior drainage, pumping stations, gates for roadways and overtopping protection. Some sites also have one or more alternate alignments. The alternate alignments were selected to lessen the impacts on wetlands, lessen the intensity of wave action or to decrease the construction costs versus adding non-structural solution areas. With all ring levee elevations and alternate alignments, there are 24 different options for further consideration.

Further inland, an existing railroad grade provided a levee-like barrier to storm surge from Katrina in some areas, (see Figure ES-4). This railway extends all the way across the State crossing both St. Louis Bay and Biloxi Bay. In Harrison County, the railway parallels the coastline just a few blocks inland. Using a parallel, high-ground alignment as the railway system, an inland barrier was envisioned that could be constructed to such an elevation as to protect from a large storm surge, even larger than Katrina. Like LOD-3, this system would require that the bays be closed off with barriers from surge to be effective. As LOD-4, this barrier was studied at elevations up to the maximum storm surge or maximum possible intensity (MPI) storm that could be predicted based on simulated hurricane events. These selected elevations are 20.0, 30.0 and 40.0 (NGVD88). Possible options for LOD-4 include omitting the surge barrier across St. Louis Bay. This would require that LOD-4 be terminated o the east side of the bay. An alternate alignment to satisfy this option was selected at Menge Avenue in Pass Christian where the LOD-4 levee could be extended northward to higher ground. This option would also leave the town of Bay St. Louis without any type of surge protection. If this alternate alignment is used, Bay St. Louis hurricane defenses could be included as a ring levee with an option under LOD-3. Many alignments for project termination on the western and eastern sides of the state were considered before one that was selected, mostly due to technical and environmental reasons. This system would not cross the Pearl River on the western side of the state nor the Pascagoula River in Jackson County. Including all the different elevations and alignments for LOD-4, there are a total of 22 options including the six options for the surge gates.



Figure ES-4. The CSX Railway parallels the coast and its embankment acted as a low levee-like storm surge barrier in some areas.

As maximum protection from the largest storm surge event, the limits of surge predicted from the MPI event was transposed to maps. This location of this line was shifted as refinements were made in the storm surge modeling. While actually a non-structural measure, it was designated as LOD-5. It would be an area north of any potential surge damage that would be recommended to local governments for location of critical infrastructure such as hospitals and emergency facilities.

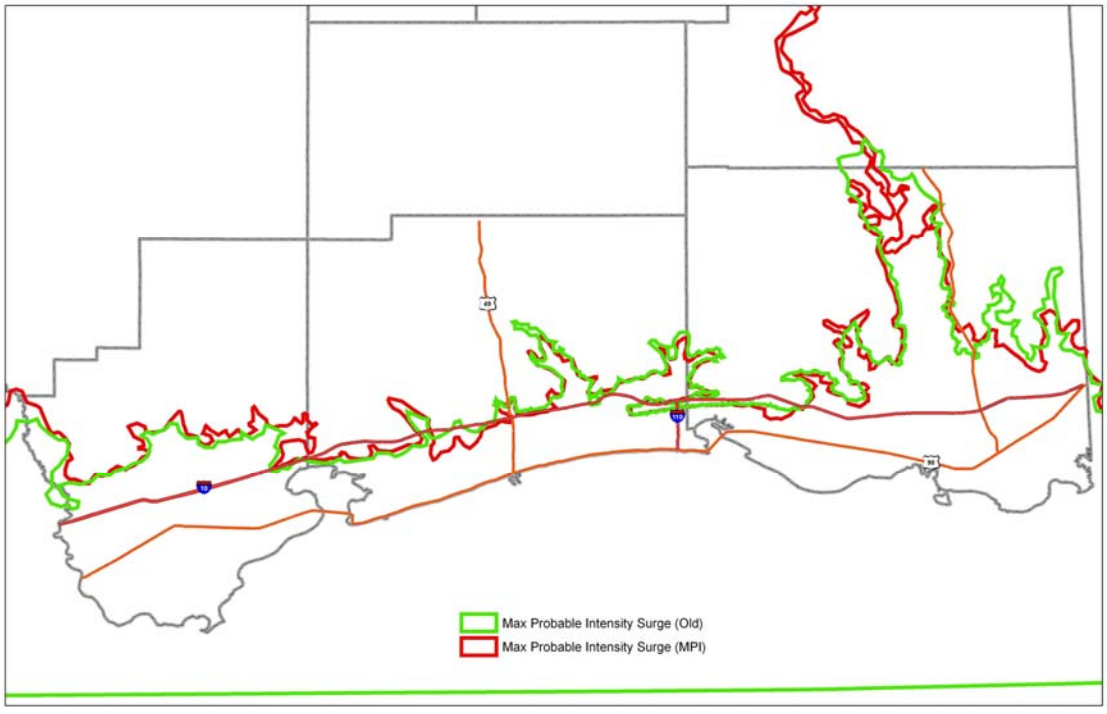


Figure ES-5. The surge limits of a computer simulated Maximum Possible Intensity hurricane based on early data and later refined modeling efforts

To proceed with initial cost estimates, various components of the structural options were conceptually designed to the selected elevations described in previous paragraphs. The initial elevations selected for each component of the lines of defense are assumed to bracket a wide range of potential storms with corresponding surge elevations. Using these preliminary designs, rough order of magnitude cost estimates were completed for each of the structural options. These cost estimates can used to develop cost curves for future use to estimate rough estimates after final design elevations are selected. With these cost curves, future studies can also select varied levels of protection based on risk assessments as well as taking into account future estimates of sea level rise.

At this phase of the plan formulation process, there were no assessments made for HTRW investigations nor remediation costs based on the vast number of properties potentially involved and the uncertainties associated with project footprints. Also, the cost of escalation will be addressed as projects are selected to proceed to feasibility level of design. The identification of a major HTRW site within a project footprint could certainly have a cost impact, but none are known to exist at this time. Likewise, depending on the time that a project is funded for further study to feasibility level, the effects of escalation could be a major factor based on fuel costs or other items that can change drastically outside the usual inflation rate.

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PART 1. GENERAL

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1.2 History of Tropical Cyclones

1.2.1 Introduction

Tropical cyclones are commonly recurring hazards in coastal Mississippi. Climatologically, the central Gulf coast region has one of the highest rates of occurrence in the United States. The Atlantic tropical cyclone database since 1886 indicates significant tropical storm impacts on the region occurring about every 2-3 years, and at least category 1 hurricane impact about every 8-9 years. However, the record since 1886 has severe limitations in assessing a longer temporal perspective on tropical cyclone activity. Historical records enable reconstruction of tropical cyclones that extend back to the eighteenth century. Meteorological records afford a detailed and continuous reconstruction at yearly resolution back to the mid 1800’s.

1.2.2 Historical Data

All available historical data has been utilized in the present study. First, tropical cyclone occurrences were compiled for each year from the HURDAT database from 1851-2005, counting each storm believed to be of hurricane intensity when it was centered within 75 miles of the Mississippi Coast. Similarly, a compilation of early nineteenth century hurricanes (1800-1850) was utilized (Bossak, 2003). This database relied primarily upon the landmark work of Ludlum (1963). All storms prior to 1800 were compiled from Ludlum (1963). For the period 1800-1870, only minor adjustments were made from a detailed examination of early instrumental records, diaries, and newspapers.

1.2.3 Results

A chronological listing of all known Hurricanes to affect Mississippi from 1711 to 2005 is given in Table 1.2-1. The resultant time series is shown in Figure 1.2-1. For the period of record, 66 tropical cyclones were identified as being of hurricane intensity Examination of the series reveals an obvious discontinuity in storm frequency circa 1840. This is simply a statistical artifact, as many tropical cyclone events prior to this time must have been unreported due to sparse population and lack of communication. Not until daily Meteorological observations were initiated by U.S. Army Post Surgeons at New Orleans in 1838, and near Mobile in 1840, can we be certain that all hurricanes were accounted for.

Temporal analysis of the tropical cyclone record, smoothed by 9-year running frequencies, indicate decadal variability in the historical past exceeding that of modern times. In particular, the 1850-1880 period was extraordinarily active. It was followed by another active period from 1910-1930. Much of the twentieth century…1930-1990…was conspicuous for relative inactivity. Indeed, it was this era that is the most anomalous period in the entire record.

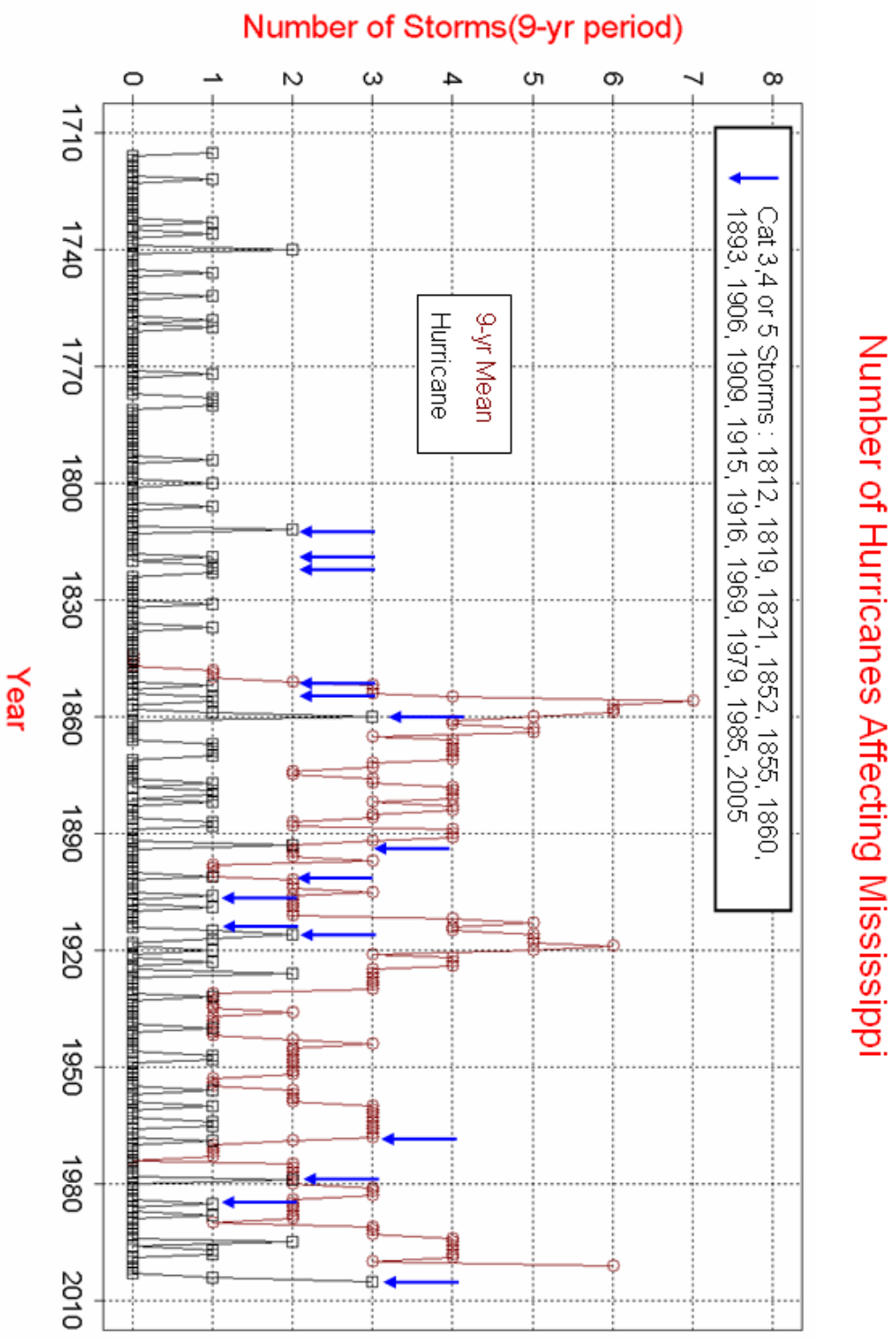


Figure 1.2-1. Hurricanes that Have Affected Mississippi

Table 1.2-1.
Hurricanes Affecting Mississippi Coast (1715-2005)

Year	Landfall	Estimated Storm Category at Landfall
1715 n.d.	Dauphin Island	(1)/Unknown
1722 Sept. 22-23	New Orleans	(1)
1733	Mobile	(1)
1736	Pensacola	(1)
1740 Sept. 22	Mobile	(1) The Twin Mobile Hurricanes of 1740
1740 Sept. 29	Mobile	(1) Second Mobile Hurricane
1746 n.d.	Ala.-Miss.-La.	(1)
1752 Nov. 3	Pensacola	(1)
1758 n.d.	N.W. Florida	(1)
1760 Aug. 12	Pensacola	(1)
1772 Aug. 30-Sept. 3	Fla.-La.	(1)
1778 Oct. 7-10	Fla.-La.	(1)
1779 Aug. 18	New Orleans	(1)
1780 Aug. 24	New Orleans	(1)
1794 Aug. 31?	Louisiana	(1)
1800 Aug	New Orleans	1
1806 Sept. 17	New Orleans	1
1812 June 11-12	Louisiana	1
1812 Aug 19	New Orleans	3
1819 July 27-28	Bay St. Louis	3/4
1821 Sept. 15-17	Bay St. Louis	3
1822 July 7-8	Biloxi	1
1823 Sept. 12-14	La.-Ala.	1
1831 Aug. 17-18	New Orleans	3/4
1837 Oct. 3-7	La.-Fla.	2
1852 Aug. 25	Pascagoula	3
1855 Sept. 15-16	Bay St. Louis	3
1856 Aug. 10-11	New Orleans	4
1859 Sept. 15	Mobile	1
1860 Aug. 11	Biloxi	3
1860 Sept. 14-15	Biloxi	2
1860 Oct. 2-3	Houma, La.	2
1867 Oct. 4-5	La.-Fla.	2
1868 Oct. 3-4	La.-Fla.	1
1869 Sept. 5	New Orleans	1
1870 July 30	Mobile	1
1877 Sept. 21	La.-Fla	1
1879 Aug. 31-Sept.1	New Orleans	2/3
1880 Aug. 26-30	Pensacola	1
1882 Sept. 10	Pensacola	3
1887 Oct. 19	Port Eads, La.	1
1888 Aug. 19-20	New Orleans	1/2
1893 Sept. 7-8	Grand Isle, La	1/2
1893 Oct. 2	Pascagoula	3
1901 Aug. 15	Gulfport	1
1906 Sept. 27	Pascagoula	3
1909 Sept. 20	New Orleans	3

Table 1.2-1.
Hurricanes Affecting Mississippi Coast (1715-2005) (continued)

Year	Landfall	Estimated Storm Category at Landfall
1915 Sept. 29	New Orleans	2/3
1916 July 5	Pascagoula	3
1916 Oct. 18	Perdido Key	3
1917 Sept. 28	Pensacola	2
1920 Sept. 21	Houma, La.	2
1923 Oct. 15	Houma, La	1/2
1926 Aug, 26	Houma, La	2
1926 Sept. 21	Perdido Key	1/2
1932 Sept. 1	Mobile	1
1940 Aug.6	La.-Tx.	1
1947 Sept. 19	New Orleans	2
1948 Sept. 4	New Orleans	1
1956 Sept. 24	Port Eads/ Ft. Walton	1
1960 Sept. 15	Gulfport	1
1964 Oct. 3	Franklin, La	1
1965 Sept. 10	New Orleans	3
1969 Aug. 17	Bay St. Louis	5
1979 July 5	Grand Isle	1
1979 Sept. 12	Mobile/Pascagoula	3
1985 Sept. 2	Biloxi	3
1988 Sept. 9	New Orleans	1
1995 Aug. 3	Pensacola	3
1995 Oct. 4	Navaree, Fla.	3
1997 July 19	Mobile	1
1998 Sept. 28	Biloxi	2
2004 Sept. 16	Pensacola	3
2005 July 6	Grand Isle, La.	1
2005 July 10	Navarre, Fla.	2
2005 Aug. 29	Bay St. Louis	3

The most active hurricane years were 1860 and 2005, with three hurricanes each. Since 1800, major Hurricane impact (category 3 or greater) is clearly evident in 1812, 1819, 1852, 1855, 1860, 1893, 1906, 1909, 1915, 1916, 1947, 1969, 1985, and 2005.

The small but extremely intense Bay St. Louis Hurricane of July 27-28, 1819 and the nearly identical Category 5 Hurricane Camille of August 17-18, 1969 were the most intense storms of record. Hurricanes Camille (1969) and Katrina (2005) produced the largest known tidal surge.

1.2.4 Conclusion

Tropical cyclones affecting coastal Mississippi appear to have been somewhat more frequent in the historical past than during the present human lifetime. Only during the last decade have we seen a significant upswing in the frequency of occurrence. Six major hurricanes struck the Mississippi coast during the 1800`s with seven major storms in the 1900`s. Only hurricane Katrina of 2005 has made landfall as a major hurricane during the 21st Century. Thus, there is no evidence that land falling hurricanes in Mississippi are becoming more intense.

1.2.5 References

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1.3 Tide Gage Stage-Frequency Analysis

The annual percent chance exceedance stage relationship, referred to as the 'stage-frequency curve,' is the single most important descriptor of a community's flood risk. The relationship describes the annual probability, expressed in percent, of a given stage (i.e. water surface elevation) being equaled or exceeded and is relied heavily upon for purposes of the National Flood Insurance Program, for the development and evaluation of flood damage reduction measures, for understanding and communicating annual and long-term risk, amongst others.

Historically, tide gage data have been used almost exclusively to describe the entirety of a given stage-frequency curve in a given coastal area. The shortcoming of this approach is that it tends to mask the true risk in the vicinity of the gage. The reasons for this are many, but perhaps the most important is related to the observation that, while the occurrence of strong hurricanes in a given coastal region is not probabilistically rare, the probability of a particular gage site taking a direct hit from one of those strong hurricanes is more rare. A more accurate representation of the true risk for severe hurricanes then can only be obtained over a long period of meteorological and water level observations (a century is not long enough) or through refined statistical analysis of storms and effects modeling efforts.

Present needs have required that a great deal of effort be placed on developing statistical methods and modeling approaches to improve our present understanding of severe hurricane risk. A Risk Assessment Group, led by scientists at the Engineer Research and Development Center (ERDC) in Vicksburg, MS, was assembled in the aftermath of Hurricane Katrina to develop such statistical and modeling methods (Ref. 1) for the Gulf of Mexico region, and those methods have been used for this program (ERDC modeling efforts are described in Chapter 2). Those efforts were focused on what might be called an extreme storm subset of the tropical storm/hurricane population. While their products and findings are many, one of their most important products was the development of 4% (1 in 25), 2% (1 in 50), 1% (1 in 100), 0.2% (1 in 500), and 0.1% (1 in 1000) annual chance stage exceedance estimates for numerous locations in the vicinity of coastal Mississippi. These estimates, combined with probabilistic analysis results of historic observed tide levels, were joined to create composite (i.e. consisting of both observed data and hydrodynamic modeling results) stage-frequency curves for planning subunits in coastal Mississippi. These in turn were used for a host of MsCIP design and evaluation efforts.

This chapter describes the available historic tide stage data and the development of that data into stage-frequency curves. The curves were compared to an historic stage-frequency curve and to ERDC model data at the location of the gage sites are displayed.

1.3.1 Background

The US Army Corps of Engineers Mobile District (CESAM) maintains a network of tide gages along the Gulf Coast from Gulfport, MS eastward to Carrabelle, FL. Gage locations are shown in Figure 1.3-1. Hurricane Katrina made landfall at the Louisiana-Mississippi State line August 29, 2005 and generated record storm surge along the Mississippi and Alabama coast. Preliminary high water mark (HWM) data values from FEMA indicate surge ranging from 28 ft at Bay St. Louis to 11.5 ft at

Mobile, AL. The following are Mobile District tide gages along the Mississippi and Alabama coast with long term records; Gulfport, MS (42 years), Biloxi, MS (123 years) Pascagoula, MS (65 years), Dauphin Island (42 years) and State Docks (65years). A graphical frequency analysis was performed on the observed historical annual peak water (tide) levels to estimate the still water storm surge return interval.

Water levels recorded at the gage sites are collected in a stilling well to minimize effects from wave height and wave run-up. In cases where the tide gage was destroyed or malfunctioned, the maximum water level was obtained from a high water mark measured in a nearby enclosed structured.

Each tide gage is installed to support our navigation coastal dredging program. Consequently the gages are installed near the navigation projects such as harbors, ports, federal docks, and shipping channels. The gages are operated and maintained by the Mobile District Engineering Division, Hydraulics & Hydrology Branch. Mobile District archives the data for legal reasons and makes it available to the public upon request. Monthly and annual reports of the tide levels are generated, archived and made available upon request. The gages are accurate to +/- 0.1 foot. There is limited quality control of the tide data.



Figure 1.3-1. Mobile District Tide Gage Network

When a hurricane is forecast to strike the Gulf Coast, CESAM personnel are dispatched to remove recorded data from coastal gages and ensure that the gages are working properly. All equipment is removed from gage sites in areas of forecasted direct storm path 1-3 days before landfall. Therefore, removing the proper gage is dependent on the accuracy of the hurricane path and surge forecast.

Two gages were removed in Mississippi and one in Alabama on 28 August 2005, one day before the projected H. Katrina landfall. Water levels along the Gulf Coast for the time period during the storm are available at 16 gages and partial record from 5 gages. A total of 9 CESAM gages were destroyed and 2 gages were damaged by the hurricane. Figure 1.3-2 shows the status of the gages shortly after H. Katrina.

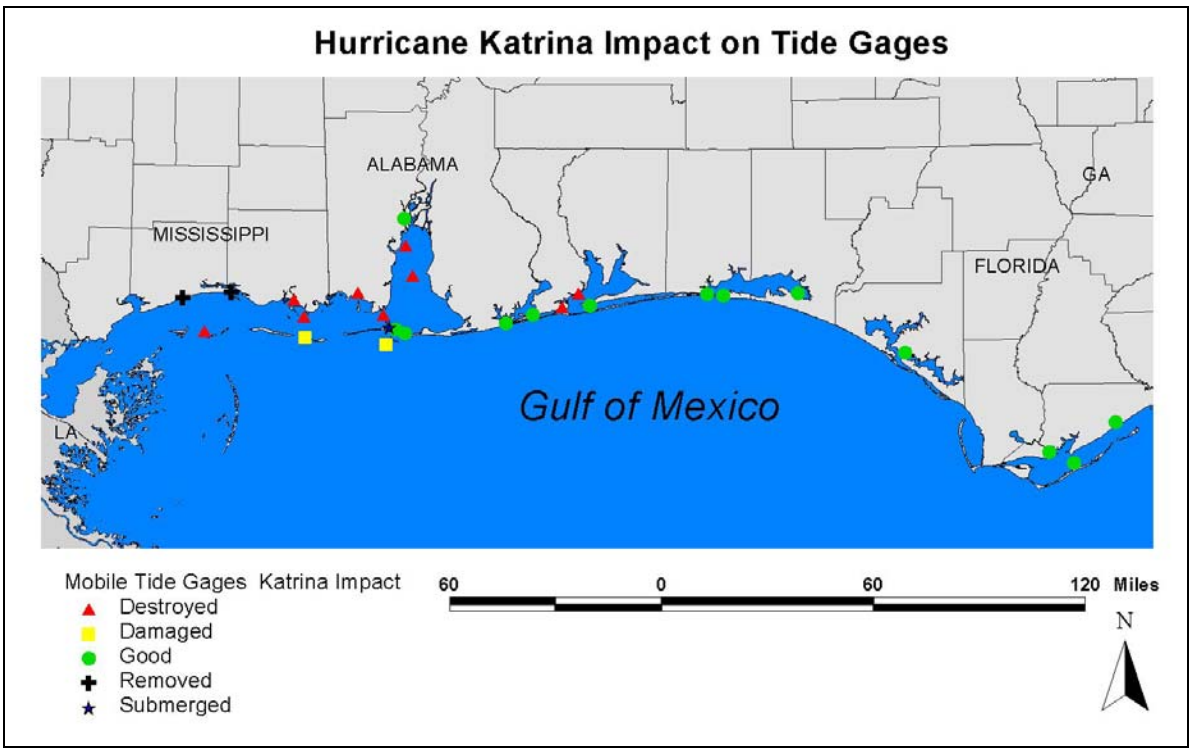


Figure 1.3-2. Hurricane Katrina Impact on Tide Gages

There are 7 active CESAM tide gages along the Mississippi Coast gages as shown in Figure 1.3-3.

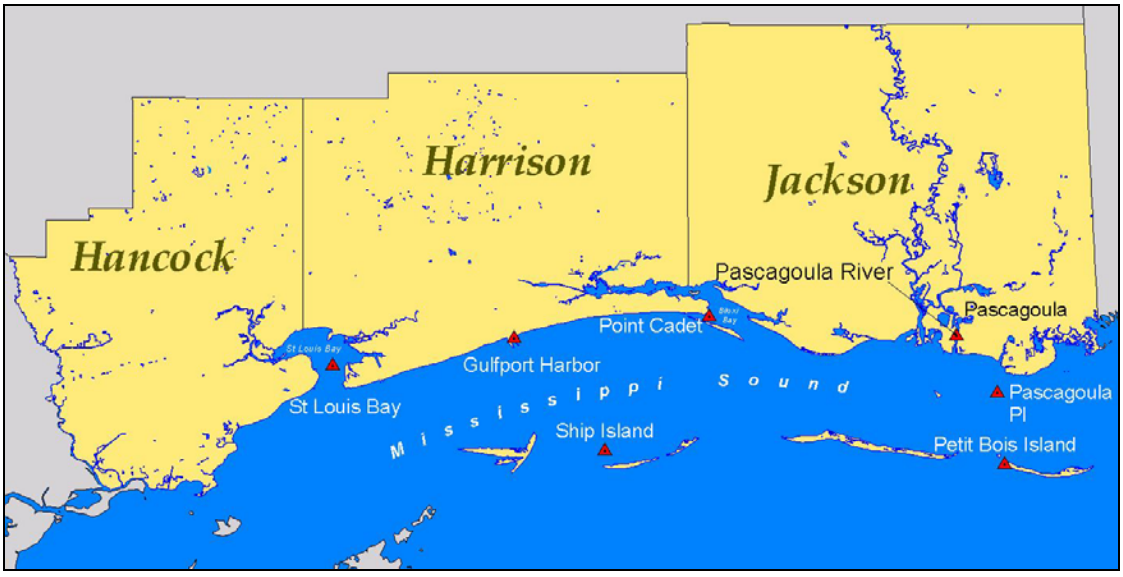


Figure 1.3-3. CESAM Mississippi Coast Tide Gages

1.3.2 Methodology

EM 1110-2-1415 (Ref. 2) recommends using graphical analysis for stage (elevation) frequency computations. The Corps of Engineers computer program Flood Frequency Analysis (FFA) was selected to compute the graphical plotting positions. Historical data was incorporated into the graphical analysis using the procedures outlined in Bulletin 17B (Ref. 3). The median plotting position formula was selected to derive probabilistic plotting positions because it corrects for the bias caused by small sample sizes.

Care was taken to select a uniform data set for the frequency analysis. Each event represents the peak water level for each January-December calendar year. There are a few years with less than 12 months of recorded data; in most cases this is due to a gage malfunction or damage from a storm event. The data set includes the effects of subsidence and sea level rise and no attempts have been made to adjust the data to account for these factors. Of these, subsidence is more important in that it affects the datum of the gage and thus the absolute water surface elevation estimate. Future analysis by this office will research the necessary adjustments. Each of the three gages has been relocated within the period of record. No adjustments were required because of the close proximity of relocations. In cases where the gage was destroyed by a severe storm, a still water high water at or near the gage used to represent the peak elevation for that storm event.

Historic data is information before the collection of systemic record. The account is often described in newspaper article, personal accounts from a witness or an investigation by some agency or entity. Historic data is very useful for locations with relative short period of record and use to extend the period of systemic record. The use of historic record can improve the frequency estimate.

The population includes annual peaks that result from storm surge and normal tidal fluctuations. There are years were multiple storms caused storm surge above normal high tide. Only the maximum recorded for each year used in the analysis. Partial duration frequency analysis was eliminated because of limited available daily data for the full period of record.

Gulfport has 43 year, 1963-2005, on continuous systematic record. Well documented historic values for the years 1915, 1926, 1947, 1948, 1955-1957, and 1960 are included in the analysis. Biloxi has 111 years, 1882-1885 and 1896-2005, of continuous systematic record. Pascagoula has 66 years, 1940-2005, of continuous systematic record. The historic record of annual maximum stages is shown in Table 1.3-7 and presented graphically in Figures 1.3-8 through 1.3-10.

1.3.2.1 Presentation of Data

Table 1.3-7.
Mississippi Coast Historic Annual Stages at Mobile District Tide Gages

		Gulfport (1963)			Pascagoula (1940)			Biloxi (1882)		
Storm	Date	Gage Height, ft.	ft. NAVD		Gage Height, ft.	ft. NAVD		Gage Height, ft.	ft. NAVD	
Sep 1882	9/10/1882								2.42	
27Sep1906	1906-Sep-27								6.05	
20Sep1909	1909-Sep-20							10.43	4.48	
12Aug1911	1911-Aug-12								4.49	
14Sep1912	1912-Sep-14								3.51	
29Sep1915	1915-Sep-29		9.13	[1]					9.05	
05Jul1916	1916-Jul-05								4.20	
28Sep1917	1917-Sep-28							8.61	2.66	
21Sep1920	1920-Sep-21								5.57	

Table 1.3-7.
Mississippi Coast Historic Annual Stages at Mobile District Tide Gages (continued)

		Gulfport (1963)			Pascagoula (1940)			Biloxi (1882)		
Storm	**Date**	**Gage Height, ft.**	**ft. NAVD**		**Gage Height, ft.**	**ft. NAVD**		**Gage Height, ft.**	**ft. NAVD**	
15Oct1923	1923-Oct-15							11.96	6.01	[7]
21Sep1926	1926-Sep-21		6.13	[1]					3.95	
Sep 1932	1932-Sep							9.16	3.21	
Oct 1932	1932-Oct							9.33	3.38	
July 1933	1933-Jul							9.16	3.21	
Sep 1933	1933-Sep							9.74	3.79	
Jun 1934	1934-Jun							8.98	3.03	
T.S. Jun 1939	1939-Jun							9.05	3.10	
26Sep1939	1939-Sep-29							9.5	3.55	
	1940-Aug-06					3.71		10.4	4.45	
12Sep1941	1941-Sep-12					3.38		9.52	3.57	
06Sep1945	1945-Sep-06						[5]	9.1	3.15	
	1947-Sep-08					2.68				[6]
19Sep1947	1947-Sep-19		14.13	[1]		7.48	[2,6]	16.88	10.93	[2,6]
04Sep1948	1948-Sep-04		6.13	[1]		4.08			5.73	
	1949-Sep-04					3.98			4.59	
Baker	1950-Aug-30					3.73			3.66	
Barbara	1954-Jul-29					2.43		9.1	3.15	
Brenda	1955-Aug-01					3.18			4.00	
26Aug1955	1955-Aug-26		6.13	[1]		2.83			3.67	
	1956-Jun-13					3.48		10.78	4.83	
Flossy	1956-Sep-24		4.13	[1]		3.18		9.39	3.44	
Audrey	1957-Jun-27					3.36			3.75	
T.S Ester	1957-Sep-18		6.63	[1]		2.63			4.77	
Ethel	1960-Sep-15		5.13	[1]		4.58			5.25	
Helda	1964-Oct-04	5.14	4.27			4.13			4.76	
Betsy	1965-Sep-09		10.83	[2,7]		6.48		14.64	8.69	
Debbie	1965-Sep-29	6.8	3.93			2.92				[6]
Camille	1969-Aug-17		19.81	[2]	11.37	11.33	[2]		15.69	[2]
Felice	1970-Sep-15	3.01	3.14		2.43	2.39		8.94	2.99	
Fern	1971-Sep-05	2.68	2.54		2.37	2.33				
Edith	1971-Sep-16	3.35	3.21		2.08	2.04			3.63	
Carmen	1974-Sep-08	4.95	4.81		3.98	3.94			4.60	
Babe	1977-Sep-06	3.9	3.76				[5]			[5]
Bob	1979-Jul-11		6.13			4.63			5.75	
Frederic	1979-Sep-12		3.43			5.86			4.03	
Elena	1985-Sep-02		5.56			5.58			6.16	
Juan	1985-Oct-28		6.63			5.39			5.96	
Bonnie	1986-Jun-23		2.73			2.45			2.83	
Gilbert	1988-Sep-08		4.90			3.10			4.06	
Florence	1988-Sep-10		4.67			3.11			6.39	
Chantal	1989-Jul-31		3.13			2.31			3.48	
Andrew	1992-Aug-26		4.02			3.18			3.90	

Table 1.3-7.
Mississippi Coast Historic Annual Stages at Mobile District Tide Gages (continued)

		Gulfport (1963)			Pascagoula (1940)			Biloxi (1882)		
Storm	**Date**	**Gage Height, ft.**	**ft. NAVD**		**Gage Height, ft.**	**ft. NAVD**		**Gage Height, ft.**	**ft. NAVD**	
TS Dean	1995-Jul-28		3.70			2.83			3.52	
Erin	1995-Aug-04		2.68			2.84			3.04	
Opal	1995-Oct-04		3.05			2.65				3
Josephine	1996-Oct-05		3.47			2.74			3.47	
Danny	1997-Jul-19		4.25			2.98			3.87	
Earl	1998-Sep-02		3.30			3.16		3.52	3.00	
Georges	1998-Sep-28		7.18			8.44	2		8.18	
T.S. Helen	2000-Nov-24		3.75			3.08			3.48	
T.S. Allison	2001-Jun-11		4.56			3.98				5
T.D. Edward	2002-Sep-06		4.13		4.09	3.45			3.57	
T.S. Hanna	2002-Sep-14	5.14	4.65		4.64	4.00			4.16	
Isidore	2002-Sep-26	8.26	7.77			5.83			6.99	
Lili	2002-Oct-04	3.79	3.30			3.96			4.88	
T.S. Bill	2003-Jul-10	4.6	4.11			3.41			4.12	
Ivan	2004-Sep-16	5.28	4.79			6.80	4		4.36	
T.S. Matthew	2004-Oct-10	4.88	4.39		3.66	3.02		4.32	3.80	
T.S. Cindy	2005-Jul-06	6.16	5.67			5.83			5.97	
Dennis	2005-Jul-10	3.63	3.14			3.33			2.99	
Katrina	2005-Aug-29		24.30	4		16.68	2		23.93	4
Storm Count			45			51			65	

1 Report on Hurricane Survey
2 High Water Mark at Gage Site
3 No Record gage vandalized
4 Gage Removed before landfall, HWM at gage site
5 No Record Gage Malfunctioned
6 No Record gage destroyed
7 Partial Record, gage malfunction

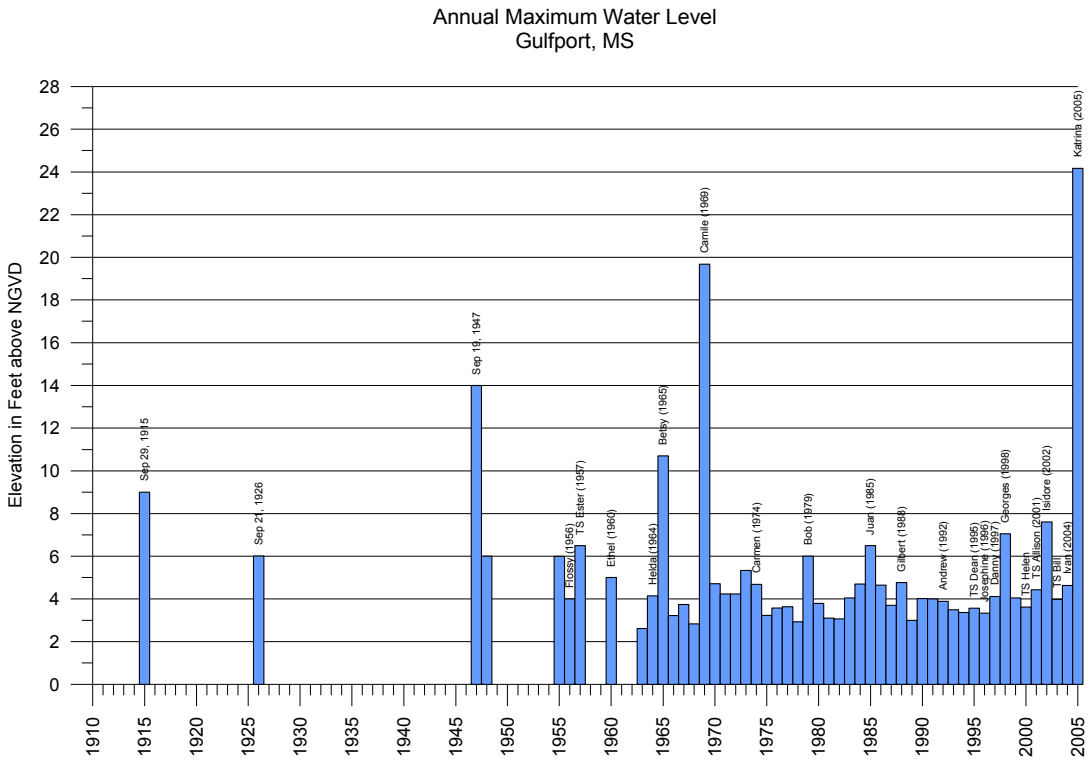


Figure 1.3-8. Gulfport, MS Annual Maximum Water Level

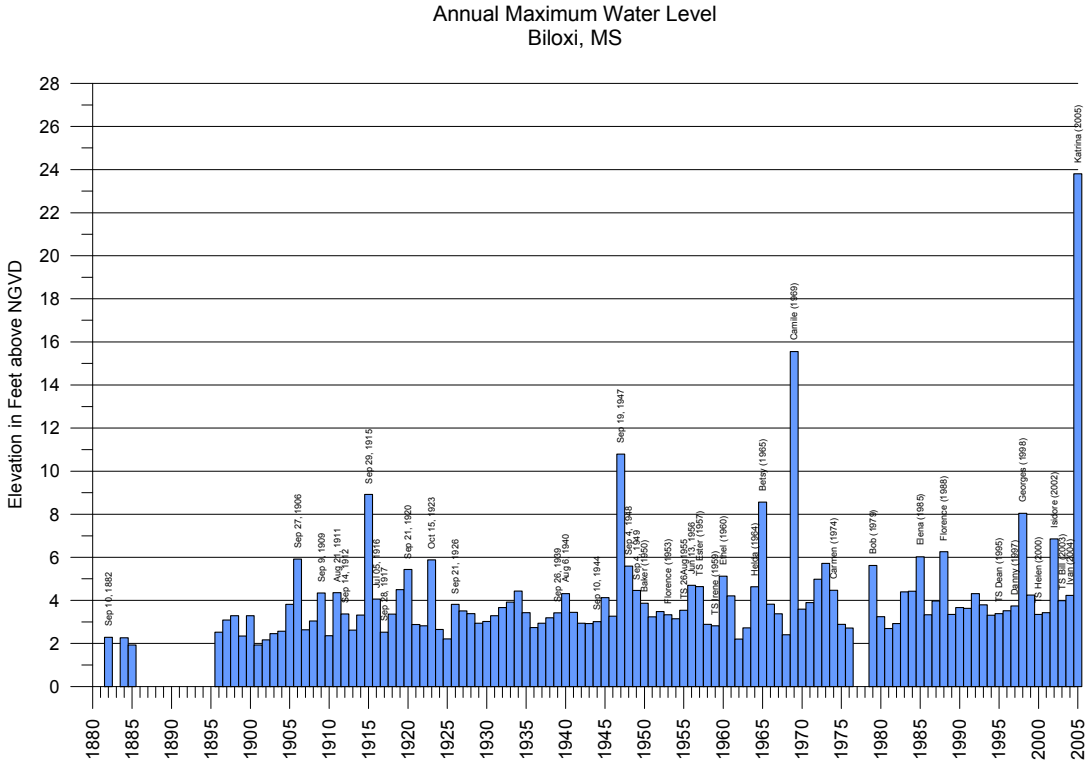


Figure 1.3-9. Biloxi, MS Annual Maximum Water Level

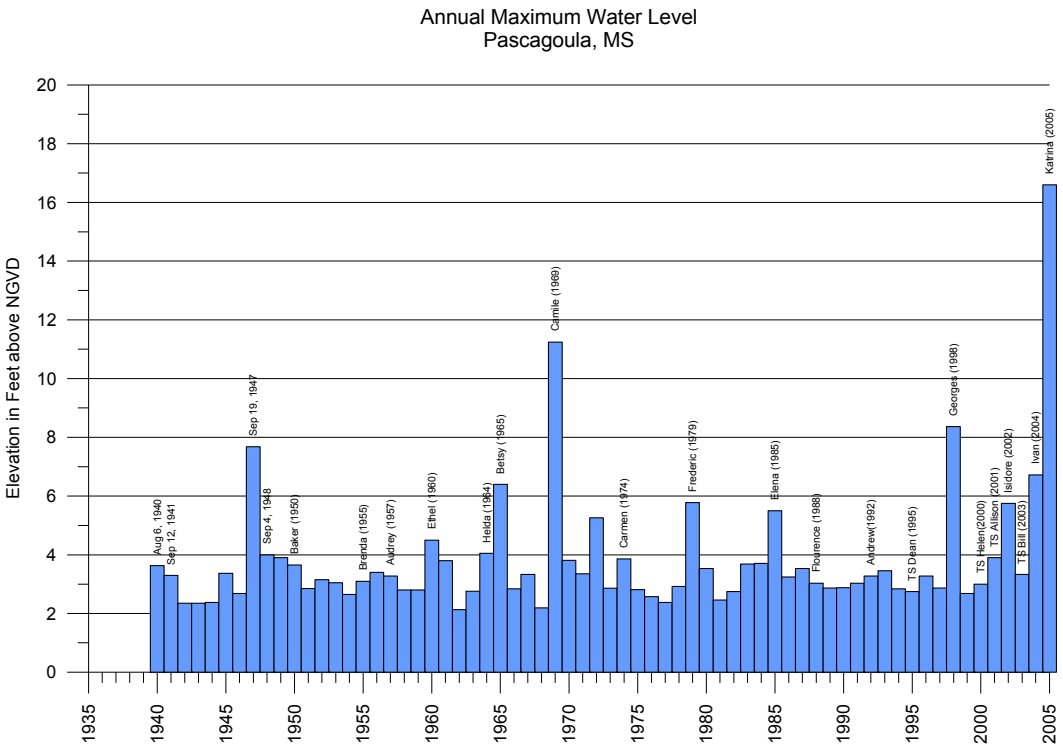


Figure 1.3-10. Pascagoula, MS Annual Maximum Water Level

1.3.3 Results

1.3.3.1 Graphical Stage-Frequency Analysis

A graphically fit (by eye) curve was drawn through the median plotting positions of the historic data for each gage site. Results for selected annual probabilities of occurrence are shown in Table 1.3-8. Comprehensive results are shown in tabular format with observed data in Tables 1.3-9 through 1.3-11. The computed Weibull plotting position is shown in those tables for reference only. Figures 1.3-11 through 1.3-13 show results presented graphically against an historic stage frequency curve. The historic curve (shown in red on the figures) was developed to represent the entire Mississippi Coast and published in a Mississippi Coast hurricane survey published by Mobile District in 1965 (Ref. 4). The hurricane survey curve was developed based on observed tidal data. That curve pre-dates some of the most intense surge-producing hurricanes to have struck the vicinity of Mississippi in the modern record: H. Betsy (1965), H. Camille (1969), H. Georges (1998), and H. Katrina (2005). The result is that, in the 40 years of record, one's impression of what the 1 in 100 chance annual stage might be according to these methods has increased dramatically, and at Gulfport that stage has nearly doubled. This observation reinforces the idea that the length of period of record is an important consideration, and that just a few historically significant events can dramatically impact the risk picture. Similarly, the tabulated results in Table 1.3-8 clearly show the influence that landfall location may impart on the stage frequency curve. While there are physical reasons why western Mississippi might register higher stages for a given hurricane than elsewhere along the Mississippi Coast, if H. Camille and H. Katrina landed more centrally there, the stage-frequency relationship would likely have been somewhat more uniform for low annual chance events at the three gages. This also demonstrates the need to combine gage data with statistical and modeling efforts to improve stage-frequency estimates.

Table 1.3-8.
Results from Graphical Frequency Analysis

Annual Percent Chance Exceedance	Pascagoula Stage	Biloxi Stage	Gulfport Stage
50	3.3	3.7	4.3
20	4.0	4.5	6.1
10	6.0	5.7	6.9
5	7.9	7.6	9.4
2	12.5	12.6	18.8
1	17.1	19.1	23.1

Period of record: Pascagoula 1916-2005, Biloxi 1882-2005, Gulfport 1941-2005.

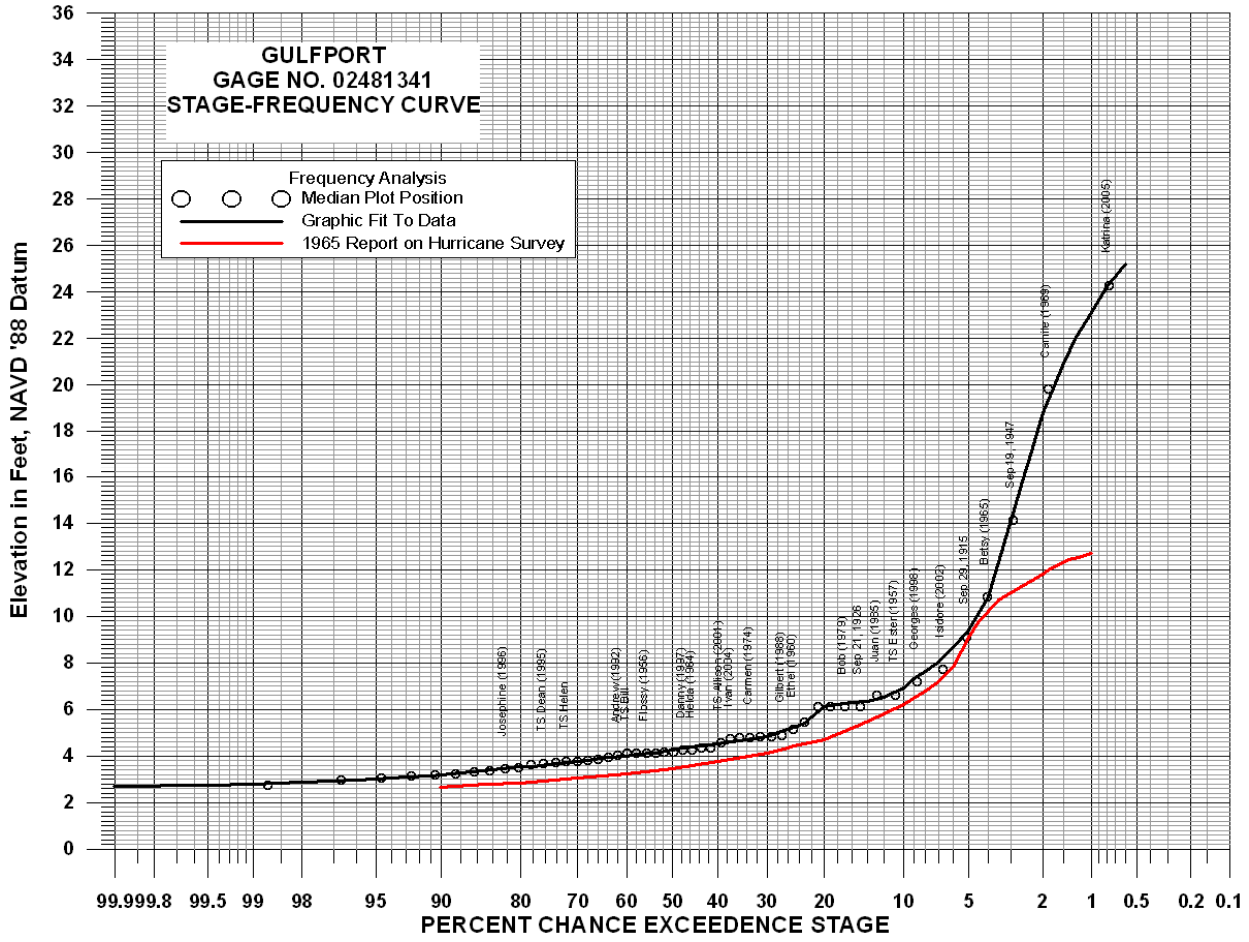


Figure 1.3-11. Gulfport, MS Frequency Curve

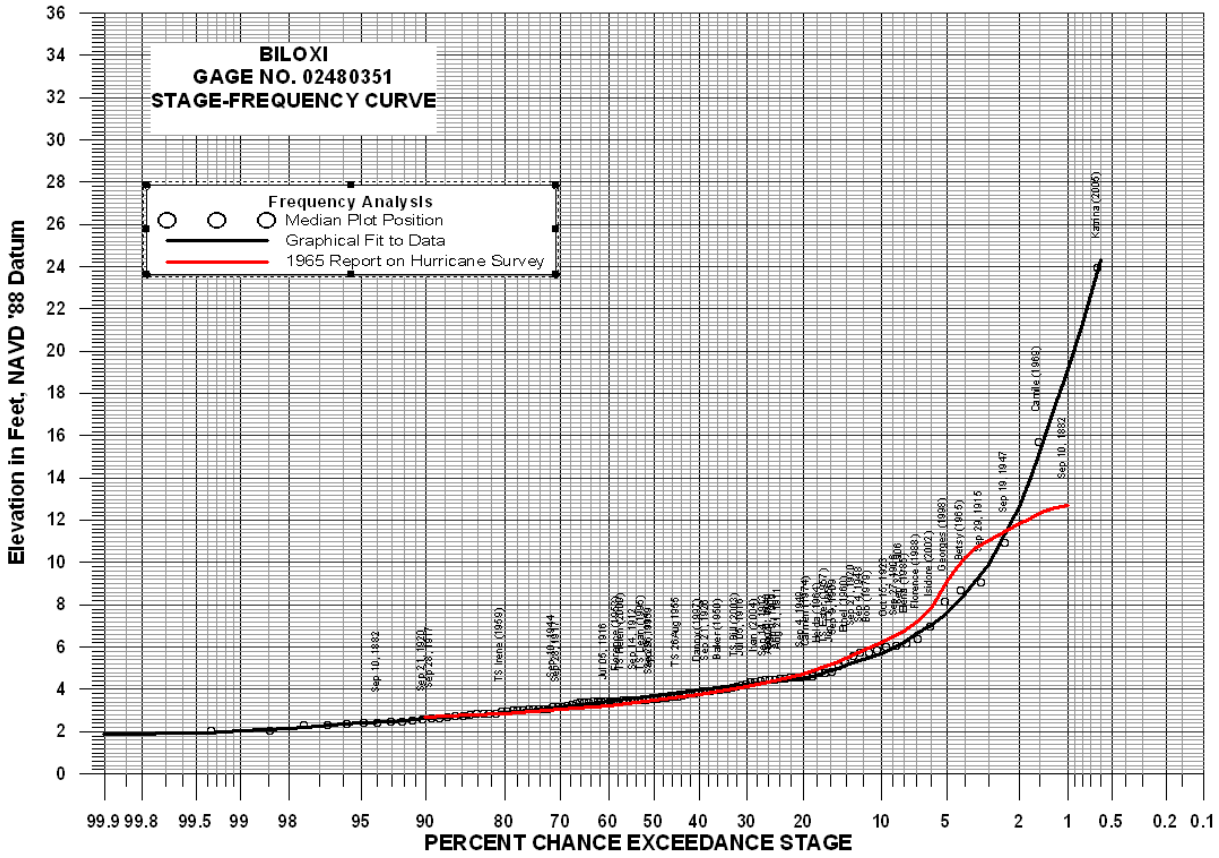


Figure 1.3-12. Biloxi, MS Frequency Curves

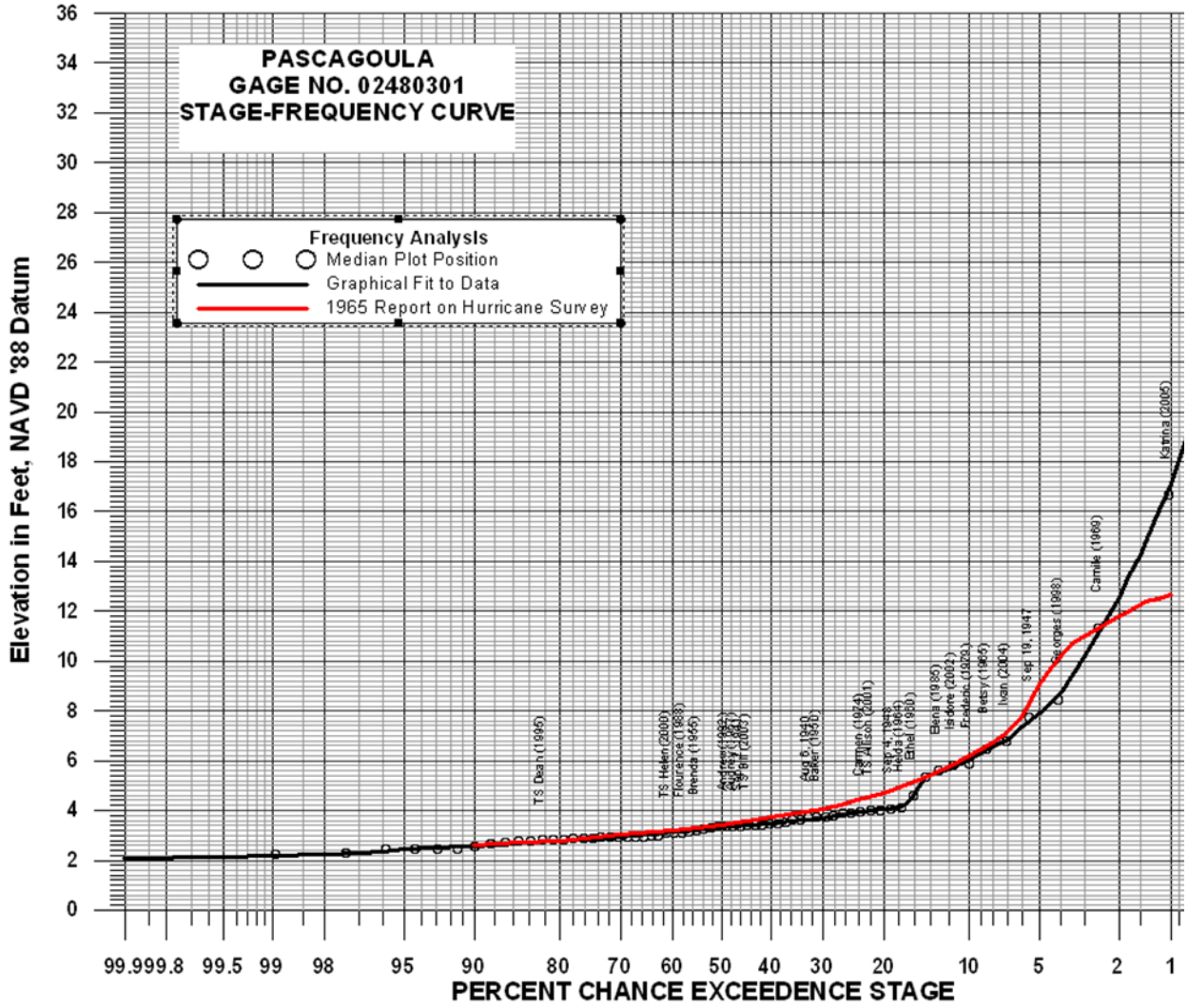


Figure 1.3-13. Pascagoula, MS Frequency Curve

Table 1.3-9.
Gulfport, MS Annual Peaks

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
2005	24.30	1	1.09	0.77	Katrina (2005)
1969	19.81	2	2.17	1.86	Camille (1969)
1947	14.13	3	3.26	2.95	Sep 19, 1947
1965	10.83	4	4.35	4.05	Betsy (1965)
1915	9.13	5	5.43	5.14	Sep 29, 1915
2002	7.74	6	6.99	6.71	Isidore (2002)
1998	7.18	7	9.03	8.76	Georges (1998)
1957	6.63	8	11.06	10.8	TS Ester (1957)
1985	6.63	9	13.09	12.85	Juan (1985)
1926	6.14	10	15.12	14.89	Sep 21, 1926
1948	6.13	12	19.19	18.98	
1979	6.13	11	17.16	16.94	Bob (1979)

Table 1.3-9.
Gulfport, MS Annual Peaks (continued)

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
1955	6.12	13	21.22	21.03	
1973	5.46	14	23.25	23.08	
1960	5.13	15	25.28	25.12	Ethel (1960)
1988	4.90	16	27.32	27.17	Gilbert (1988)
1970	4.85	17	29.35	29.21	
1984	4.83	18	31.38	31.26	
1974	4.81	19	33.41	33.3	Carmen (1974)
1986	4.78	20	35.44	35.35	
2004	4.76	21	37.48	37.39	Ivan (2004)
2001	4.56	22	39.51	39.44	TS Allison (2001)
1971	4.36	23	41.54	41.49	
1972	4.36	24	43.57	43.53	
1964	4.27	25	45.6	45.58	Helda (1964)
1997	4.25	26	47.64	47.62	Danny (1997)
1983	4.18	27	49.67	49.67	
1999	4.18	28	51.7	51.71	
1990	4.14	29	53.73	53.76	
1956	4.13	30	55.77	55.8	Flossy (1956)
1991	4.13	31	57.8	57.85	
2003	4.11	32	59.83	59.89	TS Bill
1992	4.02	33	61.86	61.94	Andrew (1992)
1980	3.93	34	63.89	63.99	
1967	3.87	35	65.93	66.03	
1987	3.83	36	67.96	68.08	
1977	3.76	37	69.99	70.12	
2000	3.75	38	72.02	72.17	TS Helen
1976	3.71	39	74.05	74.21	
1995	3.70	40	76.09	76.26	TS Dean (1995)
1993	3.62	41	78.12	78.3	
1994	3.49	42	80.15	80.35	
1996	3.47	43	82.18	82.39	Josephine (1996)
1975	3.36	44	84.22	84.44	
1966	3.35	45	86.25	86.49	
1981	3.23	46	88.28	88.53	
1982	3.20	47	90.31	90.58	
1989	3.13	48	92.34	92.62	
1978	3.06	49	94.38	94.67	
1968	2.96	50	96.41	96.71	
1963	2.75	51	98.44	98.76	

Table 1.3-10.
Biloxi, MS Annual Peaks

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
2005	23.93	1	0.89	0.63	Katrina (2005)
1969	15.69	2	1.79	1.53	Camille (1969)
1947	10.93	3	2.68	2.42	Sep 19, 1947
1915	9.05	4	3.57	3.32	Sep 29, 1915
1965	8.69	5	4.46	4.22	Betsy (1965)
1998	8.18	6	5.36	5.12	Georges (1998)
2002	6.99	7	6.25	6.01	Isidore (2002)
1988	6.39	8	7.14	6.91	Florence (1988)
1985	6.16	9	8.04	7.81	Elena (1985)
1906	6.05	10	8.93	8.71	Sep 27, 1906
1923	6.01	11	9.82	9.61	Oct 15, 1923
1973	5.85	12	10.71	10.50	
1979	5.75	13	11.61	11.40	Bob (1979)
1948	5.73	14	12.50	12.30	Sep 4, 1948
1920	5.57	15	13.39	13.20	Sep 21, 1920
1960	5.25	16	14.29	14.09	Ethel (1960)
1972	5.12	17	15.18	14.99	
1956	4.83	18	16.07	15.89	Jun 13, 1956
1957	4.77	19	16.96	16.79	TS Ester (1957)
1964	4.76	20	17.86	17.68	Helda (1964)
1919	4.64	21	18.75	18.58	
1974	4.60	22	19.64	19.48	Carmen (1974)
1949	4.59	23	20.54	20.38	Sep 4, 1949
1934	4.57	24	21.43	21.27	
1984	4.56	25	22.32	22.17	
1983	4.53	26	23.21	23.07	
1911	4.49	27	24.11	23.97	Aug 21, 1911
1909	4.48	28	25.00	24.87	Sep 9, 1909
1940	4.45	29	25.89	25.76	Aug 6, 1940
1992	4.45	30	26.79	26.66	
1999	4.38	31	27.68	27.56	
2004	4.36	32	28.57	28.46	Ivan (2004)
1961	4.34	33	29.46	29.35	
1945	4.26	34	30.36	30.25	
1916	4.20	35	31.25	31.15	Jul 05, 1916
2003	4.12	36	32.14	32.05	TS Bill (2003)
1987	4.10	37	33.04	32.94	
1933	4.05	38	33.93	33.84	
1971	4.03	39	34.82	34.74	
1950	4.00	40	35.71	35.64	Baker (1950)
1966	3.96	41	36.61	36.54	
1905	3.95	42	37.50	37.43	
1926	3.95	43	38.39	38.33	Sep 21, 1926

Table 1.3-10.
Biloxi, MS Annual Peaks (continued)

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
1993	3.93	44	39.29	39.23	
1997	3.87	45	40.18	40.13	Danny (1997)
1932	3.80	46	41.07	41.02	
1990	3.80	47	41.96	41.92	
1991	3.76	48	42.86	42.82	
1970	3.72	49	43.75	43.72	
1955	3.67	50	44.64	44.61	TS 26Aug1955
1996	3.66	51	45.54	45.51	
1927	3.65	52	46.43	46.41	
1952	3.61	53	47.32	47.31	
1941	3.58	54	48.21	48.20	
1935	3.56	55	49.11	49.10	
2001	3.56	56	50.00	50.00	
1939	3.55	57	50.89	50.90	Sep 26, 1939
1928	3.52	58	51.79	51.80	
1995	3.52	59	52.68	52.69	TS Dean (1995)
1912	3.51	61	54.46	54.49	Sep 14, 1912
1967	3.51	60	53.57	53.59	
1918	3.50	62	55.36	55.39	
1989	3.48	63	56.25	56.28	
2000	3.48	64	57.14	57.18	TS Helen (2000)
1953	3.47	65	58.04	58.08	Florence (1953)
1986	3.47	66	58.93	58.98	
1914	3.45	67	59.82	59.87	
1994	3.44	68	60.71	60.77	
1898	3.42	70	62.50	62.57	
1900	3.42	71	63.39	63.46	
1931	3.42	69	61.61	61.67	
1946	3.40	72	64.29	64.36	
1980	3.38	73	65.18	65.26	
1951	3.37	74	66.07	66.16	
1938	3.33	75	66.96	67.06	
1954	3.28	76	67.86	67.95	
1897	3.23	77	68.75	68.85	
1908	3.17	78	69.64	69.75	
1930	3.16	79	70.54	70.65	
1944	3.15	80	71.43	71.54	Sep 10, 1944
1929	3.07	81	72.32	72.44	
1937	3.07	82	73.21	73.34	
1942	3.07	83	74.11	74.24	
1943	3.05	84	75.00	75.13	
1982	3.05	85	75.89	76.03	
1921	3.02	88	78.57	78.73	
1958	3.02	86	76.79	76.93	

Table 1.3-10.
Biloxi, MS Annual Peaks (continued)

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
1975	3.02	87	77.68	77.83	
1922	2.96	89	79.46	79.62	
1959	2.95	90	80.36	80.52	TS Irene (1959)
1936	2.87	91	81.25	81.42	
1963	2.86	92	82.14	82.32	
1976	2.85	93	83.04	83.21	
1981	2.83	94	83.93	84.11	
1924	2.79	95	84.82	85.01	
1907	2.77	96	85.71	85.91	
1913	2.75	97	86.61	86.80	
1904	2.70	98	87.50	87.70	
1896	2.66	99	88.39	88.60	
1917	2.66	100	89.29	89.50	Sep 28, 1917
1903	2.59	101	90.18	90.39	
1968	2.54	102	91.07	91.29	
1910	2.50	103	91.96	92.19	
1899	2.48	104	92.86	93.09	
1882	2.42	105	93.75	93.99	Sep 10, 1882
1884	2.40	106	94.64	94.88	
1925	2.35	107	95.54	95.78	
1962	2.34	108	96.43	96.68	
1902	2.30	109	97.32	97.58	
1885	2.07	110	98.21	98.47	
1901	2.07	111	99.11	99.37	

1

Table 1.3-11.
Pascagoula, MS Annual Peaks

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
2005	16.69	1	1.49	1.05	Katrina (2005)
1969	11.33	2	2.99	2.56	Camille (1969)
1998	8.45	3	4.48	4.07	Georges (1998)
1947	7.77	4	5.97	5.57	Sep 19, 1947
2004	6.81	5	7.46	7.08	Ivan (2004)
1965	6.49	6	8.96	8.58	Betsy (1965)
1979	5.87	7	10.45	10.09	Frederic (1979)
2002	5.84	8	11.94	11.60	Isidore (2002)
1985	5.59	9	13.43	13.10	Elena (1985)
1972	5.35	10	14.93	14.61	
1960	4.59	11	16.42	16.11	Ethel (1960)
1964	4.14	12	17.91	17.62	Helda (1964)
1948	4.09	13	19.40	19.13	Sep 4, 1948
1949	3.99	14	20.90	20.63	
2001	3.99	15	22.39	22.14	TS Allison (2001)
1974	3.95	16	23.88	23.64	Carmen (1974)
1970	3.90	17	25.37	25.15	
1961	3.89	18	26.87	26.66	
1984	3.80	19	28.36	28.16	
1983	3.77	20	29.85	29.67	
1950	3.74	21	31.34	31.17	Baker (1950)
1940	3.72	22	32.84	32.68	Aug 6, 1940
1980	3.62	23	34.33	34.19	
1987	3.62	24	35.82	35.69	
1993	3.54	25	37.31	37.20	
1956	3.49	26	38.81	38.70	
1945	3.46	27	40.30	40.21	
1971	3.44	28	41.79	41.72	
1967	3.42	29	43.28	43.22	
2003	3.42	30	44.78	44.73	TS Bill (2003)
1941	3.39	31	46.27	46.23	Sep 12, 1941
1957	3.37	32	47.76	47.74	Audrey (1957)
1992	3.37	33	49.25	49.25	Andrew(1992)
1996	3.37	34	50.75	50.75	
1986	3.33	35	52.24	52.26	
1952	3.24	36	53.73	53.77	
1955	3.19	37	55.22	55.27	Brenda (1955)
1953	3.14	38	56.72	56.78	
1988	3.12	39	58.21	58.28	Florence (1988)
1991	3.12	40	59.70	59.79	
2000	3.09	41	61.19	61.30	TS Helen(2000)
1978	3.01	42	62.69	62.80	
1990	2.97	43	64.18	64.31	
1989	2.96	44	65.67	65.81	
1973	2.95	46	68.66	68.83	

Table 1.3-11.
Pascagoula, MS Annual Peaks (continued)

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
1951	2.94	47	70.15	70.33	
1966	2.93	48	71.64	71.84	
1994	2.93	49	73.13	73.34	
1975	2.90	50	74.63	74.85	
1958	2.89	51	76.12	76.36	
1959	2.89	52	77.61	77.86	
1963	2.85	53	79.10	79.37	
1982	2.84	54	80.60	80.87	
1995	2.84	55	82.09	82.38	TS Dean (1995)
1946	2.77	56	83.58	83.89	
1999	2.77	57	85.07	85.39	
1954	2.74	58	86.57	86.90	
1976	2.66	59	88.06	88.40	
1981	2.55	60	89.55	89.91	
1944	2.47	61	91.04	91.42	
1977	2.47	62	92.54	92.92	
1942	2.44	63	94.03	94.43	
1943	2.44	64	95.52	95.93	
1968	2.28	65	97.01	97.44	
1962	2.22	66	98.51	98.95	

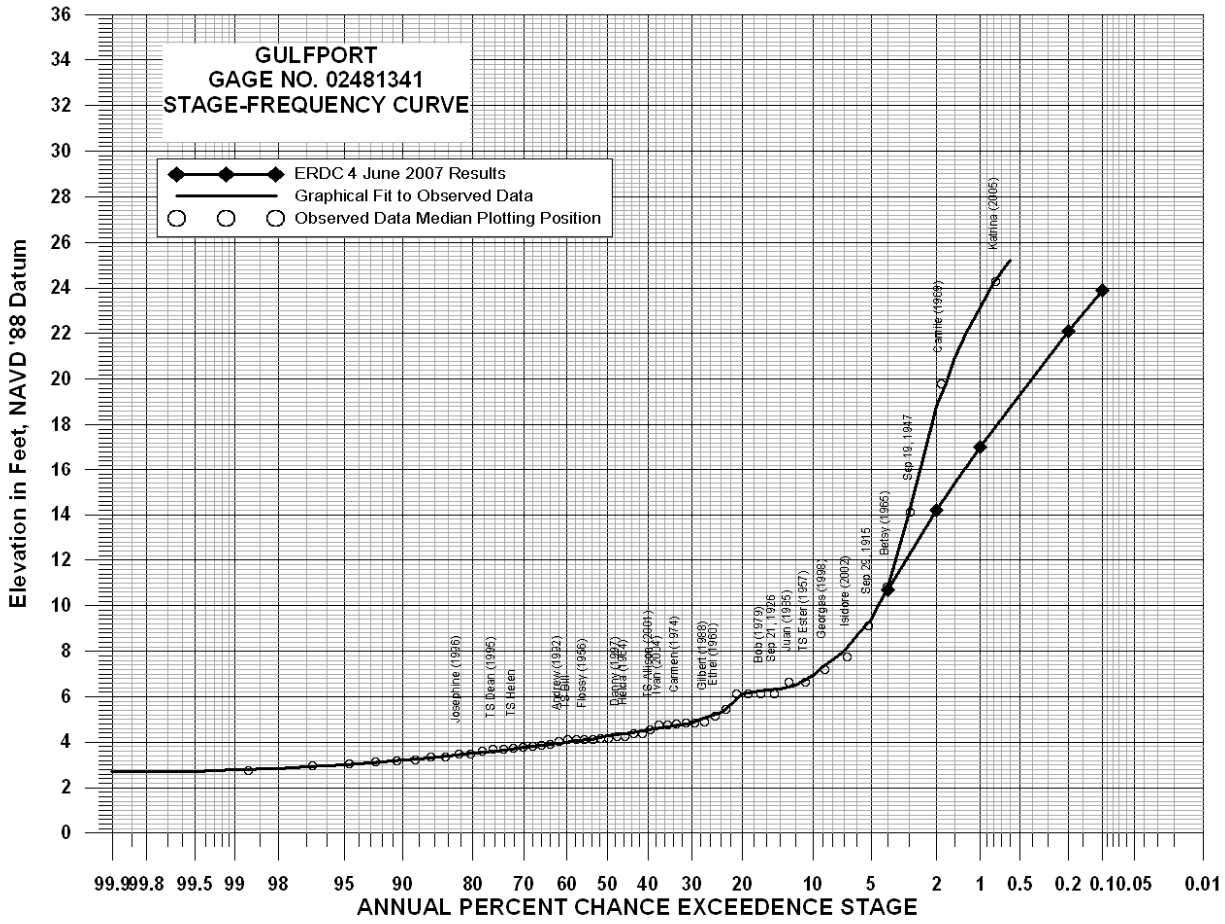
1.3.3.2 Composite Stage-Frequency Curves

As mentioned in Section 1.3, these probabilistic graphical analysis results were joined with hydrodynamic and statistical model results to create composite stage-frequency curves used for a host of MsCIP design and evaluation efforts as discussed throughout this report. This section presents ERDC modeling results at the location of the USACE gages with those results obtained by probabilistic analysis of gage data and shows how they were combined to form composite stage-frequency curves.

Figure 1.3-14 shows stage-frequency components obtained through probabilistic analysis of historic gage data at Gulfport with ERDC results for the same location. ERDC results were obtained from the results of hydrodynamic modeling of severe storm events and statistical analysis of hydrodynamic model output as described in Chapter 2. These results are referred to as 'synthetic,' as they were not explicitly developed from observed data, and represent the best estimate of stage for a given annual chance of occurrence. Uncertainty bands[1] for these best estimates were computed and are used in the analyses supporting the MsCIP program. Figure 1.3-15 shows the joined, or composite, stage frequency curves with uncertainty at 2 standard deviations. The curves were joined graphically. This figure was obtained from the HEC-FDA model, in which one hundred feet has been added to stage for computational purposes; the data are otherwise consistent. Similar figures are presented as Figures 1.3-16 through 1.3-19 for both the Biloxi and Pascagoula gage locations.

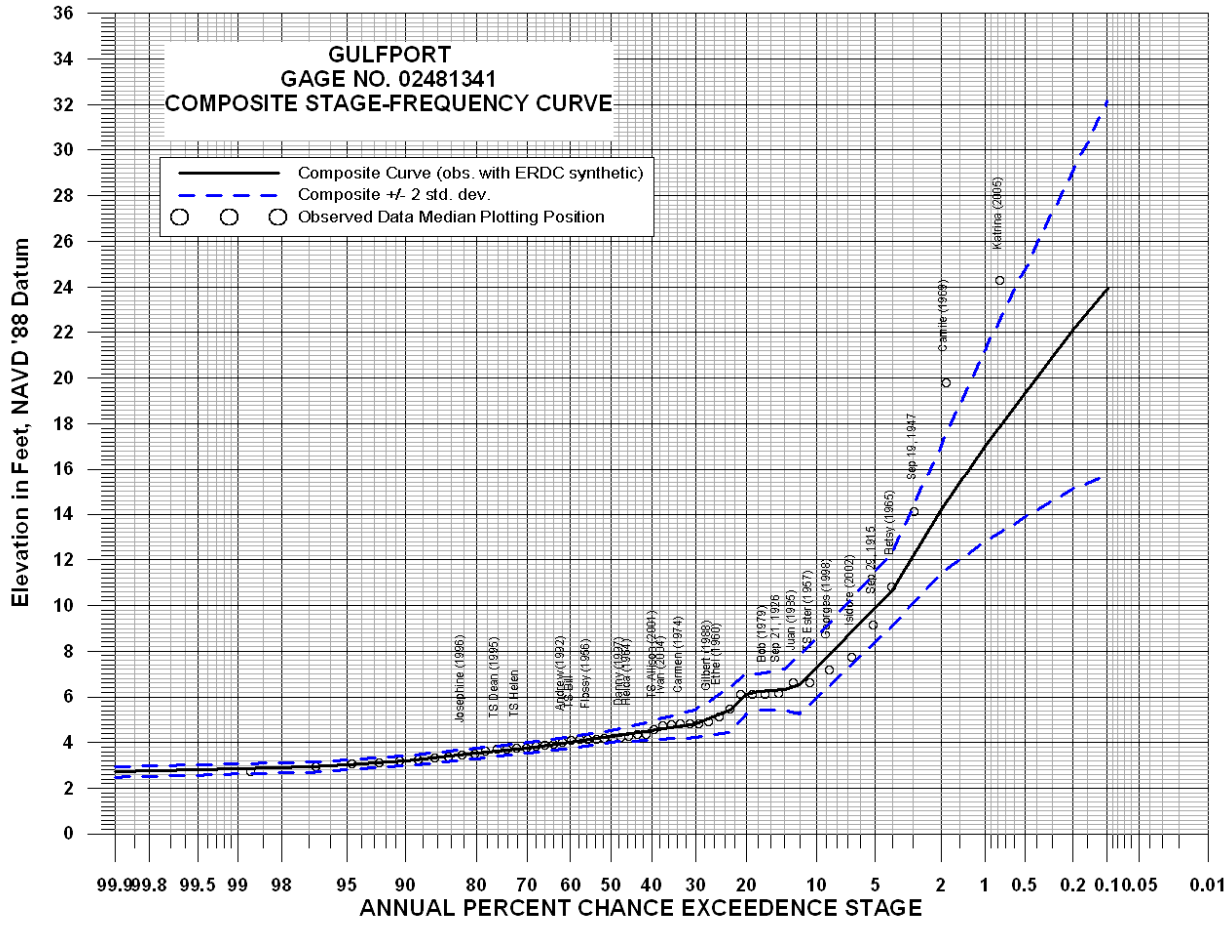
A more detailed discussion on the development and adaptation of composite stage-frequency information to the flood damage evaluation purpose is provided in section 2.16.

[1] Uncertainty computations are discussed in sections 2.9 and 2.16.



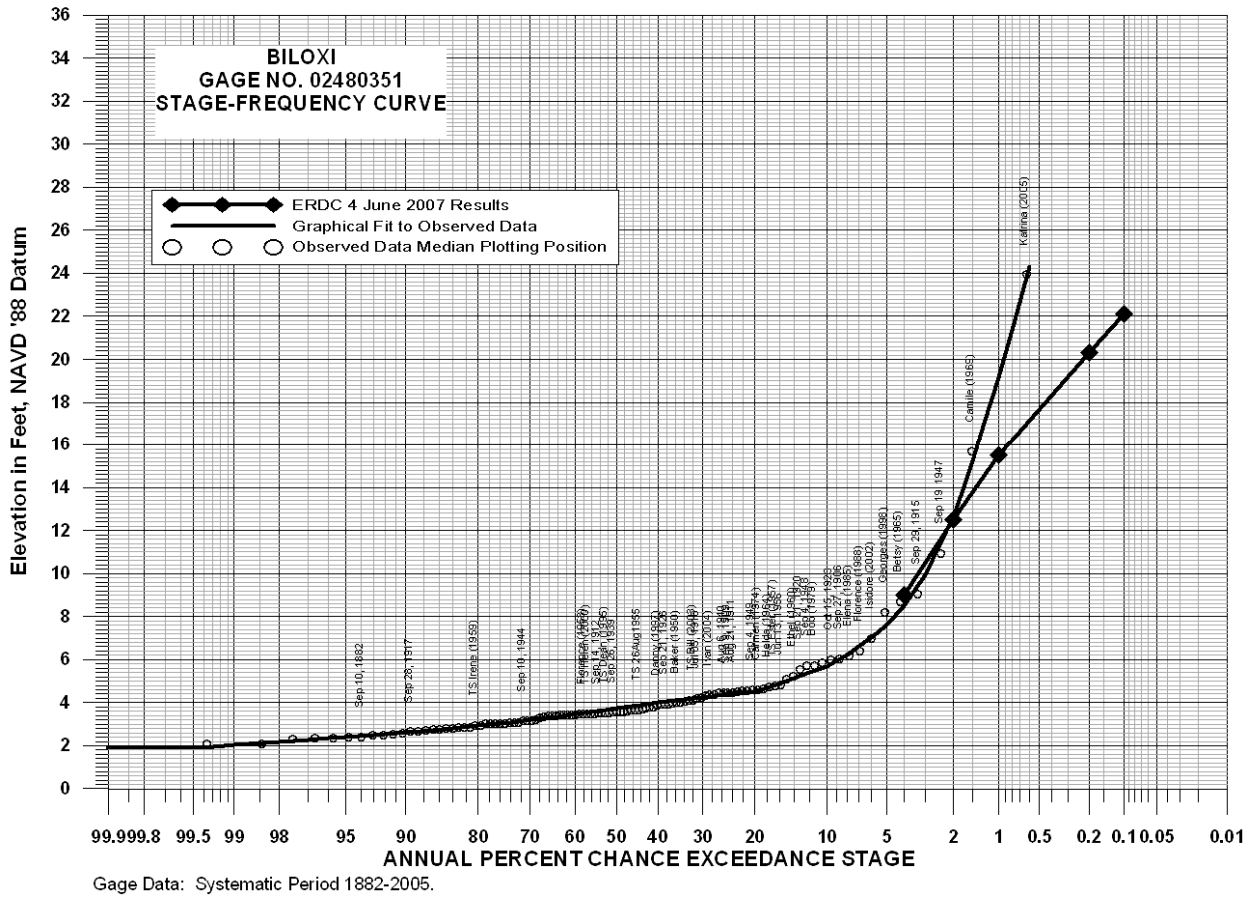
Gage Data: Historic Years 1915 & 1947, Systematic Period 1955-2005.

Figure 1.3-14. Graphical and Synthetic Stage-Frequency Curve Components at Gulfport



Observed Data: Historic Years 1915 & 1947, systematic period 1955-2005.

Figure 1.3-15. Composite Stage-Frequency Curve, Gulfport



Gage Data: Systematic Period 1882-2005.

Figure 1.3-16. Graphical and Synthetic Stage-Frequency Curve Components at Biloxi

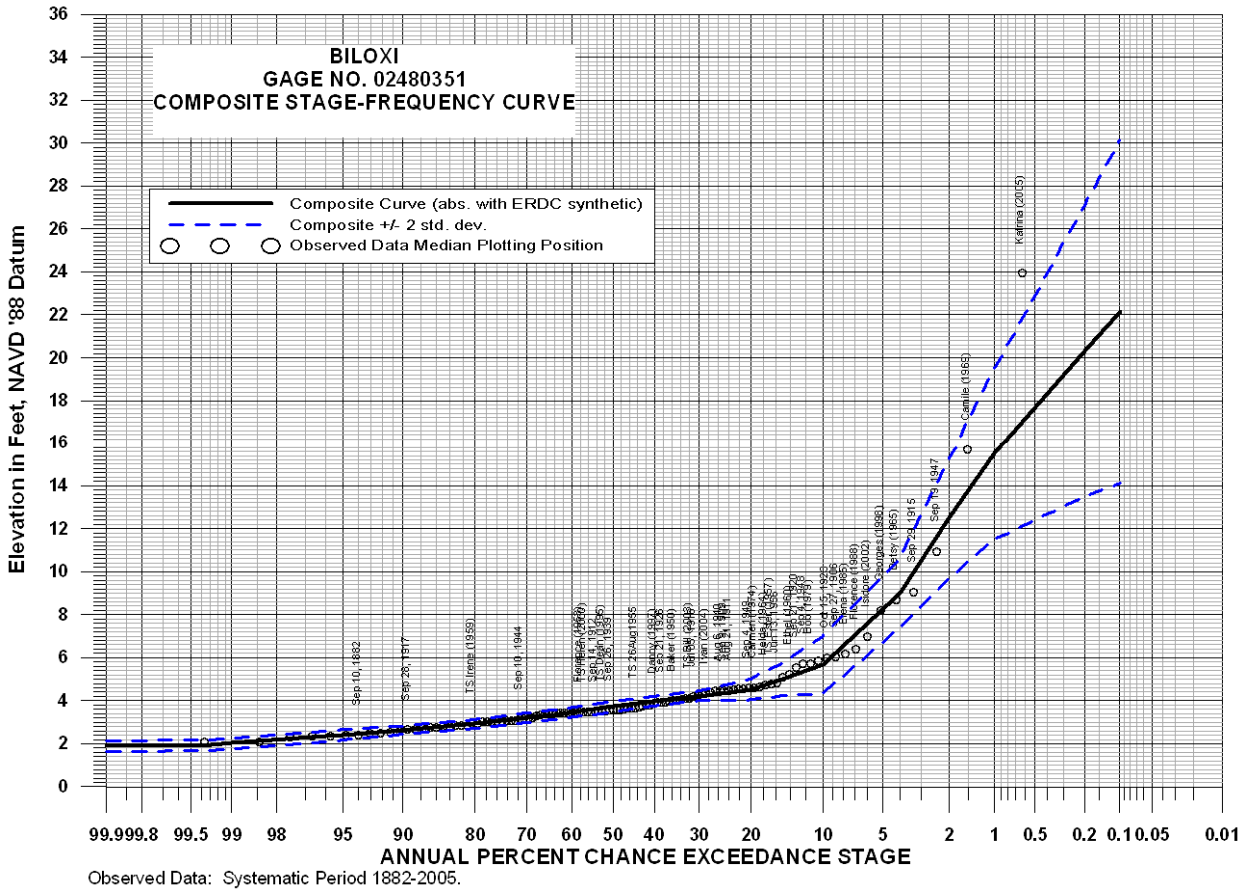
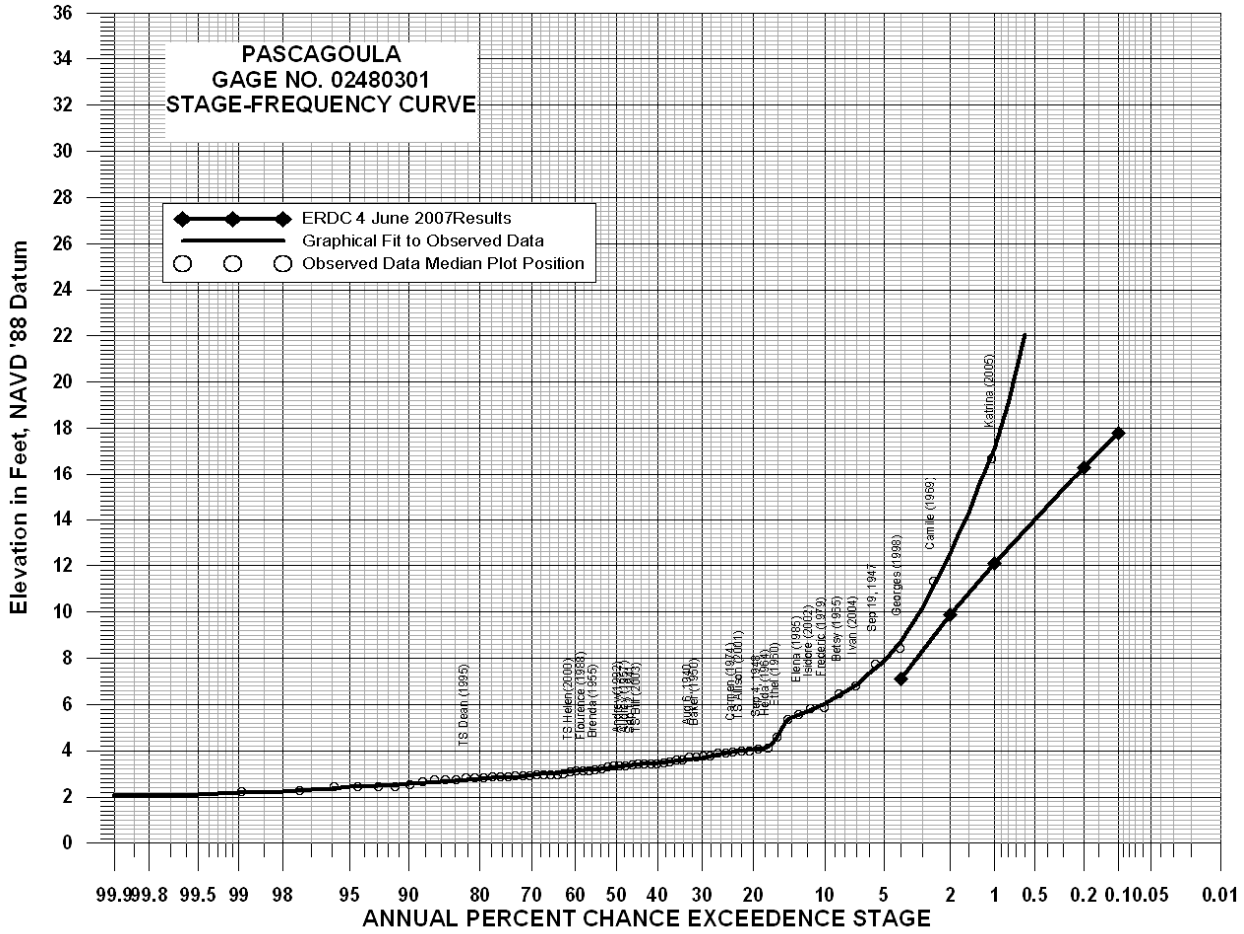


Figure 1.3-17. Composite Stage-Frequency Curve, Biloxi



Gage Data: Period of Record 1941-2005.

Figure 1.3-18. Graphical and Synthetic Stage-Frequency Curve Components at Pascagoula

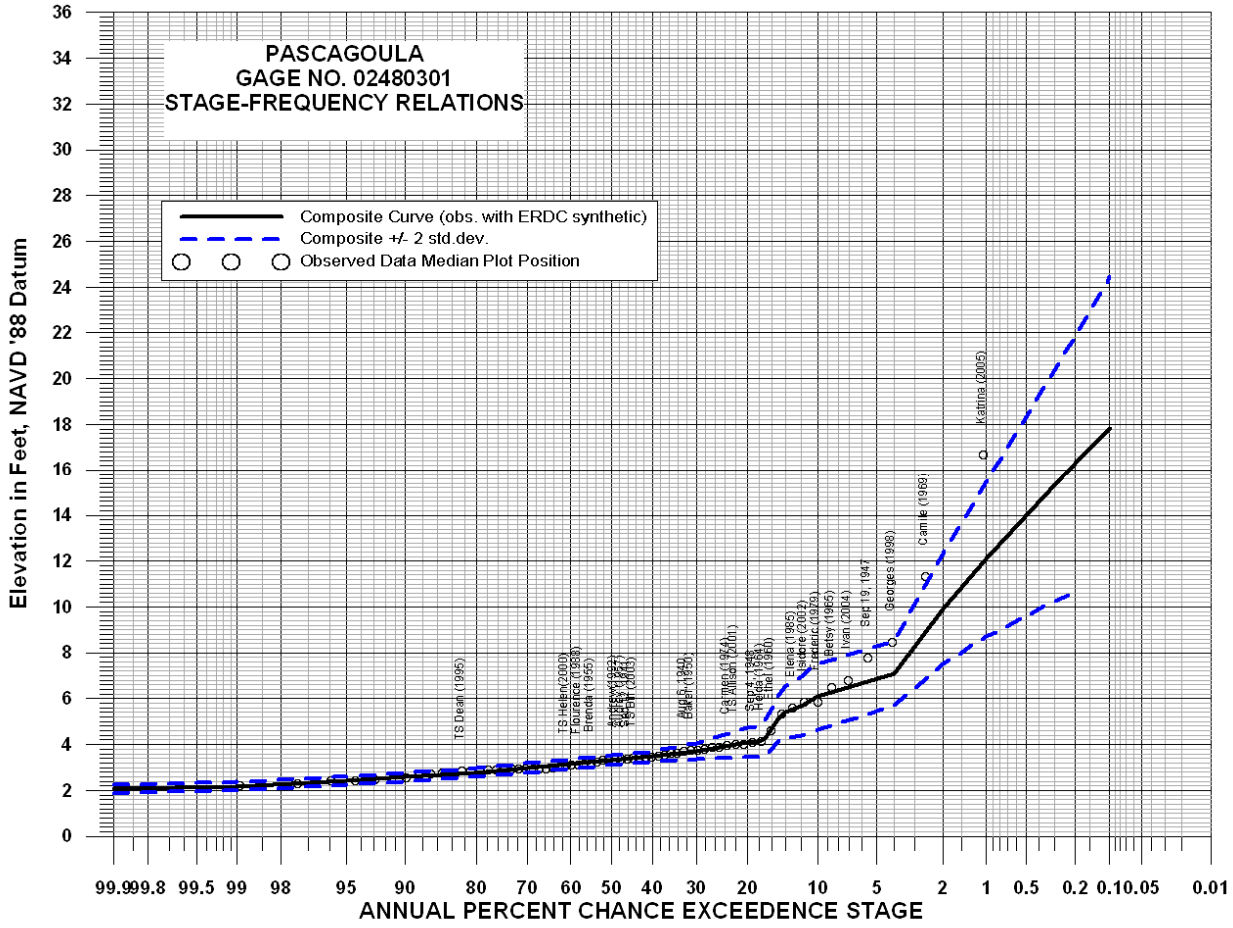


Figure 1.3-19. Composite Stage-Frequency Curve, Pascagoula

1.3.4 References

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USACE (1993). Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. US Army Corps of Engineers. Washington, DC. 5 March 1993.

IACWD (1982). Guidelines for Determining Flood Flow Frequency. Bulletin #17B. Interagency Advisory Committee on Water Data, Hydrology Subcommittee. US Department of the Interior, Geological Survey, Office of Water Data Coordination. Reston, VA. March 1982.

USACE (1965). Report on Hurricane Survey of Mississippi Coast. US Army Engineer District, Mobile, Alabama. 25 January 1965.

1.4 Typical Wind, Wave, Water Level, Current, and Sediment Transport Conditions

The Mississippi Sound extends from Mobile Bay, Alabama, to the east to Lake Borgne, Louisiana, to the west. The Sound is a mostly unstratified brackish water body approximately 81miles long, 6.8 to 15 miles wide, and 820 square miles in area. The Sound has a mean depth of 10 ft Mean Low Water (MLW) and more than 99% of it is shallower than 20 ft MLW. The Sound extends about nine miles north to south from the Mississippi mainland coastline to a series of low, typically sandy barrier islands on the edge of the coastal shelf which marks the Gulf of Mexico.

1.4.1 Winds

Prevailing winds for the Mississippi coast are produced by two pressure ridges which dominate weather conditions: the Bermuda High, centered over the Bermuda-Azores area of the Atlantic and the Mexican Heat Low centered over Texas during warm months. Prevailing winds are predominately from the east and south east during spring and summer months, and from the east and north east during fall and winter months. The strongest winds are recorded in February and March with the exception of storm and May through October hurricane conditions. Hurricane wind fields and their effects on storm surge and waves are an area of particular concern for this study and are discussed at length in Chapter 2 of this appendix.

1.4.2 Waves

Wave intensity of the Mississippi Sound is typically low to moderate. Fetch and depth limited waves within the sound average less than 1 ft in height. Breaking wave heights along the shoreline of the barrier islands average about 3 ft with periods of five to eight seconds. Hurricane and storm conditions, and strong winter cold fronts can produce significant surges and much larger wave conditions at the coast and barrier islands. Wave phenomena due to hurricanes are discussed in detail in Chapter 2 of this appendix.

1.4.3 Tides

The mean tidal range near the Mississippi Sound shoreline is approximately 1.5 ft. Although the tidal range caused by astronomical forces is relatively small, atmospheric pressure variation and, particularly, winds can induce larger variations. Strong winds blowing from the north can force water out of the sound and result in current velocities of several knots in the passes. The reverse occurs with winds blowing from the southeast, which forces water shoreward toward the Mississippi coastline. The tidal variation in the Mississippi Sound and adjacent waters is typically diurnal (one high tide and one low tide daily) though mixed tides (two high tides and two low tides) occur a few days out of the month. The average tide cycle is 24.8 hours which is slightly less than one lunar day. Mobile District has a long tide level monitoring history in Mississippi as discussed in section 1.3. The long period of record provides for an interpretation as to the relative rate of sea level rise as discussed in section 1.6.

1.4.4 Currents

The general circulation patterns in the Mississippi Sound are primarily induced by tides and winds, with freshwater inflows having secondary influences. The currents caused by the tide diverge and split the Mississippi Sound into two distinct areas. Horn Island Pass and the area north of the pass is the natural dividing point for tidal currents. Currents from this area to Lake Borgne generally flow into the Sound through the Barrier Island Passes and flow westward on the flood tide. During ebb tide,

the flow is eastward and out of the Sound. From Horn Island Pass to Mobile Bay, currents flow in through the Barrier Island Passes and eastward on the flood tide, and reverse westward and out of the sound during ebb tide. Strong winds blowing from the north can force water out of the sound and result in current velocities of several knots in the passes. The reverse occurs with winds blowing from the southeast, which forces water shoreward toward the Mississippi coastline. Typical tidal currents range between 0.5 to 1.0 ft/s.

1.4.5 Sediment Transport

The Mississippi coast is a wave-dominated coastline. Because prevailing wind in the Mississippi barrier island and mainland areas is from the eastern quadrants, most waves approach the shoreline at an angle and induce longshore currents that move sediment to the west. The islands migrate west due to littoral drift at approximately 50 ft/yr. There are a variety of structures, such as outfalls, port facilities, and sand enclosures along the Mississippi mainland coastline that divide the shoreline into closed littoral cells. For annual average wave conditions, the beaches may shift due to specific storm event but remain largely in equilibrium. For higher wave conditions there appears to be a tendency for sand to bypass the structures. Small shoreline structures such as outfall pipes produce minor localized perturbations in the coastline with accretion on the east sides of the structures indicating a westward littoral drift, however, longshore processes have minimal influence on the beaches in comparison to the cross-shore processes that exert primary control on shoreline response. The Mississippi River and several rivers along the northern border direct silt and clay into the sound. Salinity-induced flocculation of these very fine sediments induces settling and results in the continuous infilling of the sound. The high sediment load also produced elevated turbidity levels, giving the water of the Mississippi Sound its characteristically brownish appearance.

1.5 Geologic Setting and General Geophysical Investigations

1.5.1 Geologic Setting and Physiography

The coastal area of Mississippi is part of the Gulf Coastal Plain that extends from Florida westward to Texas. Coastal plains are generally characterized by gently sloping sedimentary formations that dip towards the coast line. The Gulf Coastal Plain is also affected by the Mississippi Embayment which is a trough that underlies the Mississippi River delta. This trough extends inward from the coast and is gradually subsiding near the coast under the sediment load that is being transported by the Mississippi River and deposited at the mouth of the river. Subsidence along this trough has changed the dip of formations that make up the coastal plain of Miocene an older age to a somewhat southwesterly direction. Of interest to this study are the three counties that front the Mississippi Sound. The Sound is a narrow, east-west; shallow body of water that separates the mainland from barrier islands that lie 10 to 15 miles offshore and the Gulf of Mexico southward of the islands. These counties, east to west, are Jackson, Harrison, and Hancock.

The Geologic Map of Mississippi (Moore, 1976), published by the Mississippi Geological Survey identifies three strata or formations that underlie the three subject counties. These include the alluvial/coastal deposits of Holocene age, the Citronelle formation of Pliocene/Pleistocene age, and the Pascagoula/Hattiesburg formation of Miocene age. Later and more detailed work (Otvos, 1986, 1992 and 2005) has further defined the various formations and provided information as to their depositional environment. This work also provides information concerning the barrier islands which lie off the coast of Mississippi. Some of this later work also addressed the presence of or lack of sand and other sediments along the coast, in the Mississippi Sound and near the barrier islands.

Within the Mississippi Sound, Holocene aged deposits form thin, muddy, strata that cover the older Pleistocene formations. These include alluvial, estuarine, and lagoonal-bay deposits. Sampling studies have shown the strata to contain particle sizes from colloidal to sand size depending on the energy associated with its depositional environment (Upshaw, Creath and Brooks, 1966).

Closer to the coast, late Pleistocene sea level changes associated with global glacial action caused a transgressive-regressive sequence that reworked sand along the coast. The last glacial period created a coastline near the edge of the continental shelf. As the ice began to melt, the associated sea level rise and wave action began to form the exposed sand into barrier islands with replenishment to this system coming from the east associated with sediments from the Apalachicola River that contribute to the barrier islands in northwest Florida westward into Alabama along Dauphin Island. A predominant wave action from the southeast creates a westward littoral drift that replenishes the sand to the beaches and inlands as well as causing a westward drift to some of the islands In Mississippi. The transgressive-regressive sequence has reworked sand and other sediments along the coast that has resulted in three formations that correlate from the alluvium along the coast to the barrier islands. These formations are the Prairie, Biloxi, and Gulfport formations. The Gulfport and Prairie formations are generally very sandy and have some economic value because of the sand. A generalized geologic map of the Mississippi coast based on these studies is shown in Figure 1.5-1, (after Otvos, 1997). The Prairie formation is found just landward of the coast in all three counties and the Gulfport formation is found along the beaches and barrier islands.

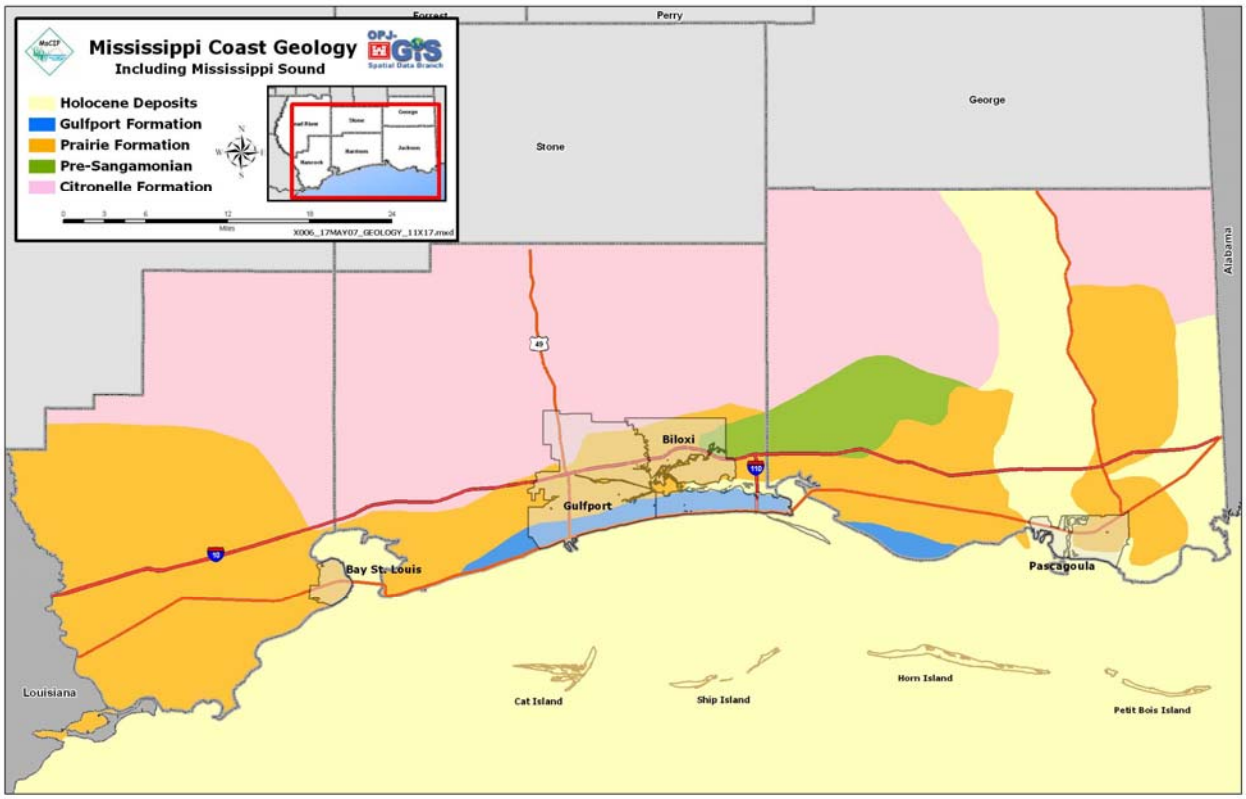


Figure 1.5-1. Generalized Geologic Map of Coastal Mississippi (After Otvos, 1997)

The Plio/Pleistocene Citronelle formation outcrops northward of the late Pleistocene formations. Utilizing outcrop, boring and fossil data from numerous locations, the Citronelle formation has been characterized as upland, alluvial/fluvial deposit that covers much of the study area. It consists

predominantly of silt and sand with some gravelly deposits. The source of the sand came from rivers that drained to the Gulf coast. Where paleo-streams and rivers have been incised into the underlying Miocene formation, Citronelle has formed thicker sequences than its general sedimentary deposits that cover much of the three counties.

The northern portions of the three counties contain limited outcrops of the Miocene aged Pascagoula/Hattiesburg formation. This formation contains inter-bedded clay, silt, and sand and is exposed along river valleys that have incised through the younger Citronelle formation which overlies it in the study area.

Collectively, the formations that outcrop within the study area provide vast quantities of useful construction material that includes high quality sand, sandy clays and clay. The nature of the various options discussed in this document will require all of these types of materials and the availability of these materials commercially throughout the area will benefit any project costs. Other than limited locations that fall within river channels or the bay bottoms, the geologic formations are expected to provide good foundation conditions. The areas within the river channels and bay bottoms will require deep geotechnical exploration to define local conditions, however the presence of major highway bridges and train trestles indicate that suitable deep foundations can be designed.

The study area is located within the East Gulf Coastal Plain physiographic province. There are two major physiographic regions in the Mississippi coastal region. The Gulf Coast Flatwoods form an irregular belt through the southern half of the three-county region. This belt consists mainly of wet lowlands and poorly drained depressions, with some higher, adequately-drained areas. The second physiographic region, the Southern Lower Coastal Plain, is rolling and gently undulating, interior uplands. Elevations range from sea level along the coast in Hancock, Harrison, and Jackson Counties to about 420 feet above sea level. The slope of the land surface is generally oriented to the south. The area is underlain by a thick sequence of sedimentary deposits dipping to the south and west.

1.5.2 Historical Offshore Sampling and Geophysical Exploration

Historical Offshore Sampling and Geophysical Exploration - To support any nourishment of sand along the mainland and on the barrier islands, extensive deposits of beach quality sand will be required. The sand will have several physical requirements that include color, grain size, and particle shape. Starting in the 1950s, literature contains extensive information about the sediments and shallow strata in the Mississippi Sound and along the shoreline. These studies supported sediment studies, the construction of beaches in Harrison and Jackson County as well as investigations for proposed bridges out to the barrier islands. The Mississippi Office of Geology, Coastal Geology Section, within the Mississippi Department of Environmental Quality maintains extensive records of the borings and sampling that have occurred in the area of the Mississippi Sound, (http://geology.deq.state.ms.us/coastal). There is also an abundance of information available from the Gulf Coast Research Laboratory (Otvos, oral comm.) located in Ocean Springs, MS. Another source of data exists with the US Geological Survey office located in St. Petersburg, Florida. Vast amounts of acoustic profiles are contained within their files in analog format. (Oral communication, Flocks, 2006) These profiles include the areas within Mississippi Sound, around the barrier islands, and southward out into the Gulf.

Extensive additional information is also stored in archives at the United States Geological Survey, but not in a user friendly format. These records include thousands of miles of acoustic profiles that exist as analog data recorded on scrolls. Through cooperation with the Mineral Management Service, efforts are underway to have these records transferred to a digital format that can be incorporated into a GIS type database. Of particular interest to this study is the St. Bernard Shoals that lie about 45 miles south of the barrier islands. St. Bernard Shoals is now a series of submerged

barrier islands that existed when the sea levels were much lower. It is believed that large quantities of high quality sand exists in the Shoals that could be used for the restoration of beaches and dunes both on the barrier islands and the mainland beaches.

1.5.3 Proposed Offshore Geophysical Exploration

Proposed Offshore Geophysical Exploration - Additional acoustic profiling is proposed for off-shore areas within Mississippi Sound and in some areas south of the barrier islands. These surveys will help identify sand deposits that could be used or re-nourishment of the islands and to provide data on the shallow strata between the islands. Some of the area is within the boundaries of the Gulf Islands National Seashore and work within these boundaries must be approved by the National Park Service. Acoustic profiling is based on a source of acoustic energy that is generated and acoustic reflections from that noise that are collected after bouncing off firm subsurface strata. The method used to perform the survey consists of towing the energy source and hydrophones behind a boat along traverse lines. The speed of the signal is measured and digitally recorded after it passes through the upper, softer strata, is reflected off the firmer sub-bottom and returns to hydrophones which act as receivers. This measured speed has a correlation to different types and thicknesses of sediments. The exact location of the reflected signal is constantly recorded during the process using GPS technology. Using data from a grid pattern, an isopach or 3-dimentional interpretation will be completed to estimate the volumes of available sand. Areas to be surveyed were selected from prior investigations that indicated large, extractable deposits of sand. This was based both on prior acoustic profiling and sampling. To ensure the resolution is sufficient to allow for proper interpolation, the proposed grid pattern will have a spacing of 500 feet while paralleling the coast and 1000 feet while operating perpendicular to the coastline. The areas proposed for the geophysical survey are shown in Figure 1.5-2.



Figure 1.5-2. Proposed Areas for Geophysical Surveys

In addition to the acoustic profiles, the bottom of the selected study areas will be surveyed with side-scan sonar. This procedure locates any abrupt change in the bottom contour that may indicate debris, shipwrecks, or even vegetation growing on the bottom. This will prevent damaging dredging equipment if debris is found within the zones selected for borrow areas or damaging vegetation that has high value to marine life.

During the geophysical survey, some locations will be selected to obtain actual samples of the sediments to provide accurate correlation between the interpretations and actual conditions. The contractor that performs the geophysical survey will obtain these samples during the operation.

These samples will also provide for a general analysis of grain size distribution, particle shape, and color. All of these are important in selecting the borrow areas prior to placing the sand on beaches.

The results of the geophysical surveys will be used to estimate both location and quantities of the required sand. After the acoustic profiling is completed, the next phase will be a more complete exploration program that will verify the results of the geophysical survey. This phase will consist of taking numerous Vibracore samples which provide a continuous sample from the sound/gulf bottom to a depth of 20 feet. The spacing of these holes will be sufficient to ensure that the extracted sand meets all quality specifications from a given location.

1.5.4 Tectonic and Seismic Considerations

Tectonic and Seismic Considerations - Numerous studies have been made concerning subsidence around the mouth of the Mississippi River. General thoughts have attributed the subsidence to the sediment loading of the lower delta as the river enters the Gulf of Mexico. Other studies have concluded that recent faulting has occurred associated with both subsidence along the coast and uplifting in the coastal plain (Bowen, 1990). While this low order faulting in soft sediments produces no significant seismic events, associated displacements must be considered even if very small. Computed subsidence of first-order benchmarks has concluded that the Mississippi coast had a subsidence rate of 5 mm/year during the later half of the 20th century and continues to subside, (Shinkle and Dokka, 2004). These rates are the subject of much discussion among various agencies due to the fact that the primary benchmarks may not be stable thus influencing the results any surveys. The need to update the benchmarks to provide accurate elevation data is recognized by the National Geodetic Survey. Mississippi's subsidence has been factored into the relative sea level rise based on over eighty years of observation at three tide gauges along the coastline, Gulfport, Biloxi and Pascagoula. The relative sea level rise is based on both actual changes in sea level and any subsidence combined into a single value. This change would be what the casual observer would notice over time along the coast. The relative sea level values will be considered in all designs.

1.5.5 On-shore Borrow Areas

Coastal Mississippi, On-shore: There are a large number of commercial sources for different types of soil along the three coastal counties of Mississippi. Depending on the project, these sources may be utilized for construction of levees, beach nourishment and dune restoration. Deposits of sand found in the Prairie formation may be of beach quality and have potential use for beach nourishment along the mainland beaches. The presence of the Prairie and Citronelle formations in much of the study area can provide necessary reserves for construction of levees. The sands included in these formations can also be evaluated for beach restoration. These sources are permitted by the Mississippi Department of Environmental Quality which publishes a list of permit holders. A review of the listed sources shows that Jackson County has 14 operations, Harrison County has the most with 63 sources and Hancock has 33 sources. These locations are shown in Figure 1.5-3. Not all the listed sources are believed to be active operations. At the present time, no information is available on specific soil properties such as classification, gradations or color, all of which will be important characteristics if used for beach nourishment. This information will be collected before any material is selected for use. Attempts will be made to contact each of the listed operators to compile a current list of sources that will provide an estimate of reserves, operational output, and more specific information on the material that is actually produced. A review of the permitted size (acreage) of most of the operations indicates that their individual site reserves may be less than one million cubic yards, but collectively contain vast quantities of material. Many of the sources list specific information as to what type of material that they produce while some of the permits do not indicate the type of formation that is being mined other than a general statement such as "dirt". A list of the permitted

sources for Jackson, Harrison and Hancock Counties are shown in Table 1.5-1, 1.5-2, and 1.5-3, respectively.

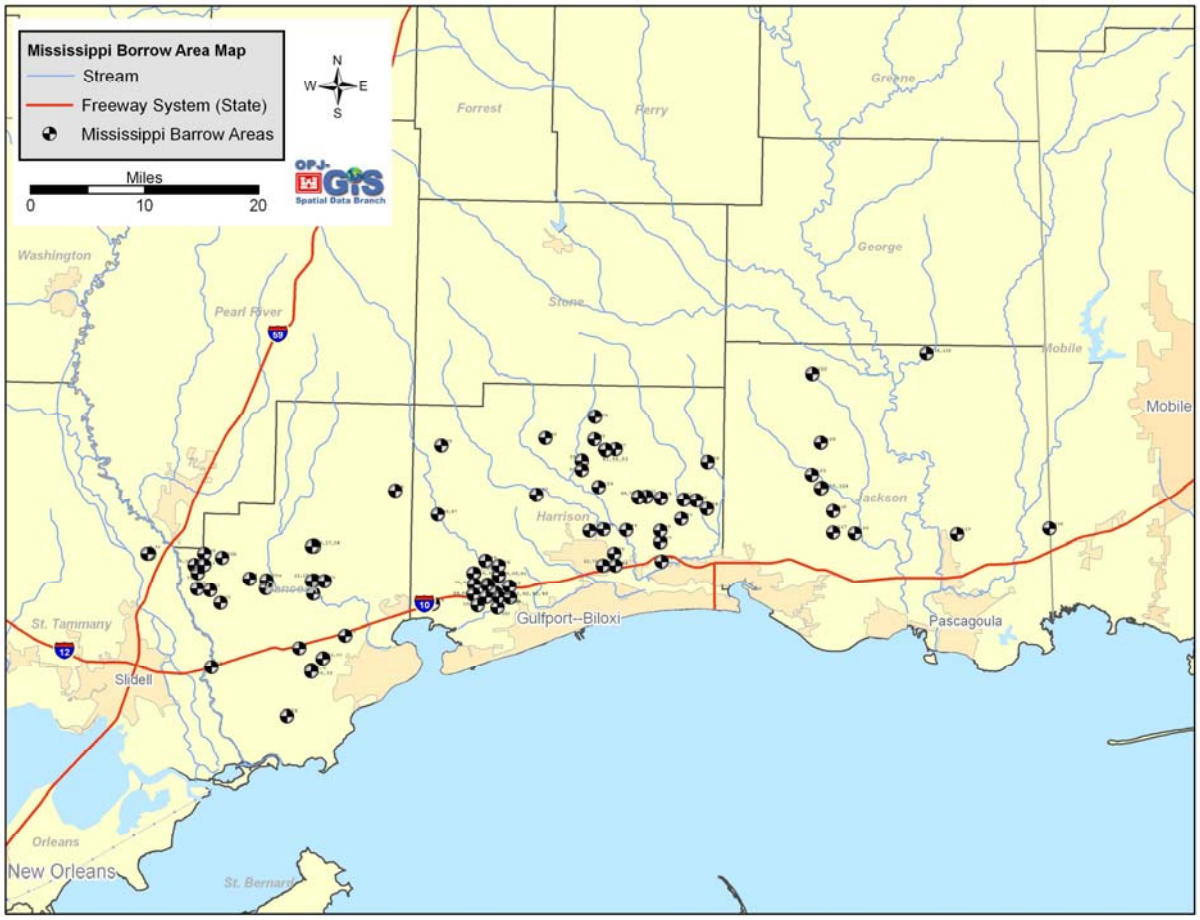


Figure 1.5-3. Location of Permitted Mining (Borrow) Operations in Coastal Mississippi Counties

Table 1.5-1.
Permitted Borrow Areas in Jackson County

County	Operator	Permit #	Permitted Acres	Material
Jackson	Bright	N/A	20	sand and clay
Jackson	Ward	P02-037	35	sandy clay
Jackson	Hence	P04-019	25	clay and sand
Jackson	Blain	P83-002	6	sand
Jackson	Yates	P-87-045T	29	sand and clay
Jackson	Jackson C	P91-061	10	sand and clay
Jackson	Mellette	P92-054	19	sand clay
Jackson	Talley	P93-020	24.8	dirt
Jackson	Graham	P93-029	20	sand and clay
Jackson	Dees	P94-036	6	dirt
Jackson	Dees	P95-058	16	dirt
Jackson	Jackson C	P96-014	19.5	soil clay fill
Jackson	Mellette K	P98-057	30	clay & sand
Jackson	Ward	P98-063	60	sandy clay

Table 1.5-2.
Permitted Borrow Areas in Harrison County

County	Operator	Permit #	Permitted Acres	Material
Harrison	Waits	N/A	40	fill dirt
Harrison	Fore	N/A	40	
Harrison	Blacker	N/A	49.6	soil
Harrison	Dirt works	P00-020	9.7	sand
Harrison	Anchor	P00-065	20	fill dirt
Harrison	Dirt works	P01-014A	21.98	dirt/clay
Harrison	Williams D	P02-004	25.6	dirt
Harrison	Edwards	P02-007	12.7	dirt, sand and gravel
Harrison	Wallace T	P02-018	53	dirt
Harrison	Wallace T	P02-045	40	dirt
Harrison	fore	P03-010	38.2	dirt and sand
Harrison	Edwards	P03-044	7	sand, gravel and dirt
Harrison	TCB	P03-046	20	clay/sand
Harrison	Lamely D	P04-006A	25	clay, sand
Harrison	Edwards	P04-017AA	22.5	sand and dirt
Harrison	Du Pont	P04-036	38	clay
Harrison	Wetzel	P04-37	5.6	sand
Harrison	Fore	P04-043A	46.17	sand
Harrison	Fore_W. C.LLC	P05-005	40.02	sand
Harrison	Fore_W. C.LLC	P05-006	40.4	sand
Harrison	Saunders	P05-007	14.2	clay, sand
Harrison	Fore_W. C.LLC	P05-010	44.23	sand
Harrison	Warren Paving	P05-025	14.5	dirt
Harrison	Dirt	P06-002	15	dirt
Harrison	Cams	P80-022	20	fill dirt

Table 1.5-2.
Permitted Borrow Areas in Harrison County (continued)

County	Operator	Permit #	Permitted Acres	Material
Harrison	Griffin	P81-030T	8	fill dirt
Harrison	Fore	P87-027	28	sand and clay
Harrison	Blackmer	P87-029T	8	clay/sand
Harrison	Dirtworks	P87-048T	5	fill dirt
Harrison	Mid C	P88-012	20	fill material
Harrison	Gulf	P88-025T	12	sand and gravel
Harrison	Fore	P88-027	30	sand and clay
Harrison	Fore	P88-027A	76	sand and clay
Harrison	Parker	P89-007	5	fill dirt
Harrison	Cams	P89-019	10	sand clay
Harrison	Lamey D	P89-022	5	fill dirt
Harrison	Ladner	P90-023	6.5	sand and gravel
Harrison	TCB	P90-024T	4	sand and gravel
Harrison	Ray	P92-014	10	soil/borrow
Harrison	Parker	P92-066	3	dirt
Harrison	Holden	P92-079T1	4.5	dirt
Harrison	Blackmer	P92-089	12	clay/sand fill
Harrison	Twin	P92-093	10	clay/sand fill
Harrison	Ladner	P93-009	6	sand and gravel
Harrison	Holden	P93-012	8	sand and clay
Harrison	Holden	P93-041	19.4	sand-clay
Harrison	Lamey D	P93-051	10	fill dirt
Harrison	Breeland	P93-064T	32	fill dirt
Harrison	Dubuison	P93-113	0.7	sand clay
Harrison	Newells	P94-035	11.5	clay sand gravel
Harrison	Holden	P94-064T1	4	fill material
Harrison	Blackmer	P95-018	28	sandy clay
Harrison	Holden	P95-073	20	clay, sand-clay
Harrison	Dirtworks	P95-080T	7	fill dirt
Harrison	Fore P	P95-082	3	sand and gravel
Harrison	Fore P	P95-083	3	sand and gravel
Harrison	Holden	P96-022T1	8	dirt
Harrison	Fore C	P96-047	30	sand and clay
Harrison	Parker	P96-067	3	dirt
Harrison	Holden	P97-021	15	clay and sand clay
Harrison	Twin	P98-048	35	sand and gravel
Harrison	Prince	P98-055	10	sand and clay
Harrison	Wallace T	P99-052T	22	sand clay

Table 1.5-3.
Permitted Borrow Areas in Hancock County

County	Operator	Permit #	Permitted Acres	Material
Hancock	Gibson	P00-034	4	fill dirt
Hancock	Boudin	P00-058	10	sand/clay/fill
Hancock	Phillips Tru	P02-016	40	sand and clay
Hancock	Fore	P02-027	37.25	dirt and sand
Hancock	Cuevas	P02-058	4	clay gravel
Hancock	B&C	P03-011A	12	dirt and sand
Hancock	Henley C	P03-028	8.75	clay and sand
Hancock	DK Agg	P04-007	40	sand and gravel
Hancock	DK Agg	P04-008	20	dirt/clay
Hancock	Frierson	P04-012	6	sand and clay
Hancock	Larry Nicks	P05-001	12	sandy clay
Hancock	Phillips Tru	P05-003	25	sand and dirt
Hancock	Knight	P86-016	1	sand and gravel
Hancock	Fore	P92-024	20	borrow/soil
Hancock	TCB	P93-022	25	sand clay
Hancock	SCI	P93-033	13.1	borrow
Hancock	Fore	P93-048	29	fill dirt
Hancock	Fore	P93-048	N/A	fill dirt
Hancock	Ladner P	P93-079	15	sand and clay
Hancock	Haas	P93-110	16.3	sandy clay
Hancock	Frierson	P95-012	4	dirt
Hancock	Fore	P95-047T	10	sand and sandy clay
Hancock	Henley C	P96-008	3.7	clay/sand
Hancock	C & G	P96-064	5	dirt/sand
Hancock	Ladner R	P97-023	3	fill dirt
Hancock	Pittman	P-97-032	46	sand and clay
Hancock	Fricke's	P97-044	6	sand and sandy clay
Hancock	Fore S	P-97-045T	20	sand and gravel
Hancock	Thigpen	P98-017	9	sand and gravel
Hancock	Fore	P98-064T	10	sand/clay/fill
Hancock	Fricke’s	P98-065	8.7	sand, sandy clay
Hancock	Moran	P99-021	31.5	fill dirt
Hancock	Thigpen	P99-034	14	sand and gravel

Some projects along the coast are already under design as interim projects and will require sand for beaches. These projects are located in all three coastal counties and the in-place quantities are as follows:

- Jackson County, Pascagoula Beach - 270,000 cubic yards sand
- Harrison County Beach - 681,000 cubic yards sand
- Hancock County, Bay St, Louis Seawall - 159,000 cubic yards sand

All of these projects are limited in scope and could be easily supported by local on-shore commercial operations or sand deposits that have located just offshore. These offshore sand deposits are limited

in size and may be due to past beach construction and nourishment projects where the sand was eroded from the beach due to storms and wave action.

1.5.6 Offshore Borrow Areas

To provide the sand necessary to rebuild or nourish the beaches on the barrier islands, large quantities of quality sand must be located. The inventory of these sand resources has been the subject of many studies. Within the Seven Point Hurricane Recovery Strategy developed by the Governor of the State of Mississippi, one is restoring the barrier islands of the coast of Mississippi to a pre-hurricane Camille footprint. This is addressed in this appendix as Option A under the Barrier Islands. This will involve establishing islands of a size similar to a pre-Camille condition with allowances made for migration of the islands over time. This includes an estimated 30 percent loss of volume during placement due to the losing finer sand particles in the outwash. All of these areas may be contained within the littoral drift zone that transports sand along the chain of barrier islands. The impacts of transferring this sand within the littoral drift zone will be evaluated through sediment transport models. Some of these areas also are within the boundaries of the Gulf Islands National Seashore which extend one mile from the shores of Petit Bois, Horn, and Ship Island. Other than close to the mainland and island beaches, most areas within the Sound are expected to have muddy Holocene deposits overlying any sand deposits. These deposits may render the sand unusable without segregation of the different materials prior to being placed along the beaches.

At the present time, four areas have been selected for acoustic profiling near the barrier islands to assist in identifying potentially useful deposits of sand. An initial quantity of 66,000,000 cubic yards of sand has been estimated for use on the barrier islands as the quantity of sand for restortation to a pre-Camille footprint as described above and would be the target for this survey. During hurricane Katrina, the breach of Ship Island was widened to approximately three to four miles. This breaching also occurred during Hurricanes Fredrick and Camille with a low sand spit reforming over time. This erosion and other lesser amounts of erosion on the other islands has scattered sand on an area of unknown extent. Much of this sand may still remain in the littoral drift zone. It may eventually be transported where it could be naturally deposited on a beach. However, this process is slow and will not aid in storm protection for a very long period of time. Identification of these sand deposits and using them to restore the island would provide a more timely protection for the coast during lower intensity storms.

If the islands were restored to the pre-Camille footprint, the restoration of Ship Island will be the largest single project requiring up to 30,000,000 cubic yards of excavated sand. This volume is roughly based on restoring the breach to an island width of 2,000 feet (including submerged portion) for the full length of the breach and bringing sand dunes to at least 20 feet above sea level with a 10 foot existing water depth. This height will allow better protection against breaching during future low intensity storms (Otvos, oral comm. 2006). Based on previous work (Otvos, 1975/76 and Upshaw, Creath, and Brooks, 1966) which involved sampling and sub-bottom profiling, four areas have been selected for exploration using acoustic profiling and vibracore sampling. This procedure has been previously described in Proposed Off-shore Geophysical Exploration and the proposed areas are shown in Figure 1.5-2. Three of the areas are located either partly or wholly within the boundaries of the Gulf Islands National Seashore and any work within these boundaries must be coordinated with the National Park Service. These boundaries include Petit Bois, Horn and Ship Islands. Petit Bois and Horn Islands are also designated as Wilderness Areas by the Park Service and receive a higher level of protection than Ship Island.

Review of the samples that were collected during these and other studies also indicate that sand deposits underlie some of the Holocene deposits within the Mississippi Sound. The use of these sands for beach nourishment would be dependant on segregation and removal of the overlying

muddy Holocene sediments. The Holocene sediments may have some value for use in the creation of marshes and wetlands that could be considered if the underlying sands were needed to complete a project. An example of this condition exists about two miles south of Deer Island. In a boring referenced as Hole 785 and reported by Otvos (1985), the bottom of the Sound was recorded at 9.0 feet. From 9.0 to 13.3 feet the sample was described as muddy medium sands, poorly sorted. Underlying this muddy sand, the samples showed medium sand from 13.3 to 16.7 feet and very to well/moderately sorted, fine sand from 16.7 to 27.1 feet.

As one might expect, much of the quality sand deposits are within the littoral drift zone of the barrier island chain. This high energy environment provides a sorting process that allows for deposition of sand while preventing finer grained sediments from being deposited. While not removing the sand from the littoral drift zone, the process of relocating of sand from any given area within the drift zone and transporting it to another area within the zone must be considered. Using the same reference as above (Otvos, 1985), a boring taken within the littoral drift zone between Horn and Ship Inland, Boring S-6, the upper eleven feet of sediment to be well to moderately well sorted medium sand with additional sand units below.

Prior studies of the St. Bernard Shoals (Oral Communication, USGS, 2006) are probably the best source of the sand, although additional studies and sampling will be required to ensure the sediments meet the quantity and quality requirements. St. Bernard Shoals are a series of submerged barrier islands located south of the existing islands (see Figure 1.5-4) and are believed to contain substantial quantities of high quality sand, more than enough to supply the quantity needed for any use at the barrier islands. The US Geological Survey is presently compiling historical data on offshore sand deposits that will include the St. Bernard Shoals area. This study will also include some sampling of selected areas.

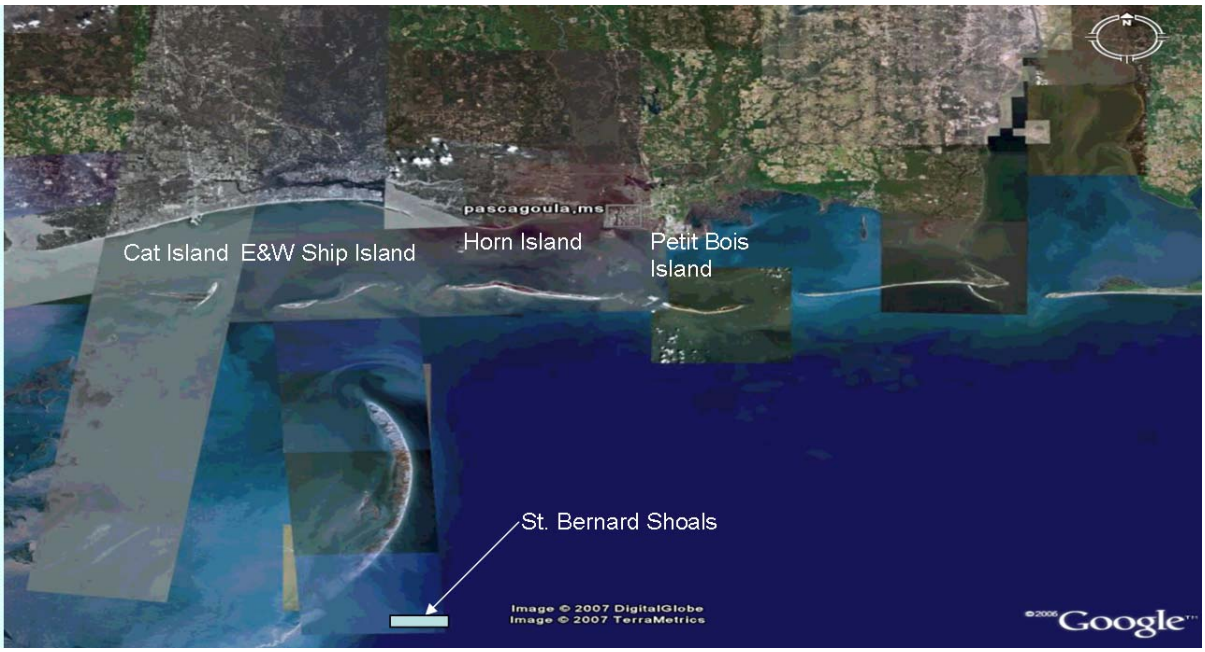


Figure 1.5-4. Map Showing the Location of St. Bernard Shoals

1.5.7 Inland River System Sand (Dredged Material)

After the construction of inland waterways in Alabama and Mississippi, maintenance dredging is sometimes required to maintain the channel depths and alignments. This material is typically moved to disposal areas along the banks of the river where it accumulates in diked areas. Figure 1.5-5 shows an aerial view of one of the sites. Dredging of some of the areas along the river produces large quantities of sand that have potential use for beach nourishment. An inventory of current disposal sites indicates that approximately 30,000,000 cubic yards of sand may be available. Information on available sand on these two river systems is shown in Tables 1.5-4 and 1.5-5. Only disposal sites that contain a minimum of 100,000 cubic yards of sand were included in the inventory. Of interest to this study are disposal sites that are located along the Black Warrior – Tombigbee River system and the Tennessee – Tombigbee Waterway. Figure 1.5-10 shows the relationship of these disposal areas to the project sites along the Mississippi coast. The range of haul distances (by water) to the barrier islands western extent varies from 163 to 500 miles. Material from these sites could easily be transported by barge down the river system for use along the beaches. The cost to store this type of dredged material is high and it has recently been estimated that removing the sand from the existing disposal areas would save the Government over $100,000,000 at today's cost.



Figure 1.5-5. Sunflower disposal area on the Tombigbee River with large quantities of sand available for use on coastal projects in Mississippi

Table 1.5-4.
BWT Dredge Material Disposal Areas Over 100,000 CY

Site	River Mile	Acquisition	Access/ Land	Access/ River	Est Material Placed To Date(CY)
C	78.2	Easement	No	Yes	1,500,000
D-1	82	Easement	No	Yes	515,000
E	86	Easement	No	Yes	250,000
E-2	87	Fee	No	Yes	110,000
F	88.5	Easement	No	Yes	315,000

Table 1.5-4.
BWT Dredge Material Disposal Areas Over 100,000 CY (continued)

Site	River Mile	Acquisition	Access/ Land	Access/ River	Est Material Placed To Date(CY)
I	91.5	Easement	Yes	Yes	260,000
J	96	Easement	No	Yes	140,000
N	103.5	Easement	No	Yes	1,400,000
R	105	Fee	No	Yes	130,000
X-2	108	Fee	No	Yes	205,000
X	108.2	Easement	No	Yes	1,500,000
X-4	108.4	Fee	No	Yes	810,000
Z	108.6	Easement	No	Yes	1,250,000
CA-1	191.3	Easement	Yes	Yes	135,000
BA	297	Easement	No	Yes	300,000
AD	299.2	Easement	No	Yes	440,000
AE	300.4	Easement	No	Yes	465,000
AF	307	Easement	No	Yes	1,600,000
AG	313	Easement	No	Yes	1,020,000
BE	324	Easement	Yes	Yes	160,000
BD	329	Easement	No	Yes	170,000
TOTAL					**12,675,000**

Table 1.5-5.
TTW Dredge Material Disposal Areas Over 100,000 CY

Site	River Mile	Acquisition	Access/ Land	Access/ River	Est Material Placed To Date(CY)
D-20	243.5	Easement	Yes	Yes	721985
D-24	249.5	Easement	Yes	Yes	196392
D-25	250.6	Easement	No	Yes	257137
D-29	256.5	Easement	Yes	Yes	127014
D-30A	257.3	Easement	Yes	Yes	750654
D-30B	257.7	Easement	Yes	Yes	195291
D-31A	259.3	Easement	Yes	Yes	298684
D-31B	260.3	Easement	Yes	Yes	231121
D-33	263.1	Easement	No	Yes	1825225
D-36	265.4	Easement	Yes	Yes	900317
G-13	287.8	Easement	No	Yes	242129
G-14	289.4	Easement	Yes	Yes	622745
G-15	290.5	Easement	No	Yes	710754
G-18	295.4	Easement	Yes	Yes	249803
G-20A	297.6	Fee	No	Yes	209650
G-21	299.8	Fee	No	Yes	1653977
G-22	301.8	Easement	No	Yes	116938
G-24	303.6	Easement	No	Yes	244175
G-25A	304.8	Easement	Yes	Yes	694172
G-26	305.7	Easement	Yes	Yes	295961
AL-7	317.3	Easement	Yes	Yes	109131

Table 1.5-5.
TTW Dredge Material Disposal Areas Over 100,000 CY (continued)

Site	River Mile	Acquisition	Access/ Land	Access/ River	Est Material Placed To Date(CY)
AL-9	320.4	Easement	No	Yes	334863
AL-13	326.4	Easement	Yes	Yes	1274697
AL-14	328.2	Easement	Yes	Yes	271563
AL-16	333.6	Easement	Yes	Yes	130691
C-14	350	Easement	Yes	Yes	575875
C-18	352.1	Easement	No	Yes	140864
C-19	353.3	Easement	Yes	Yes	1049792
C-20B	355	Easement	Yes	Yes	148024
AB-6	362.3	Easement	No	Yes	270663
AB-9	364.3	Easement	Yes	Yes	116522
AB-12	365.9	Easement	Yes	Yes	3171722
AB-13	366.5	Easement	Yes	Yes	448743
PE-3	410.2	Easement	No	Yes	195636
PE-4	411.1	Easement	No	Yes	122290
TOTAL					18,905,200

Because of the shortage of additional disposal areas, the Corps of Engineers' Operations Division has contracted for several studies on the beneficial use of the sand. Some of these studies have been targeted at using the sand for beach nourishment, (Thompson Engineering, 2001). Using sand samples from some of the inland disposal areas along the Black Warrior – Tombigbee River, a series of analyses were conducted on the samples. For comparison purposes, several samples of actual beach sand and from the littoral drift zone from coastal Alabama were taken and subjected to the same tests. These tests included grain size distribution (gradation), color and roundness. The results of the tests indicated that some of the samples may be suitable for beach nourishment. The sand from the river was typically a finer grain size that the beach sand with the predominant river size being a fine sand while the beach sand was mostly medium sand. It was also noted that the beach sand was slightly more rounded than the river sand.

One factor that warranted further analysis was the color difference of the river sand as compared to the beach sand. All of the river sand had a brown tint described as "very pale brown" or "light yellow brown". This compared to the beach sand samples which were described as "pale olive, white or light grey". These colors were assigned along with evaluations for hue, value and chroma from a Munsell Soil Color chart which provides a standard method of assigning color to soils. The report also noted that beach sand came from a higher energy environment where any staining due the depositional environment may have been removed by abrasion due to wave action. It also noted that the sand might undergo bleaching from the ultraviolet radiation from the sun if the color was caused by a mineral staining. To test these conditions that may change the color of the sand, a series of tests were conducted on samples from the same areas that were used during the initial analyses, (Thompson, 2002). The samples were subjected to two tests. The first involved actual bleaching of the samples using a chemical oxidizer, hydrogen peroxide, for different periods of time. These tests did indicate that the bleaching process was detectable after 72 hours. Other tests were conducted to simulate the process of wave action causing an agitation of the particles which may remove any mineral coating or staining along with exposure to ultraviolet light. This process was conducted for 144 hours without a notable difference in color.

Other studies on the dredge disposal areas by the Bureau of Mines, U.S. Department of the Interior were conducted to characterize the sand for use as an aggregate in making concrete (Smith, 1995). While these tests were not directed at use of the sand for beach nourishment, they did supply information on chemical and physical characteristics of the materials from several locations. These tests provided data that shows the sand to be clean, mostly fine grained, quartz sand with little of no fines, to be non-toxic based on Toxic Characteristic Leachate Procedure (TCLP) and to contain very little heavy minerals. All of these tests would indicate the material would be safe to place on a beach.

Review of the documents referenced above indicated that the color issue was not resolved and this would be an important factor in the use of the sand on the barrier island beaches. The methods employed, beaching and agitation with exposure to ultraviolet light, were not considered to be effective in removal of what is suspected to be the basis of the color on the sand grains, amorphous iron oxide more commonly referred to as rust. Hydrogen peroxide is a common household bleaching agent that is effective in oxidation of organic matter, but would not effect iron oxide through chemical removal. The same is true for the effects of ultraviolet light on iron oxide. The idea of using agitation would be the most effective of the methods attempted if the color was a coating on the mineral grains, but the test, as conducted, was not conclusive.

With the renewed interest in the possibility of using the sand as a source of material for the littoral zone associated with the Mississippi barrier islands, the disposal areas warranted further study. Again the color of the sand is a concern that has been raised by the National Park Service who has control of the Mississippi Barrier Islands. This concern has both aesthetic and environmental aspects. Aesthetically, the beaches on the barrier islands are composed of relatively white sand. Numerous studies have indicated that the primary source of this sand is an Appalachian origin probably associated with river systems discharging onto the Continental Shelf of present-day Florida (Stone and Others, 2004). This sand is transported westward from the discharge of the river into the Gulf of Mexico. Transport of this sand along the prevailing littoral current has created the white beaches and barrier islands that extend from the mouth of the river in Florida westward across Alabama to Mississippi.

Looking at the color differences of the sand along this system reveals a definite change as shown in Figure 1.5-7. The sample on the left was taken from sand dredged from the Chattahoochee River which is a major tributary of the Apalachicola River. This sampling location is approximately 150 river miles above the Gulf. The middle sample was taken from Disposal Area 39 on the Apalachicola River approximately 37 river miles above the Gulf. The sample on the right was taken from the south beach of Petit Bois Island in Mississippi. Note the change progressive change in color from brown to tan to white.

Geochemical processes could account for the consistent staining of the sand grains while in the river system. As the sand entered the Gulf's littoral system, changes in the geochemical process would not allow additional staining of the sand and any removal of the coating would allow the underlying sand grain to display its true color. The mechanical process of abrasion would occur both in the river system and the littoral system, but if the iron oxide staining was continuously reoccurring in the river system, the resulting color would remain. As the sand grains entered a different geochemical environment where re-staining did not occur, it would account for the difference where the color was a coating. Review of selected sand samples taken from the Black Warrior–Tombigbee River system disposal areas the reveal the same general color that is characteristic of the Chattahoochee-Apalachicola River system. Figure 1.5-8 is a photograph of five samples that include the same samples used in Figure 1.5-7 plus two additional samples, one from the Black Warrior River and another from the Tombigbee River. Note the similarities in color of the Apalachicola River (fourth from left), the Black Warrior (third from left and marked BWT North Star), and the Lower Princess (second from left, Lower Tombigbee River).

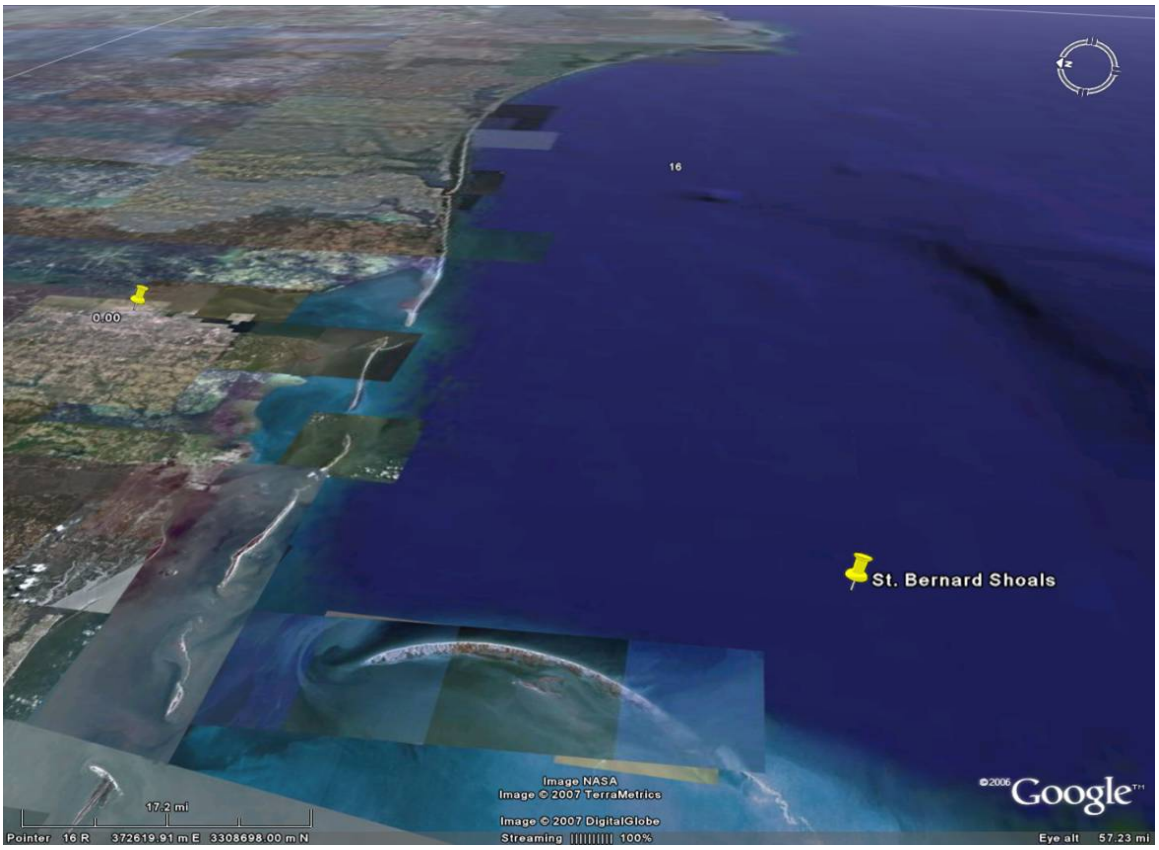


Figure 1.5-6. Littoral zone (white beaches and islands) along Central Gulf Coast extending from Bay County, Florida (top of picture) to Mississippi Barrier Islands (lower left), looking east



Figure 1.5-7. Samples of sand taken from (left to right) Chattahoochee River Mile 150, Disposal Area #39 on the Apalachicola River, and Petit Bois Island



Figure 1.5-8. Samples of sand taken from (left to right) Chattahoochee River Mile 150, Disposal Area #39 on the Apalachicola River, North Star disposal area on the Black Warrior River, Lower Princess disposal area on the Tombigbee River, and Petit Bois Island in Mississippi

Assuming that the previous testing was not effective at removing the iron oxide staining on the sand grains, a different bench-top test was performed. If iron oxide is only a coating on the sand grains and occurs as a stain, abrasion would be effective in the removal. The addition of a week acid would also aid in keeping the iron oxide from re-coating the sand grains as it is being removed. For the experiment, I used a small "rock tumbler" of the type used to polish small stones. Into the chamber of the rock tumbler was added a small quantity of sand obtained from the Lower Princess disposal area on the Tombigbee River, enough water to just cover the sand and a tablespoon of "Zud". Zud is a household cleaning product that is composed of oxalic acid and abrasives. Oxalic acid is a weak acid commonly used to remove rust stains. Zud contains about 10% oxalic acid and 90% fine abrasives. The tumbling chamber was closed and placed the tumbler. An electric motor spins the chamber which allows the contents to tumble. This process would mimic the process of sand grains being transported along the littoral zone with the sand grains being abraded as they strike each other. In the almost infinite volume of water in the Gulf, any iron stain that was removed would not re-coat the sand, but be diluted away. This process started on 4 October 2007 and concluded 10 October 2007. The tumbler did not run over the included long weekend, but did operate for about 4 days. At the completion of the tumbling process, rinse water was added and decanted several times until the turbidity levels dropped and the fines were removed. The remaining sand was air dried and placed in a clear plastic bag for comparison with sand from the same parent sample. As shown in Figure 1.5-9, the results of the experiment are quite dramatic. The tumbled sand lost most of the tan color and is approaching white. This supports the process that occurs with the tan sand from the Apalachicola River system becoming the white sand so familiar to beach-goers along the central Gulf Coast.



Figure 1.5-9. Samples of sand taken from (left to right) North Star disposal area on the Black Warrior River, Lower Princess disposal area, and "Tumbled Lower Princess disposal area"

Adding the sand into the littoral system along the gulf coast should provide the proper geochemical and mechanical processes to remove the iron staining and provide the quality of sand that is desired as it is transported along the littoral drift zone which contain the Mississippi Barrier Islands. Littoral zone placement will also allow additional sorting by the currents and rounding of the sand grains through continued abrasion during transport. Additional research and testing will be conducted to ensure that these processes will in fact provide sand that is compatible with the existing sand in the barrier island system.

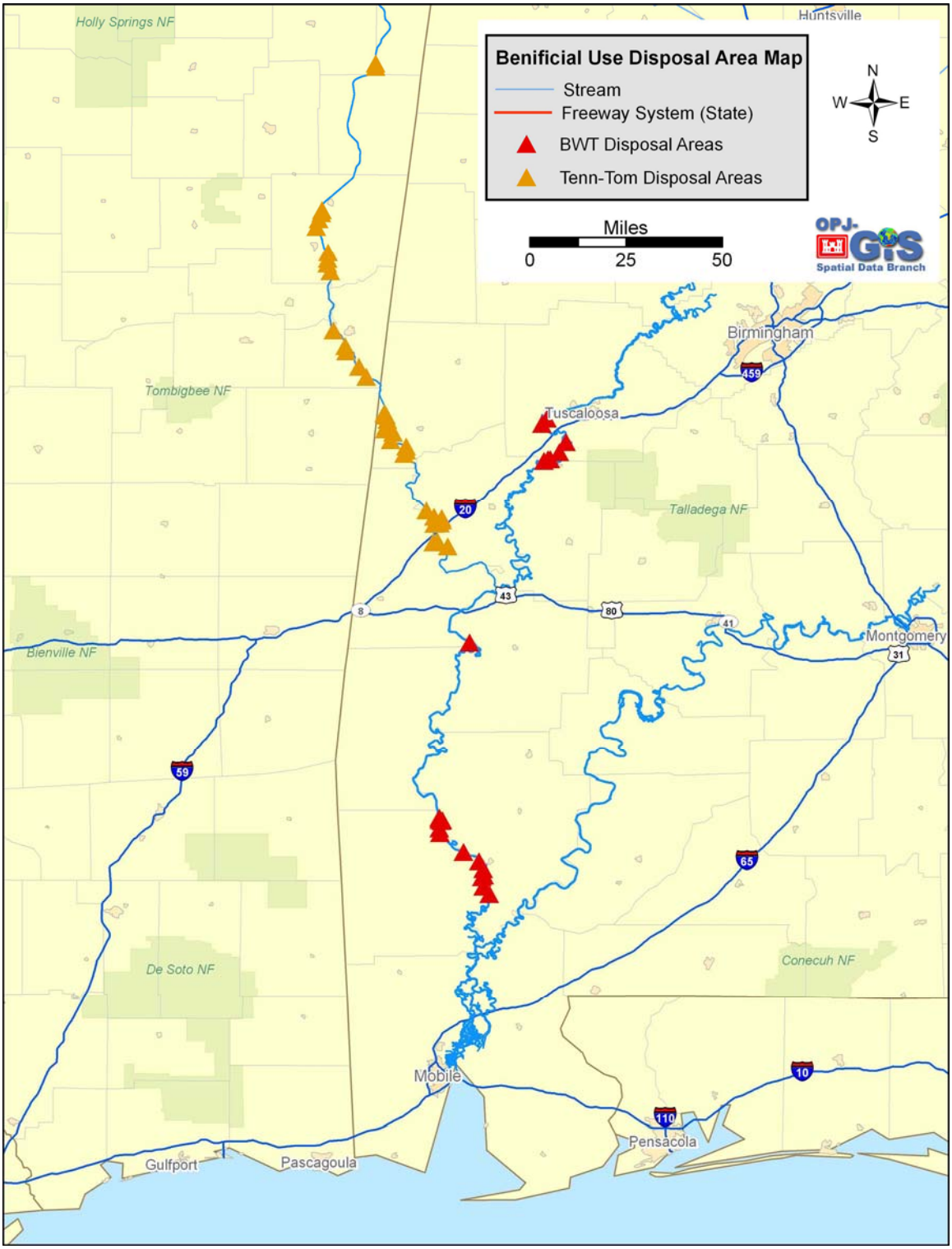


Figure 1.5-10. Inland Disposal Areas that Contain Economic Deposits of Sand

1.5.8 References

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1.6 Sea Level Rise

Systematic long-term tide elevation observations suggest that the elevation of oceanic water bodies is gradually rising and this phenomenon is termed ‘sea level rise.’ The rate of rise is neither constant with time nor uniform over the globe. Present estimates of recent (over about the last 100 years)

global average, or eustatic, sea level rise are varied but the average value is about 2 millimeters per year. Sea level is rising due to global warming, and there is uncertainty as to the future rate of sea level rise, how much sea level will rise at any particular location, what the primary drivers of global warming really are, and whether the rate of rise will be relatively constant or accelerate. Regardless of these uncertainties, with 60 percent of the world's population, and 53 percent of the US population, living near the shoreline (Reference 1), sea level rise is a phenomenon which requires society's sustained attention and requires planning with consideration to the needs and protection of future generations.

Sea level rise may be viewed in different ways. 'Eustatic' sea level rise refers to estimates of the rate of sea level rise applied uniformly over the earth's oceanic water bodies. This is an interesting concept and useful for communicating an averaged rate, but because sea level rise is not uniform over the globe, it is not perhaps the most useful concept from a local or regional engineering point of view. Eustatic sea level concepts are usually associated with studies of pre-historic sea level and predictions of future sea level behavior but have been used in the Gulf Coast region in forensic studies of modern coastal subsidence rates (Ref. 2).

'Relative' sea level rise (RSL) at a given location is the change in mean sea level at that location with respect to an observer standing on or near the shoreline. It is determined by fitting a linear relationship to monthly mean or annual mean sea level, either of which is computed from tide gage observations. The slope of the fitted line gives the rate of sea level rise at the location of the tide gage. The computed rate includes the rate of subsidence or uplift of the location upon which the tide gage is founded, and thus the computed RSL rates may be extended locally or regionally to areas with similar geotechnical and tidal conditions.

The National Research Council (NRC) alternatively defines relative sea level change as "the difference between eustatic (global) sea level change and any change in local land elevation" (Ref. 3). This definition is in keeping with the previous interpretation in that local vertical land motion is represented in the change estimate, however, it seems to equate eustatic sea level change to the local absolute sea level component of that change, whereas the previous interpretation makes no such assumption. In practice, the distinction is often ignored because, excepting at the poles where sea level rise would be expected to be higher than an average eustatic value, there are no consistent relationships between eustatic sea level rise and sea level rise at any particular location.

Corps of Engineers Planning Guidance Notebook (Ref. 4) states that potential relative sea level rise should be taken into consideration for coastal or estuarine projects at the feasibility level of study and recommends, given the uncertainty of future sea level rise estimates, preference be given to developing strategies that are robust over the entire range of potential sea level rise rates versus those that perform well only over a limited range of potential sea level rise rates. The guidance states that, at a minimum, project performance would be evaluated based on extrapolation of the observed historic rate and should also consider a higher rate than that historically observed. The guidance specifies, in the absence of more current, definitive information, that Curve 3 of the 1987 NRC study (Ref. 2), a curve presented as a high forecast rate of rise, be used as the eustatic component in estimating the locally 'higher than observed' rate.

It is necessary then to determine (a) the observed historic relative rate of sea level rise along the Mississippi Gulf Coast, (b) the observed and/or forecast rates of subsidence there, and (c) the Curve 3 rate and, if available, other updated, definitive estimate of eustatic sea level rise that may be extended to the Mississippi coast. The following sections describe these determinations.

MsCIP studies are interpreting the guidance as requiring estimates of the magnitude of sea level rise for the expected project life beginning at the base year. Early on in the study, this time period was set at 2005-2100, but has since been revised to 2012 through 2011 (100 years). A number of engineering activities had been well underway or substantially completed by the time the project

lifetime window had been revised and as such the relative sea level rise values used for those activities were not revised to the period 2012 to 2100. It will be shown that the difference in selected sea level rise predictions accorded these time windows is small and would not be expected to materially change one's impression of project performance in and of itself.

1.6.1 Mississippi Coast Relative Sea Level Rise

Apparently, no long-term Mississippi coast tide gage records had been used to quantify relative sea level rise since 1947. Mississippi is the only Gulf Coast state for which this is true.

The National Oceanic and Atmospheric Administration (NOAA) is responsible for monitoring, forecasting, and publishing U.S. tide data. In 2001, NOAA published RSL estimates for all of its National Water Level Observation Network (NWLON) tide gage stations with records equaling or exceeding 25 years (Ref 5). Twenty-five years is considered the minimum record from which reasonably reliable sea level rise rates might be determined. There were no NWLON stations in Mississippi meeting this criterion and no RSL estimates were published.

The Permanent Service for Mean Sea Level (PSMSL) was established in 1933 at the Proudman Oceanographic Laboratory, Liverpool, England and collects and interprets sea level data from approximately 2,000 tide stations world-wide. The PSMSL regularly updates RSL estimates for most locations they monitor; one of these is the NOAA station at Bay Waveland Yacht Club (USGS station no. 8747437), though the period of record at that station is considered too short to provide a reliable estimate of RSL.

Mobile District has long-term tide gages at Gulfport (USACE station no. 02481341), Biloxi (02480351), and Pascagoula (02480301). A 1947 report of the Mobile District Engineer submitted to Congress for the Harrison County Beach Erosion Control Study reported, based on 49 years of record at the Biloxi gage, that annual mean stage was "rising gradually and is now approximately 0.3 of a foot higher than at the turn of the century."[2] RSL was computed for these and other stations for present purposes by using the method of least squares to fit a linear relationship to the monthly mean tide level (MTL). Monthly MTL is the average of the daily high and low water observations. The resultant rate was multiplied by 12 to arrive at the average annual RSL rate. Annual MTL values (the average of a calendar year's monthly MTL values) were also fit for comparison to RSL rates computed using monthly data. This method is similar to that employed by NOAA and the PSMSL, though there are differences. Monthly data were not weighted by the number of days in each month in computing the annual MTL. Records for years missing more than 3 months of data were discarded to minimize seasonal bias. The differences are not of significance here.

Computed RSL rates and the standard error of rates, in millimeters per year, spanning coastal Mississippi are presented in Table 1.6-1. Computed RSL rates from the Permanent Service for Mean Sea Level (PSMSL) web site, from NOAA's report (Ref. 5), and from Mobile District, USACE are shown for comparison. Large discrepancies in the rates are mostly attributable to the period of record analyzed; in general, rates computed from longer records are considered superior. Smaller discrepancies are due to differences in methods used to compute the rates.

Neither NOAA nor PSMSL had estimated rates for the Mississippi tide gages at Gulfport, Biloxi, nor Pascagoula. This is probably because these gages have historically been owned and operated by the Corps of Engineers, though the Corps turned the Biloxi gage over to NOAA (USACE continues to collect data from that gage) in September of 1999.

[2] As reported in U.S. House of Representatives Document No. 682, 80th Congress, 2nd Session, 1948. 'Annual Mean Stage' is therein defined as the average of all hourly tidal readings in a calendar year (8,760 readings might be obtained in one year) and is analogous to 'annual mean sea level.'

The Gulfport and Biloxi gages are in Harrison County. The Pascagoula gage is in Jackson County. Long-term gage data is not available for any locations in Hancock County, but data from short-record gages at Waveland Yacht Club (Y.C.) and Waveland were analyzed and are presented in Table 1.6-1 but application of those results is not recommended due to the short periods of record at these sites.

Table 1.6-1.
Relative Sea Level Rise Rates in the Vicinity of Coastal Mississippi

			USACE based on			
			Monthly Average Data		Annual Average Data	
			MTL	MSL	MTL	MSL
	PSMSL (2006)	NOAA (2001)	mm/yr. + - std. error			
Grand Isle, LA	9.52 +/- 0.37	9.85 +/- 0.35				
Record	1974-2003 (52 yrs.)	1947-1999				
Bay Waveland Y.C., MS	16.31 +/- 7.83	NA	5.40 +/- 0.17	5.21 +/- 0.16	4.65 +/- 2.04	4.44 +/- 2.06
Record	1987-1992 (5 yrs.)		1979-1992		1979-1992	
Waveland, MS	N/A	8.05 +/- 9.28*	9.33 +/- 0.42	10.58 +/- 0.41		
		1997-? 6 yrs.	1997-2005			
Gulfport, MS	N/A	N/A	1.70 +/- 0.04	N/A	1.96 +/- 0.7	N/A
Record			1964-1999		1964-2002	
Biloxi, MS	N/A	N/A	4.73 +/- 0.04	N/A	2.26 +/- 0.26	N/A
Record			1960-‘98		1928-’76, ’79-98	
Pascagoula, MS	N/A	N/A	2.9 +/- 0.04	N/A	3.72 +/- 0.30	N/A
Record			1960-‘97		1940-‘97	
Dauphin Island, AL	3.31 +/- 0.62	2.93 +/- 0.59	3.07 +/- 0.04	3.08 +/- 0.04	2.96 +/- 0.52	3.01 +/- 0.55
Record	1967-2003	1966-‘97	1967-’68, ’72-’74, ’76-’80, ’82-’97, ’02-04		1967-’68, ’72-’74, ’76-’80, ’82-’97, ’02-04	
Pensacola. FL	2.12 +/- 0.17	2.14 +/- 0.15				
Record	1924-2003 (78 yrs.)	1923-‘99				

*NOAA (2004) TR NOS/NGS 50.

Table 1.6-2 shows what were adopted, based on length of record, as the RSL rates for the vicinity of USACE gages in Mississippi. The computed rate for Biloxi, taken in conjunction with the 0.3 feet observed rise from 1900-1947 (1.94 mm/yr), suggests a 20th century relative sea level rise there of between 7.8 to 9.3 inches. These values may be compared to those computed by NOAA (Ref. 5) for all Gulf of Mexico tide stations with records exceeding 25 years in length shown in Table 1.6-3. The RSL rates computed for the Mississippi stations are lower than the average of all Gulf station values and consistent with those for coastal Florida and the southwestern Texas coast.

Table 1.6-2.
Relative Sea Level Rise as Indicated by USACE MS Coast Gages

Location	Rise in mm/yr	Std. Error of Rise
Gulfport, MS	1.70	0.04
Record	1964-1999	
Biloxi, MS	2.26	0.26
Record	1928-’76, ’79-98	
Pascagoula, MS	3.72	0.30
Record	1940-‘97	

Table 1.6-3.
Relative Sea Level Rise Rates at Various Gulf Coast Gages

Station Name	First Year	Record Length	MSL Trend (mm/yr)	Std. Error (mm/yr)
Key West	1913	87	2.27	0.09
Naples	1965	35	2.08	0.43
Fort Meyers	1965	35	2.29	0.45
St. Petersburg	1947	53	2.4	0.18
Clearwater Beach	1973	27	2.76	0.65
Cedar Key	1914	86	1.87	0.11
Apalachicola	1967	33	1.53	0.58
Panama City	1973	27	0.3	0.64
Pensacola	1923	77	2.14	0.15
Dauphin Island, AL	1966	32	2.93	0.59
Grand Isle, LA	1947	53	9.85	0.35
Eugene Island, LA	1939	36	9.74	0.63
Sabine Pass, LA	1958	42	6.54	0.72
Galveston Pier 21, TX	1908	92	6.5	0.16
Galveston Pleasure Pier, TX	1957	43	7.39	0.53
Freeport, TX	1954	46	5.87	0.74
Rockport, TX	1948	52	4.6	0.41
Port Mansfield, TX	1963	35	2.05	0.75
Padre Island, TX	1958	37	3.44	0.56
Port Isabel, TX	1944	56	3.38	0.27
Average		49.2	4.00	
Weighted Average			4.06	
Median		42.5	2.85	

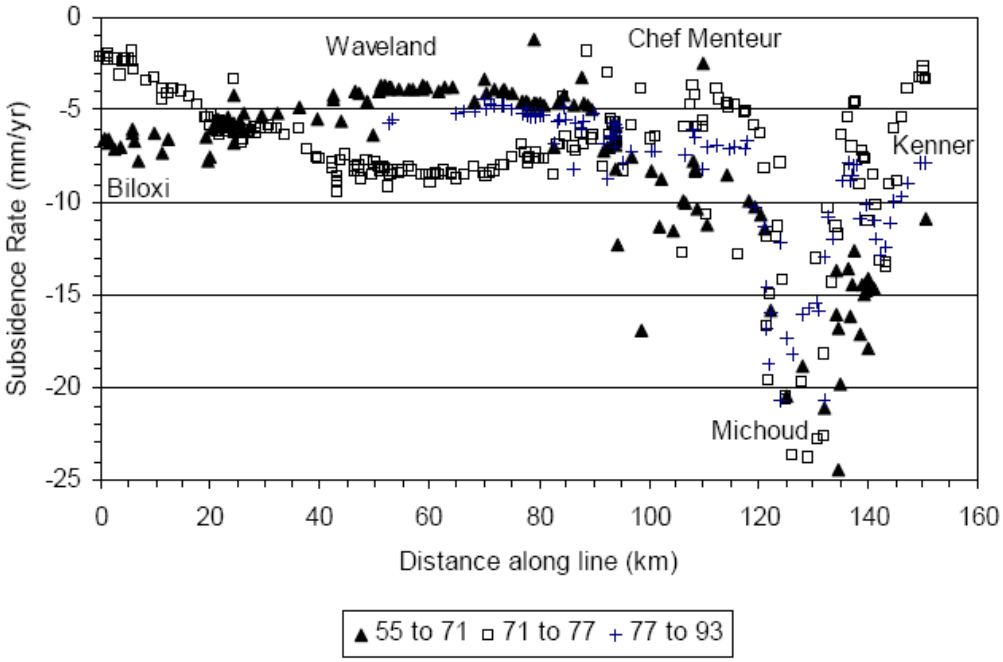
From Ref. 5.

1.6.1.1 Mississippi Coast Subsidence

NOAA's National Geodetic Survey published (Ref. 2) estimated relative vertical displacement rates for areas including the Mississippi Gulf Coast in 2004. The rates were estimated by adjusting historic first-order leveling runs according to the estimated historic elevation of a Louisiana tide gage benchmarks in Louisiana. The elevation of said benchmark at the time of the historic leveling surveys was estimated by assuming it was subjected to an averaged eustatic sea level rise of 1.25 mm/year. This value is comparable to the 1.20 mm/year given in NRC's document for 20th century eustatic sea level rise. The leveling data were then adjusted to estimate their true elevations at the time of the surveys; the elevation of a given point in one year was then compared to the elevation of the same point during a following survey many years later, which gave an estimate of the rate of subsidence. Results for surveys generally following the east-west alignment of the CSX railway line across Mississippi are shown in Figure 1.

Figure 1.6-1 gives estimated subsidence rates for the periods 1955 to 1971, 1971 to 1977, and 1977 to 1993. The figure suggests that Mississippi coast subsidence varies from about -2 mm/year to -9 mm/year and that the average subsidence is on the order of -6 mm/year (negative values imply that the ground is subsiding). It is interesting that series of the Mississippi portion of the comparison appear to be reflections of each other, though the reason for this is not apparent. The average

subsidence rate, approximately 6 mm/year, of the railway line near the coast exceeds the RSL rates (1.7 to 3.7 mm/yr) determined from tide gage data.



From Ref. 2 Appendix 4.

Figure 1.6-1. Biloxi, MS to New Orleans, LA Subsidence Rates for Periods Indicated in Years

If equal confidence is given to both the RSL rate and the subsidence data, one must conclude that eustatic sea level in the Gulf of Mexico is not rising, but falling; this is doubtful. Therefore, it appears that either the gage data is erroneous, the subsidence estimates are flawed, or both. While it is most likely that neither the subsidence estimates nor the RSL estimates are infallible, the RSL rates are generally consistent with those observed elsewhere along the Gulf Coast, excepting those areas in Louisiana which are known to subside at abnormally large rates. This suggests that, while subsidence is probably occurring in Mississippi, tide gage data suggest that it may be occurring over much of the Mississippi coast at a rate that is consistent with Gulf Coast locations not associated with Mississippi River Delta formations. Also, since the question as to why subsidence estimates, taken in conjunction with tide gage data, suggest that sea level is dropping, as opposed to rising, remains unresolved, there is at present no clear rationale nor means to employ these subsidence estimates for purposes of estimating future RSL.

1.6.2 Projected Sea Level Rise

Table 1.6-4 shows extrapolated RSL for the period 2005-2100 based only on the rates derived from historic USACE station records (Table 1.6-2). The total relative rise predicted for the 95 year period is consistent with that suggested by Biloxi gage records over the 20th century.

Table 1.6-4.
Relative Sea Level Rise Assuming Observed Rates Persist, 2005-2100

Gulfport		Pascagoula		Biloxi	
meters	**feet**	**meters**	**feet**	**meters**	**feet**
0.16	0.53	0.35	1.16	0.21	0.70

1.6.2.1 National Research Council (NRC) Methods

Corps of Engineers guidance recommends Curve 3 of the NRC report (Ref. 3), or more definitive information, be used as the eustatic component of RSL for future high scenario estimates.

The NRC produced three curves, Curves 1, 2, and 3, which might be thought of as low, medium, and high rate of rise estimates due to climate change and are reproduced here as Figure 1.6-2. These curves were developed based on studies published between 1983 and 1986 and assume in global eustatic sea level of 0.5 meters, 1 meter, and 1.5 meters, respectively between 1986 and 2100. The curves are a function of time squared and thus suggest that the rate of sea level rise will increase into the future, though as of 2001, no such increase had been detected (Ref. f). The suggestion that sea level rise rates will increase in the future is common to all reports reviewed. These curves yield high, medium, and low eustatic sea level increases of 0.47 m., 0.95 m., and 1.44 m. (1.54 ft., 3.13 ft., 4.72 feet) respectively for the period 2005 to 2100. Relative sea level rise for a given location at the

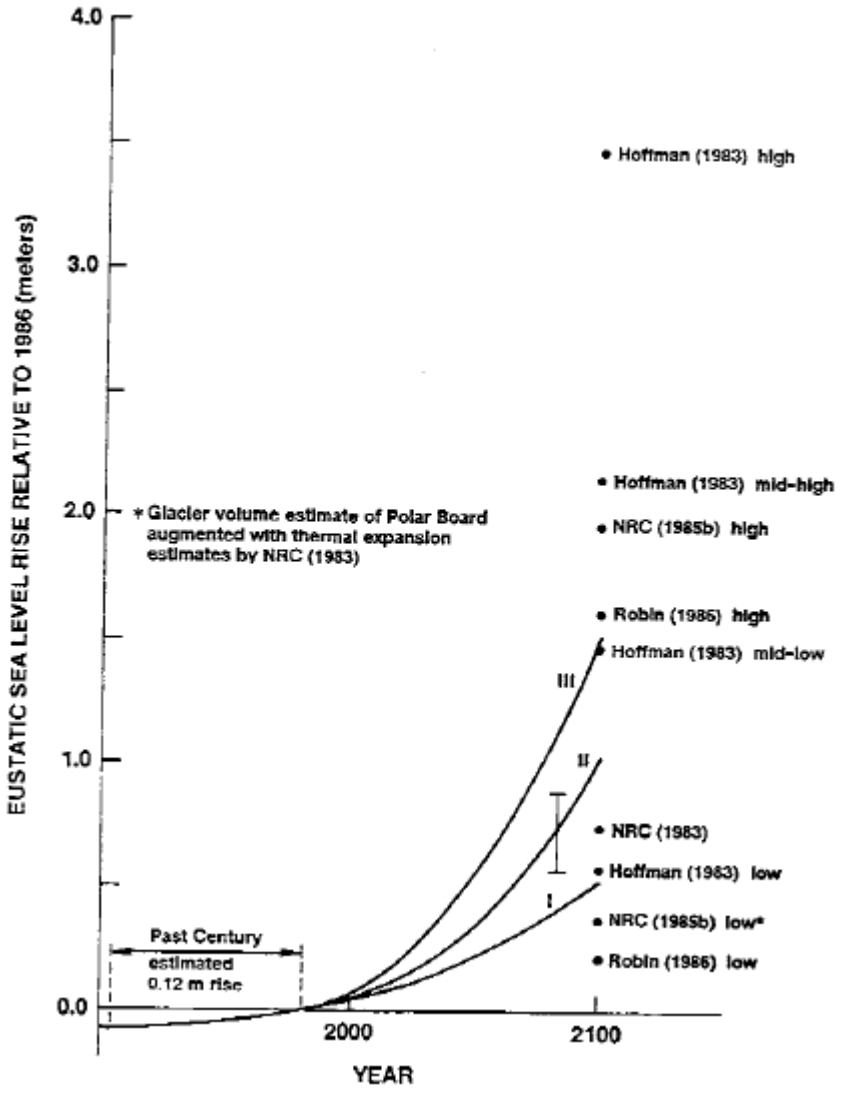


Figure 1.6-2. Eustatic Sea Level Rise Scenarios (Figure 2-2 from NRC, 1987)

year 2100 would be arrived at by adding these values to the locally predicted subsidence, where the local subsidence would be the observed (or estimated rate where observations were not available) subsidence rate multiplied by the time span (in this case, 2100-2005 = 95 years). The document implies that local subsidence rates might be estimated by subtracting 1.2 mm/year (the assumed rate of global eustatic sea level rise) from RSL rates computed from tide gage data.

Relative sea level rise estimates for the period 2005 to 2100 at the locations of coastal Mississippi USACE tide stations using NRC methods are shown in Table 1.6-5. The values in the table have been computed converting the gage RSL rates to subsidence rates by subtracting 1.2 mm/year as suggested by the NRC. The total rise given in this table for Curve 3 is five to eight times those predicted by extrapolation of rates computed from historic gage data (Table 1.6-4).

Table 1.6-5.
Relative Sea Level Rise Estimates by NRC (1987) Methods, 2005-2100

	Gulfport		Pascagoula		Biloxi	
Basis	**meters**	**feet**	**meters**	**feet**	**meters**	**feet**
Curve 1	0.51	1.69	0.71	2.32	0.57	1.86
Curve 2	1.00	3.28	1.19	3.91	1.05	3.46
Curve 3	1.49	4.88	1.68	5.51	1.54	5.05

1.6.2.2 Environmental Protection Agency (EPA) Methods

The EPA (Ref. 6) estimated future eustatic sea level rise and also attempted to identify the probability distribution of this rise occurring. The EPA report is the only report reviewed which has attempted to assign probabilities to the sea level rise phenomenon. The one percent, mean, and 99 percent non-exceedance eustatic sea level rise estimates for the time interval 1990 to 2100 are -0.01 m. (-0.03 ft.), 0.34 m. (1.11 ft.), and 1.04 m. (3.41 ft.). Estimates are also provided by EPA for the years 2050 and 2200. As with the other eustatic sea level rise forecasts discussed in this document, the estimates account for only those changes in sea level which might be attributed to climate change.

The EPA report recommends a simple procedure for estimating regional sea level rise based on their eustatic sea level rise estimates. The procedure is to add a normalized projection to the current (observed) relative rate of sea level rise as given by the following equation:

Local (t) = normalized (t) + (t -1990) x trend Eqn. 1.6-1

Where: Local (t) is the projected local rise in sea level in some future year t.

Normalized (t) is the normalized eustatic rise given by Ref. 6 Table 9-1.

Trend is the observed trend at a representative gage location.

The ‘normalized’ eustatic rise value was developed by EPA in order to avoid double-counting the effects of the historic contribution of climate change, which are inherent in the observed trend value; double-counting would occur were future projections made using the predicted (as opposed to the normalized) eustatic sea level rise values in this equation. This concern over double counting does not come into effect if the predicted eustatic sea level rise contribution were to be combined with a known local subsidence rate.

EPA methods were used to develop sea level rise estimates for the period 2005 to 2100 for the vicinities of the USACE tide gages at Biloxi, Gulfport, and Pascagoula. The 50% and 99% non-exceedance eustatic normalized sea-level rise predictions were used in conjunction with the

historically observed rates for this purpose. Results are shown in Table 1.6-6. These values compare favorably to values give by NRC Curves 1 and 2 but are, as a rule, much lower than those given by Curve 3 (see Table 1.6-5). The 50% values are approximately 0.7 to 0.8 feet higher than those predicted by historical rates alone (see Table 1.6-4).

Table 1.6-6.
Relative Sea Level Rise Estimates by EPA (1995) Methods, 2005-2100

Location	m	feet
Gulfport 50%	0.39	1.3
99%	0.99	3.2
Biloxi 50%	0.44	1.4
99%	0.98	3.2
Pascagoula 50%	0.60	2.0
99%	1.18	3.9

1.6.2.3 Intergovernmental Panel for Climate Change (IPCC) Methods

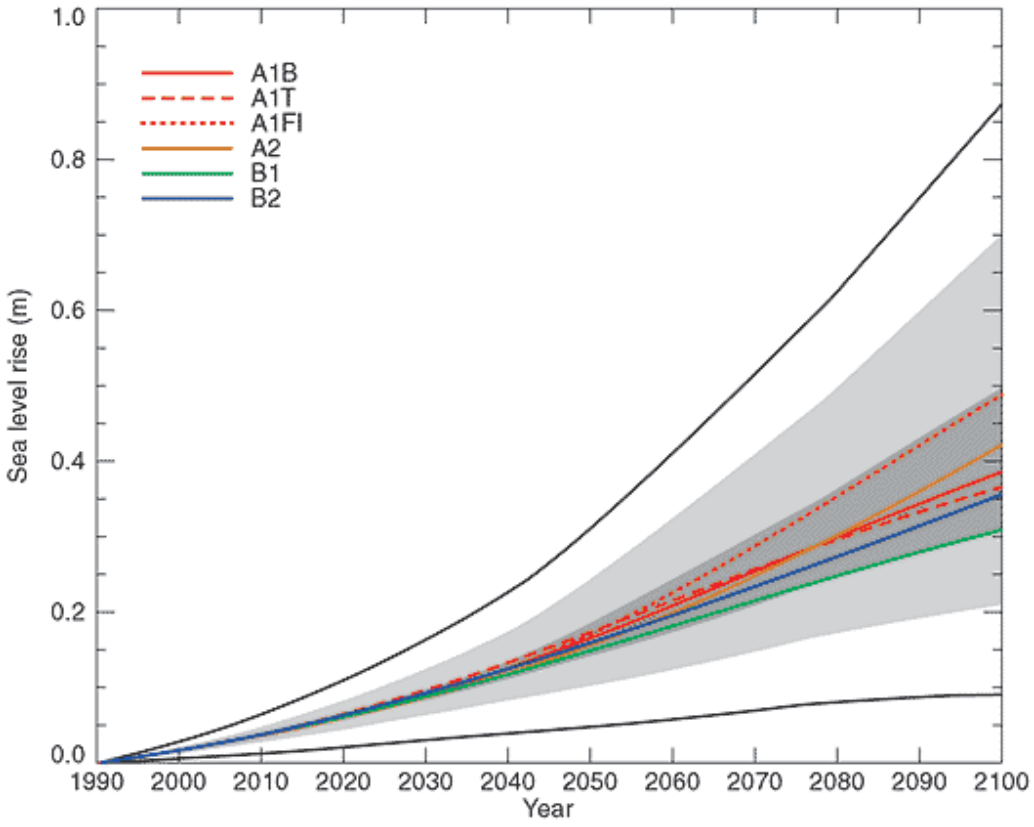
The Climate Change 2001 document (Ref. 7) by the IPCC is the most current and comprehensive publication available for this effort regarding the science of climate change and its implications for sea level rise. An updated IPCC climate change report is due in May of 2007 but due to the MsCIP schedule it arrives too late to be of use for estimating future sea level rise, though a summary of the findings of that report, released in early 2007, suggest that the global eustatic sea level rise central value estimate has not changed significantly.

The full suite of IPCC sea level rise projections is shown in Figure 1.6-3. The projections result from over 35 climate change scenarios, run in a number of different global circulation models. The projections represent the contribution of climate change to global average sea level rise. The IPCC predicts eustatic sea level rise of 0.09 to 0.88 m between 1990 and 2100 with a central value of 0.48 meters. The central value averaged over this time period is 4.36 mm/year, which is two to four times the average rate suggested by 20th century Mississippi Coast tide gage data.

In Figure 1.6-3:

- The black outer lines describe the range of all model estimates, including sensitivity to land ice withdrawal, sedimentation, and other assumptions.
- The lightly-shaded region shows the range from 35 scenarios tested in all circulation models.
- The darkly-shaded region shows the range of the average of those scenarios.
- The colored lines represent the computed average from each demonstration model, which are a subset of the 35 scenarios.

The values shown in Figure 1.6-3 are lower than those suggested in the earlier NRC study, and similar to those in the EPA publication. Since publication of the NRC document, estimates of the magnitude of future global warming have been cut in half, and this resulted in a reduction of the range of estimates of future sea level rise. The IPCC document suggests this reduction is primarily due to improvements in technology, improvements in the understanding of pollutant behavior (particularly aerosols), and revised pollutant discharge forecasts.



From Ref. 7 Figure 11.12.

Figure 1.6-3. IPCC Global Eustatic Sea Level Rise Estimates

The IPCC does not prescribe how these global eustatic sea level rise estimates might be adapted to estimate future local relative sea level rise. Like the EPA before it, the IPCC acknowledges double-counting as a valid issue, but does not provide normalized sea level rise estimates for use with their eustatic sea level rise estimates, nor do they provide explicit instructions for adapting their predicted sea level rise values to specific locations. The IPCC report does, however, suggest that the approach advocated in EPA's report might be used.

Comparison of EPA's normalized and non-normalized eustatic sea level rise estimates (Tables 9-1 and 7-4, respectively, Ref. 6) reveal that EPA estimates the 20th century climatological contribution to sea level rise at 0.82 mm/year. This contribution is essentially constant throughout the range of EPA's probable sea level rise estimates. This value is reasonably consistent with IPCC's central value (c.v.) estimate of said contribution at 0.7 mm/year (Table 11.10, Ref. 7). Since EPA has applied a constant normalizing rate adjustment, it may be argued that the IPCC's estimate of 0.7 mm/year might be used in the same manner to normalize IPCC's estimate and facilitate use with RSL rates obtained from gage data.

Therefore, future estimates of local sea level rise over the interval 2005 to 2100 might be obtained using IPCC values as follows:

Local rise = [(IPCC 2100 – IPCC 2005) – n*(2100-2005)] + (2100-2005) * trend Eqn. 1.6-2

Where: IPCC is the projected eustatic rise in sea level for the given year, from Figure 3 herein.

Trend is the observed trend at a representative gage location.

n is the normalizing factor = 0.7 mm/yr.

The normalization function is shown in brackets on the right-hand side of Equation 1.6-2.

Results of this method applied to the vicinity of the USACE gages are shown in Table 1.6-7.

Table 1.6-7.
Relative Sea Level Rise Estimates using IPCC Predictions, 2005-2100

Location	m	feet
Gulfport c.v.	0.54	1.8
high	0.96	3.2
Biloxi c.v.	0.60	2.0
high	1.02	3.3
Pascagoula c.v.	0.74	2.4
high	1.16	3.8

1.6.3 Relative Sea Level Rise Summary

Corps of Engineers Planning Guidance Notebook (Ref. 4) states that potential relative sea level rise should be taken into consideration for coastal or estuarine projects at the feasibility level of study and recommends. At a minimum, project performance would be evaluated based on extrapolation of the observed historic rate and should also consider a higher rate, based on NRC Curve 3 or more definitive data, than that historically observed.

'High,' 'medium,' and 'low' eustatic sea level rise estimates as given in the NRC in 1987 and more recent authoritative reports by the EPA (1995) and IPCC (2001) reports are summarized below in Table 1.6-8. The values in the table are eustatic values only and do not reflect local nor historic trends at the Mississippi Coast. While the three methodologies differ slightly, they commonly adjust, according to each agency's prediction of climate change effects, extrapolated historic local relative sea level rise. In other words, the only difference in the predicted RSL for each scenario at each location is that portion of rise attributed to possible effects of climate change. The table shows that the climate-driven component of sea level rise estimates has dropped substantially since publication of the NRC report, primarily due to advances in global fluid dynamics modeling technology and revised pollutant discharge estimates.

Table 1.6-8.
Comparison of Eustatic Sea Level Rise Predictions, 1990-2100

	Low, in m. (ft)	Medium, in m. (ft)	High, in m. (ft)
NRC[1] (1987)	0.47 (1.53)	0.95 (3.13)	1.44 (4.72)
EPA[2] (1995)	-0.01 (-0.03)	0.34 (1.11)	1.04 (3.41)
IPCC[3] (2001)	0.09 (0.29)	0.48 (1.57)	0.88 (2.89)

Notes: 1. NRC (1987) curves 1, 2, and 3 respectively. 1%, 50%, and 99% non-exceedance probabilities, respectively. From Ref. 6 Table 7-3. 2. Low and high values represent the extreme range with uncertainty and the medium value is the 'central estimate.'

The observed historic relative rates of relative sea level rise along the Mississippi Gulf Coast were determined from long-term USACE tide gage data and are summarized in Table 1.6-2. The rates are typical of RSL rates determined from other long-term Gulf of Mexico tide and lower than rates observed in Louisiana and eastern Texas.

Extrapolation of historically observed Mississippi coast RSL rates results in a relative sea level rise of 0.5 to 1.2 feet for the period 2005 to 2100. Extrapolation of observed rates is inconsistent with the climate change community view, held since at least the early 1980's, that sea level rise will accelerate in the 21st century. The USACE Mississippi coast gage data have not been interrogated to detect RSL rise acceleration for present purposes.

Subsidence rates and magnitudes have been estimated for the MS Coast but the estimated rates, weighed in consideration of RSL rates derived from tide gage data, do not seem to support the generally accepted view that sea level is rising. The reason this is so cannot at present be resolved and therefore the subsidence estimates were not used in favor of RSL rates determined from tide gage records to estimate future sea level rise.

Future relative sea level rise estimates were developed using NRC, EPA, and IPCC projections. The IPCC estimates are the most current available. The findings are summarized in Table 1.6-9 and rounded to the nearest 0.1 feet.

IPCC's 'high' values compare to within 0.1 feet of those computed using EPA's 99% non-exceedance values, while IPCC's central value (c.v.) estimates are slightly higher than those yielded using EPA's 50% (mean) normative sea level rise values. The 'high' and c.v. are similar to values yielded using NRC's Curve 1 ('low') and Curve 2 ('expected'; see Table 1.6-5).

The IPCC 2001 predictions were the most current and definitive available. The IPCC 'high' values were selected for evaluating project performance as the 'higher than observed rate' versus those predicted using EPA and NRC methods because the IPCC values are more recent and more widely (globally) used. In a subtle departure from USACE guidance, relative sea level rise values based on IPCC 'expected' (also referred to as 'medium' and 'central value') eustatic sea level rise predictions were adopted for present study purposes in lieu of rise computed using extrapolated historic rates because most experts believe that the rate of sea level rise will increase in this century and extrapolated historic rise assumes past relative sea level rise rates will persist.

Table 1.6-9.
Comparison of Computed Relative Sea Level Rise Estimates, 2005-2100

	Gulfport		Pascagoula		Biloxi	
Basis	**High[1] m. (ft)**	**Expected[2] m. (ft.)**	**High[1] m. (ft)**	**Expected[2] m. (ft.)**	**High[1] m. (ft)**	**Expected[2] m. (ft.)**
Extrapolated	-	0.16 (0.5)	-	0.35 (1.2)	-	0.21 (0.7)
NRC (1987)	1.49 (4.9)	1.00 (3.3)	1.68 (5.51)	1.19 (3.9)	1.51 (5.0)	1.05 (3.5)
EPA (1995)	0.99 (3.2)	0.39 (1.3)	1.18 (3.9)	0.60 (2.0)	0.98 (3.2)	0.44 (1.4)
IPCC (2001)	**0.96 (3.2)**	**0.54 (1.8)**	**1.16 (3.8)**	**0.74 (2.4)**	**1.02 (3.3)**	**0.60 (2.0)**

Values in **bold** are adopted.

Notes: 1. NRC Curve 3; EPA 99% non-exceedence; IPCC upper-bound. 2. NRC Curve 2; EPA 50% non-exceedeence; IPCC 'central value'.

It was mentioned earlier that the project lifetime evaluation period had been revised from 2005 – 2100 to the 100-year period 2012 through 2111 after the time had passed for which RSL revisions might have been able to have been incorporated into related engineering efforts. RSL estimates were generated for the revised time frame using the IPCC predictions and compared to the adopted results from the 2005-2100 time frame as in Table 1.6-10. The project lifetime shift results in about 0.2 feet (2.4 inches) difference which is believed to be insignificant for present purposes.

Table 1.6-10.
Comparison of Adopted RSL 2005-2100 Versus Computed 2012-2111 RSL

	Gulfport		Pascagoula		Biloxi	
Time Frame	High[1] m. (ft)	Expected[2] m. (ft.)	High[1] m. (ft)	Expected[2] m. (ft.)	High[1] m. (ft)	Expected[2] m. (ft.)
2005-2100	**0.96 (3.2)**	**0.54 (1.8)**	**1.16 (3.8)**	**0.74 (2.4)**	**1.02 (3.3)**	**0.60 (2.0)**
2012-2112	1.01 (3.3)	0.60 (2.0)	1.21 (4.0)	0.81 (2.6)	1.05 (3.5)	.66 (2.2)
	Values in **bold** are adopted.					

Notes: 1. IPCC upper-bound. 2. IPCC 'central value'.

1.6.4 Relative Sea Level Rise Application

Plan formulation has identified three RSL scenarios to be evaluated over the project lifetime: (1) existing sea level; (2) 'expected' sea level rise, and (3) 'high' sea level rise. Existing sea level was selected primarily for exploratory comparative economic analysis of damage attributable to sea level rise in and of itself, which can be inferred by comparing storm damages due to storm surge at existing sea level against storm damage due to storm surge at some higher sea level. Note that there is no accompanying expectation or recommendation that any storm damage reduction system or element would be formulated or proposed based on a future sea level as it exists today. Expected relative sea level rise is interpreted to be that prediction based on IPCC's 'central value' eustatic sea level rise, and 'high' sea level rise was adopted based on the upper bound of IPCC's scenario testing results. Results are consistent with the level of detail appropriate for present needs but should be viewed as a 'first cut' at identifying historic and predicted relative sea level rise in the vicinity of coastal Mississippi.

The effects of sea level rise are many. From a practical standpoint, it is impossible to thoroughly explore all ramifications of sea level rise. Sea level rise implications will be tested in economic terms using the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software, and the Engineer Research and Development Center's BeachFX program; these efforts are discussed in Chapter 2 of this Engineering Appendix, and related plan formulation considerations are discussed in the main body of this report. Flood damage evaluations will also be performed in HEC-FDA over a 50-yr planning period to test the sensitivity of economic damages to the assumed project lifetime; computed relative sea level rise values using IPCC (2001) eustatic sea level rise predictions for this purpose are shown in Table 1.6-11. Coastal levee construction cost and levee protection implications are also discussed in Chapter 3 of this report.

Table 1.6-11.
Computed 50-year Relative Sea Level Rise Estimates, 2005-2055

	Gulfport		Pascagoula		Biloxi	
	High m. (ft)	Expected m. (ft.)	High m. (ft)	Expected m. (ft.)	High m. (ft)	Expected m. (ft.)
Extrapolated	-	0.09 (0.3)	-	0.19 (0.6)	-	0.11 (0.4)
IPCC (2001)	0.40 (1.3)[1]	0.26 (0.9)[2]	0.60 (2.0)[1]	0.46 (1.5)[2]	0.46 (1.5)[1]	0.32 (1.0)[2]

Notes: 1. IPCC upper-bound. 2. IPCC 'central value'.

Future design and evaluation efforts will require that these relative sea level rise predictions be updated, as (a) the IPCC published updated climate change effects documents in May of 2007 and (b) there are opportunities to improve local relative sea level rise estimation and prediction methods versus the status quo methodologies presented herein.

1.6.5 References

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PART 2. LONG-TERM ENGINEERING SOLUTIONS

2.1 Long-term Engineering Solutions

With the task of developing a hurricane damage reduction plan for the coast of Mississippi, several issues had to be considered. First, it had to be technically feasible. Could a storm damage reduction system be designed that would be constructible and at the same time not destroy what it was supposed to help protect? It had to be reliable so when needed, it would do the job it was designed for. It also needed to be cost effective. This system also had to integrate into other storm reduction concepts such as non-structural solutions such as buy-out programs and re-establishing some areas as environmental components of the plan. The development along the coast had some areas that were not contiguous to highly developed areas like found in Harrison County where the entire coastline is densely developed. These outlying areas may require individual means for any storm damage reduction. Almost any project along a coastline has environmental concerns and this is true in Mississippi. In Jackson County, the Pascagoula River system separates the city of Pascagoula from most of the coast to the west. This river system in one of the last major free-flowing rivers in the southeast and is home to endangered fish. In the western portion of the state, extensive marshes create other concerns along with the Pearl River that separates Mississippi from Louisiana. Other technical issues also made working in this river problematic. Another issue that was voiced early in this project was the population did not want a high structural seawall along the coast. The concern of losing the view of the water and beaches was repeated consistently in public meetings.

Review of the coastline in Mississippi using aerial photographs, topographic maps, LIDAR surveys, and storm inundation data revealed that natural topography could play a major role in forming storm barriers. Other features such as the offshore barrier islands, extensive beaches in many areas, and existing beach-front roadways were also realized as having a role in formulating a storm defense system. An existing railway track crosses the entire state near the coast and in the typical fashion of railways, these tracks follow high ground. This same general alignment was judged to be favorable for any type of inland barrier.

Review of the inundation maps from Katrina also revealed the extensive low-lying areas associated with two bays that extend inland from the coast. It was apparent that any storm protection systems would have to consider these as breaks in the line. Closing off rivers and bays with surge gates are used in Europe to protect inland areas and these type structures could be considered for Mississippi.

During planning sessions with the project delivery team, a structural “Lines of Defense” (LOD) concept was drafted that started with the offshore barrier islands and progressed inland to what could be considered the worst possible scenario with a extremely large hurricane, even worse than Katrina. Research identified numerous methods that have been developed to provide protection from flooding. Along with the traditional methods of levee or structural seawall construction, many other types of protection were reviewed. These included inflatable barriers, concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall, sliding panel gates, offshore breakwaters, and many types of surge barriers to close off the bays. The lines would also provide increasing levels of protection as you transgressed inland. It was understood that some lines would not provide protection from large storms. It was also evident that several areas of the coast could not be included in continuous line of defense and would be either placed in a ring levee system or designated to a non-structural solution.

In the early stages of the study, it was understood that the results of proposed storm surge modeling would not be available to the designers. These studies would be used to develop new stage-

frequency curves to predict a wide range of storm surge for the entire cost of Mississippi based on a large suite of storms. This modeling effort would also provide a prediction of the largest hurricane surge event that is considered possible along the coast of Mississippi. This storm, labeled the Maximum Possible Intensity (MPI) event would be used to define a line, based on ground surface elevation that a storm surge would not exceed.

From the planning session came five conceptual lines of defense. The general concept for this plan was made during project delivery team meetings that included engineers, environmentalists, planners, and geologists. Information from along the coastline was gathered that included large scale aerial photography, topographic maps, navigation maps, and a large collection of pre and post-Katrina photographs. As this discussion progressed, a color illustration, shown in Figure 2.1-1, was drawn that evolved into the five lines of defense that is the foundation to the structural aspect of this study. A refined version by a graphic artist, Figure 2.1-2, was completed based this initial sketch.

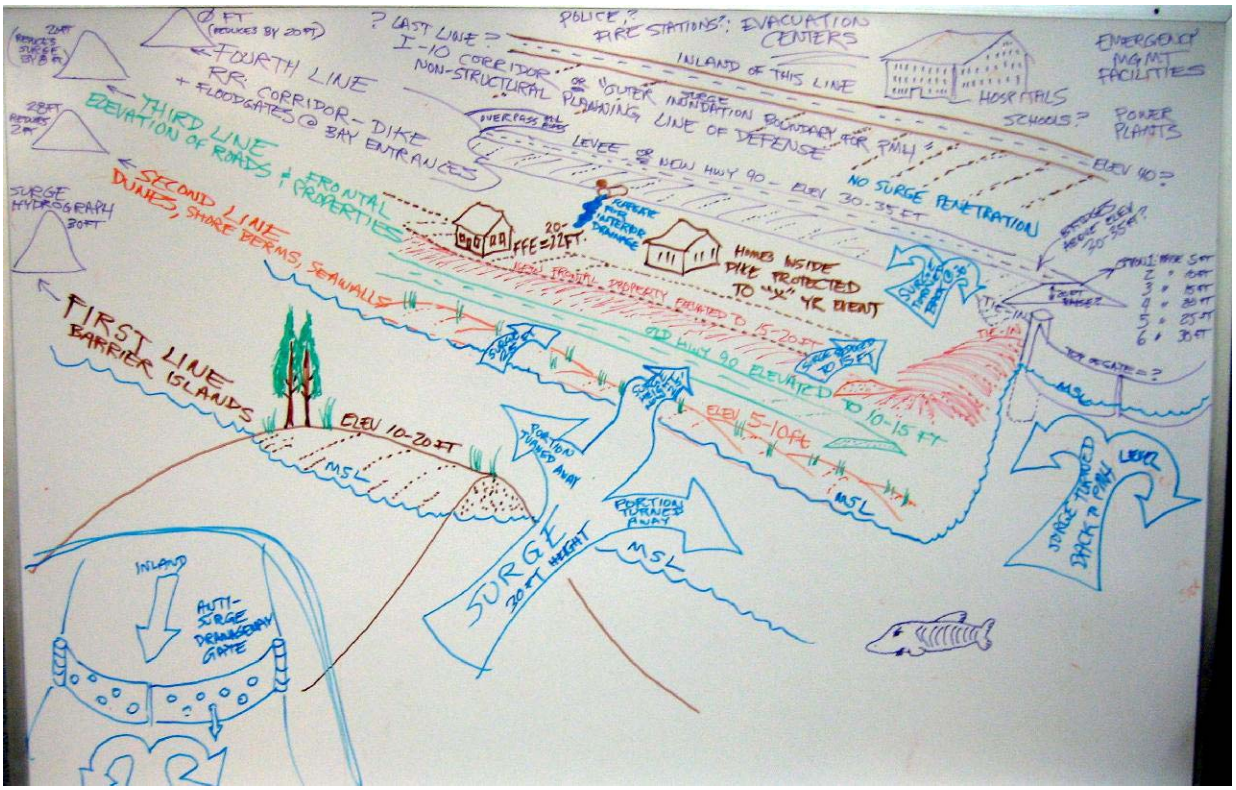


Figure 2.1-1. Graphic developed during initial planning sessions that visualized a "Lines of Defense" approach

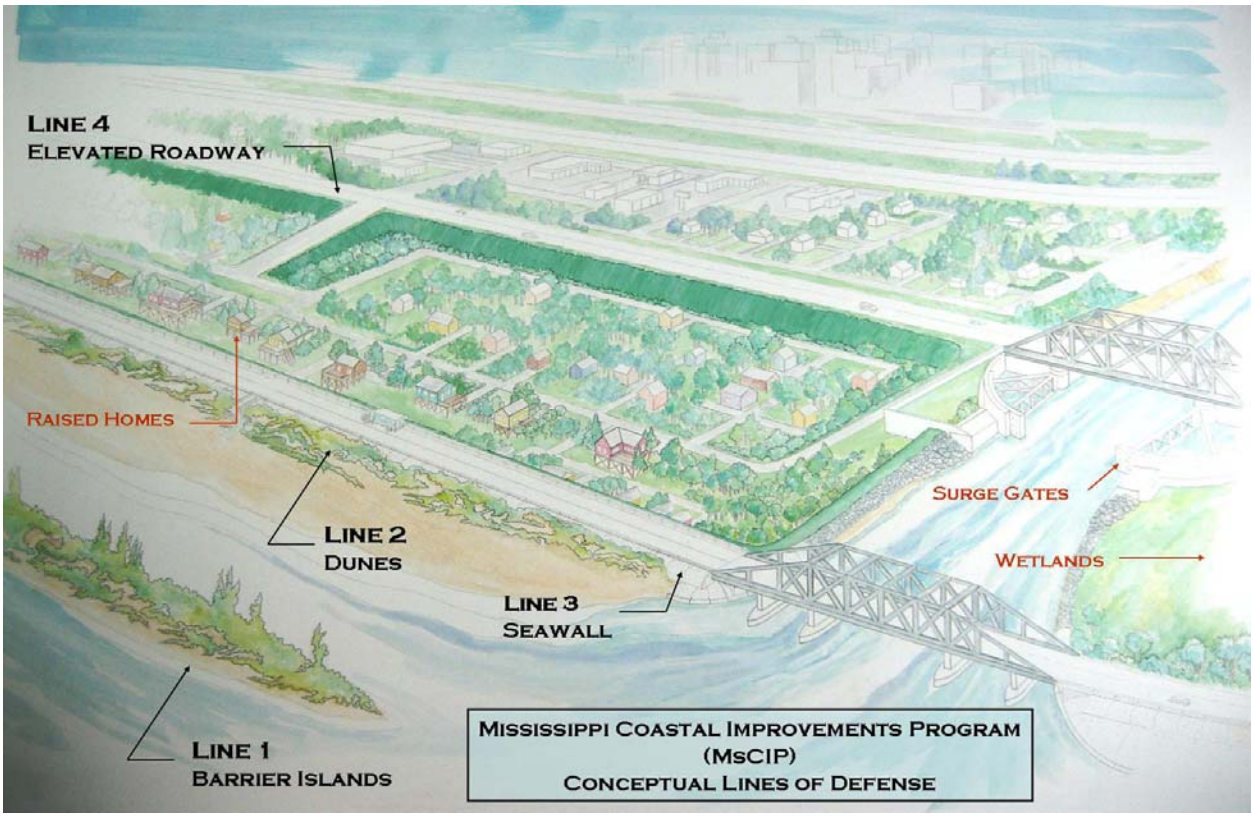


Figure 2.1-2. Artist's conceptual drawing based on the initial vision for Lines of Defense (Dawkins, 2006)

The first apparent feature to be discussed was the offshore barrier islands that had been included in the Mississippi Governor's recovery plan. Designated as LOD 1, the barrier islands have been eroded by numerous storms. In 1969, Hurricane Camille caused extensive erosion on the islands and created a large breach in Ship Island. After Katrina, it was widely expressed that if the islands had been in a pre-Camille condition, the storm surge would have been much less along the mainland coast. It was decided to model that scenario to help predict what effects the islands play in storm reduction.

The beaches (manmade in the 1950s) that extend along much of the coast were also considered as a feature that could be modified to provide some level of protection by the inclusion of dunes on the beaches. Other projects were underway to improve the some of the beaches and proposed projects would construct small dunes on most of the beaches. Improving on these by studying dunes at crest elevations of 10.0 (NGVD88) and 15.0 (NGVD88) was designated as LOD-2. These would not provide protection from large storms, but would be beneficial for smaller storms and would provide recreational and environmental benefits.

Another existing condition along the coast is roadways that coincide with the beaches. It was envisioned that raising these roadways would have minimal environmental impact and provide the first hardened barrier to surge damage. These roadways, while not continuous along the coast, were designated as LOD-3. Elevations of 12.0 (NGVD88), 18.0 (NGVD88) and 24.0 (NGVD88) were initially selected for study. It was also recognized that LOD-3 would require that barrier be placed at the mouths of the bays to be effective.

Some areas of the coast were not associated with these beaches and existing roadways or for environmental and/or technical reasons could only be viewed as stand alone projects such as ring

levees. These areas included six communities in Jackson County and one in Hancock County. For discussion purposes, these were also included in LOD-3 and would be studied at the same proposed elevations.

Further inland, the existing railroad grade had provided a levee-like barrier to storm surge from Katrina in some areas. Using the same high-ground alignment, an inland barrier was envisioned that could be constructed to such an elevation as to protect from a large storm surge, even larger than Katrina. Like LOD-3, this system would require that the bays be closed off from surge to be effective. As LOD-4, this barrier was to be studied at elevations of 24.0 (NGVD88), 32.0 (NGVD88) and 40.0 (NGVD88). Many alignments were considered before one that was recommended due to technical and environmental reasons. This system would not cross the Pearl River on the western side of the state nor the Pascagoula River in Jackson County.

For the highest level of protection from the largest storm surge event, the limits of surge predicted from the MPI event was transposed to maps and while a non-structural measure, it was designated as LOD-5. It would be an area north of any potential surge damage that would be recommended for location of critical infrastructure such as hospitals and emergency facilities.

Figure 2.1-3 represents a section extending from the barrier islands to the MPI line.

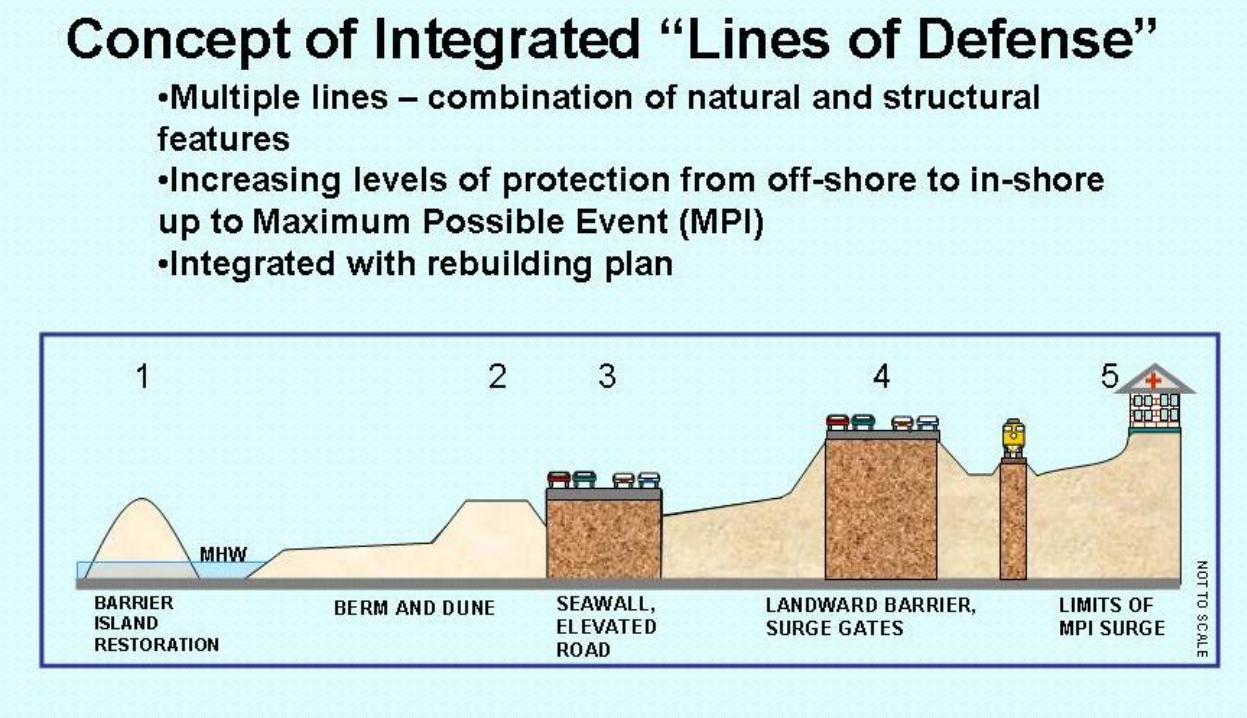


Figure 2.1-3. Conceptual section that includes five lines of defense extending from the barrier islands inland to the upper limits of the maximum possible intensity (MPI) hurricane

The proposed alignments for the LODs in each of the three coastal counties are shown in Figures 2.1-4, 2.1-5 and 2.1-6.

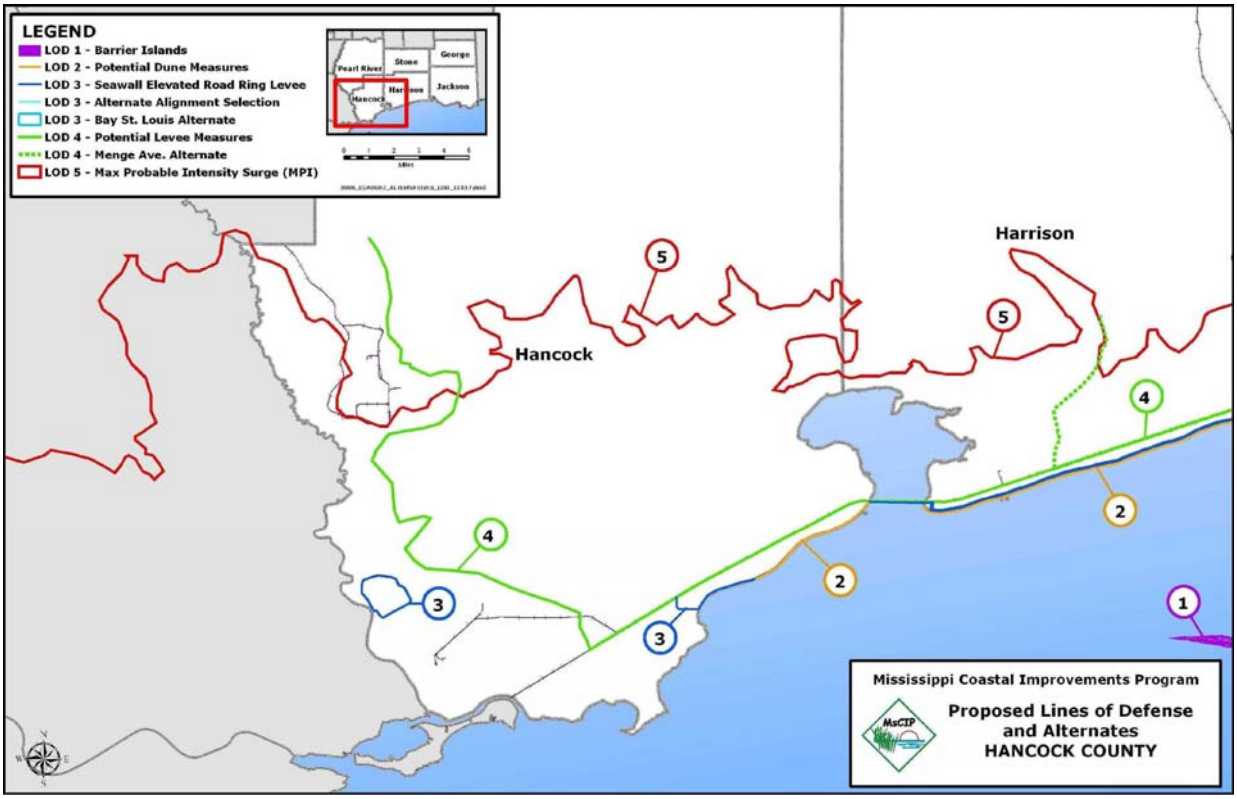


Figure 2.1-4. Line of Defense Alignments in Hancock County

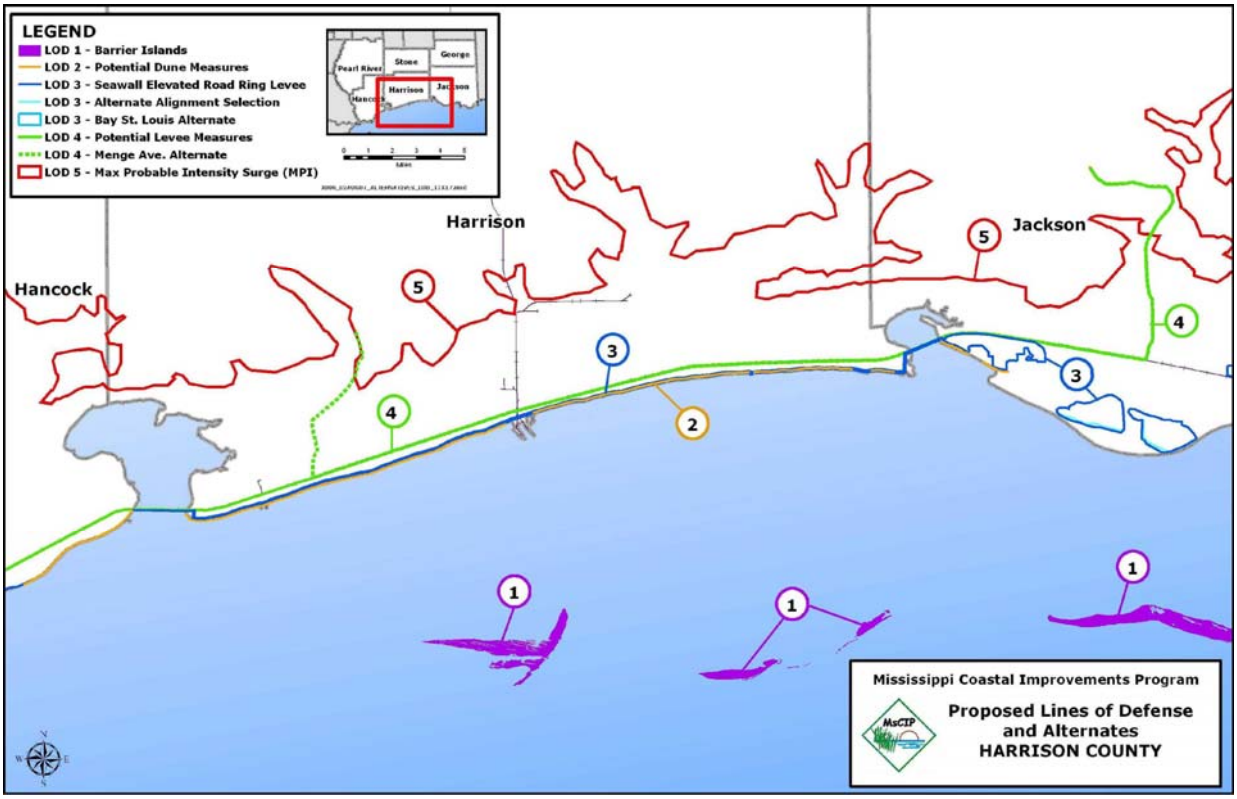


Figure 2.1-5. Line of Defense Alignments in Harrison County

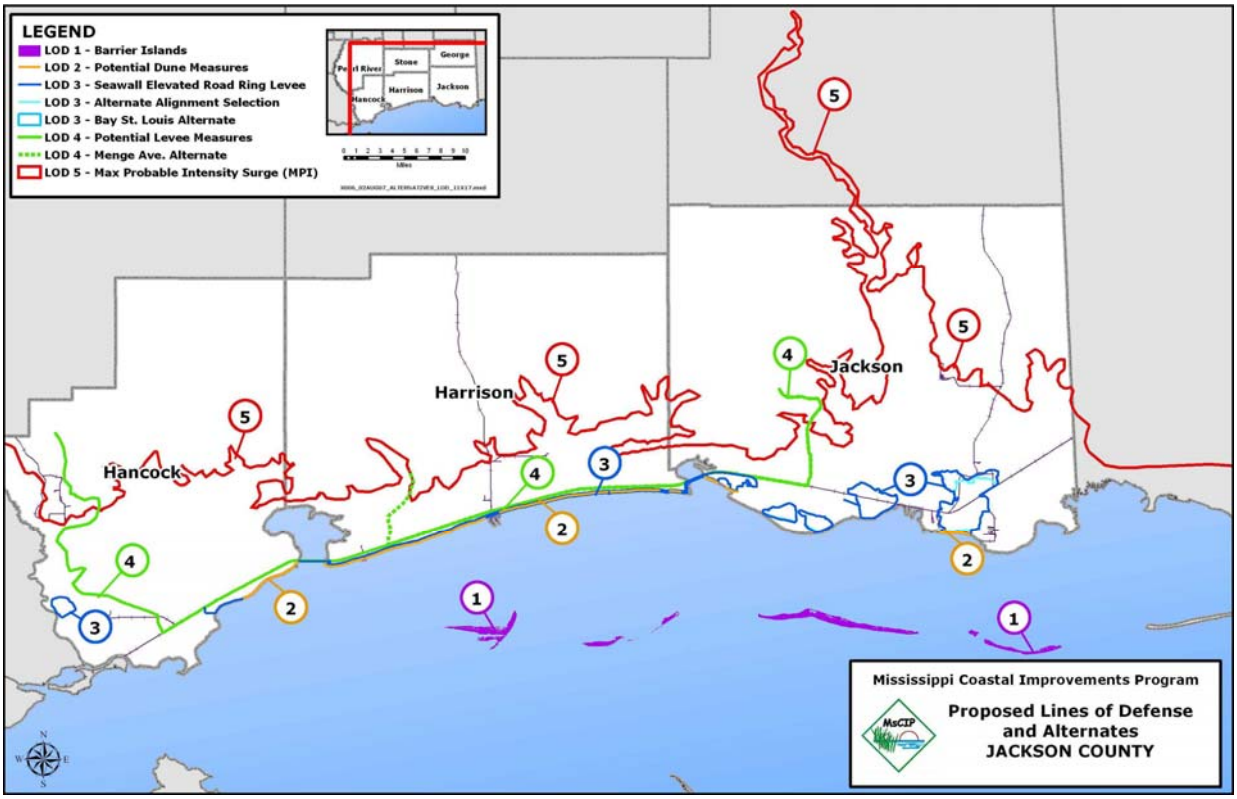


Figure 2.1-6. Line of Defense Alignments in Jackson County

The following discussions provide more detailed descriptions of the evolutions of each of the Lines of Defense from the initial concepts. Since this study generally did not provide feasibility level of design, there is still components that must be completed during "engineering and design" activities as shown in the cost estimates. This will include the completion of geotechnical investigations on the options that are carried forward. Part of the geotechnical work will be the verification of the different borrow areas including both onshore and off-shore sources.

2.1.1 First Line of Defense – Barrier islands

The coastline of mainland Mississippi is bordered on the south by the Mississippi Sound, a shallow body of water that separates the coast from four barrier islands that lie 10 to 15 miles to the south. These barrier islands are located along a littoral drift zone that moves sand westward creating three elongated islands and then to the westward most Cat Island where littoral currents are not as well defined. As shown in Figure 2.1-7, the islands are near several navigation channels. From east to west, the islands are Petit Bois, Horn, Ship, and Cat. Ship Island has been breached by prior hurricanes and now is actually two small islands, West Ship Island and East Ship Island, with a shallow sand bar between the two. Figure 2.1-8 shows the effect of recent hurricanes on Ship Island.

Since Hurricane Camille in 1969, the breach in Ship Island has existed with varying amounts of natural rebuilding between later storms as documented by the Mississippi Department of Environmental Quality, (Schmid and Yassin). The western ends of both Petit Bois and Ship Islands have migrated to the edge of navigation channels and the continuing littoral drift of the sand into the channels is causing an artificial termination of the migration. A new island has emerged on the west side of the channel from Petit Bois Island, created from the dredged sand coming from island that is disposed of on the west side of the channel.

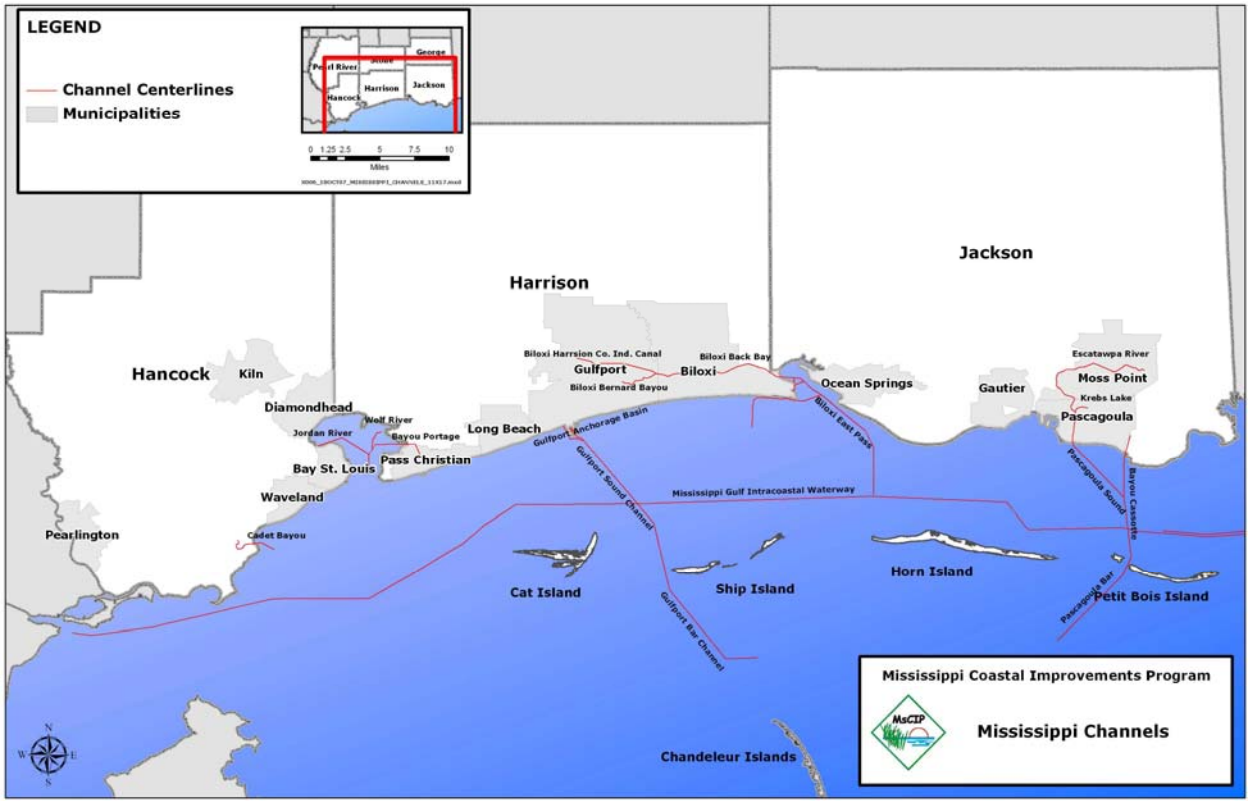
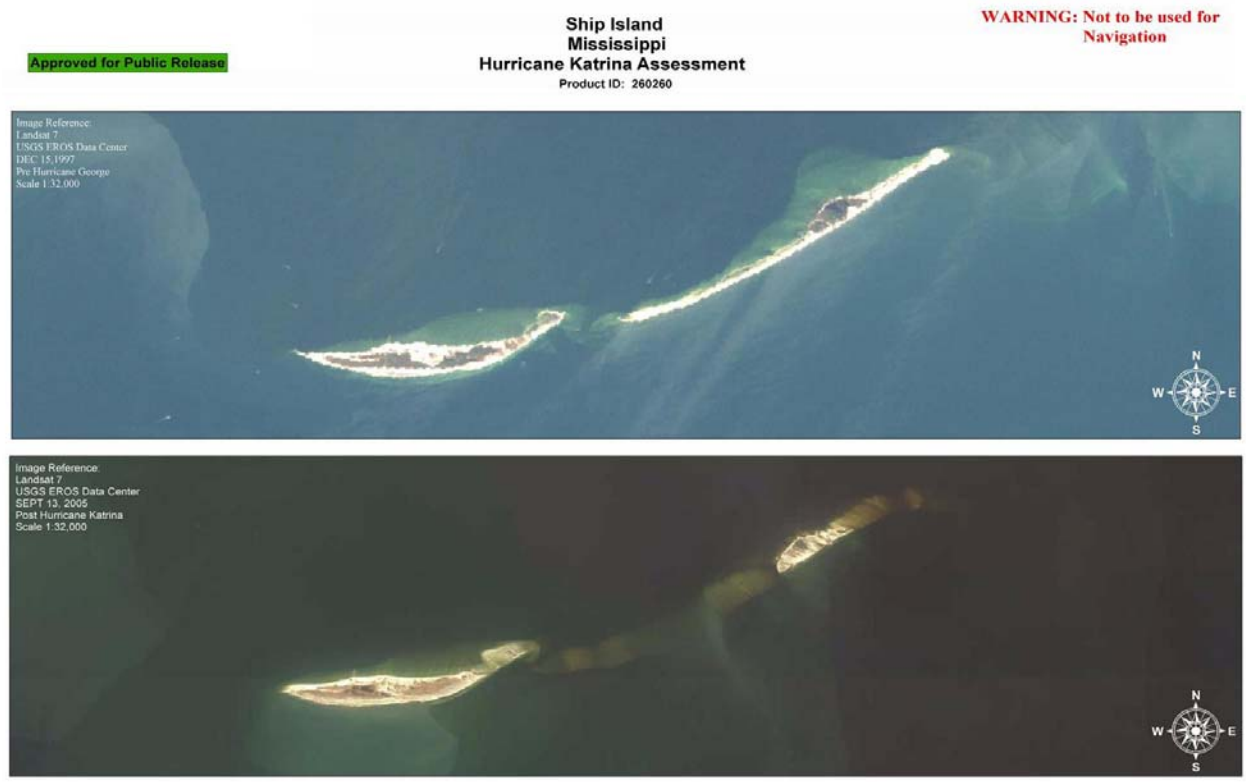


Figure 2.1-7. The Mississippi Barrier Islands shown in relationship to the numerous navigation channels near the islands

All of Petit Bois, Horn, and Ship Islands and part of Cat Island are within the boundaries of the Gulf Islands National Seashore under the jurisdiction of the National Park Service. In most cases, the boundary extends one mile from the shore of the island. The National Seashore boundaries are shown in Figure 2.1-9. Petit Bois and Horn Islands have also been designated as Wilderness Areas by the U.S. Department of the Interior and have a higher degree of protection than the other islands.

Other locations outside of park boundaries were studied for potential sites to construct breakwater type barriers that might serve the same purpose as a barrier island. Numerous constraints were identified with this concept. The depth of the water, other than being very close to the mainland shoreline, would have required a vast amount of material such as jetty stone in creating these breakwaters. And, as identified as a concern to local residents, locating these type structures close to the mainline shoreline would not be aesthetically acceptable.

Soon after Hurricane Katrina, it was reported that many in Mississippi felt that if the islands had been in the condition that existed prior to Hurricane Camille, there would have been less damage along the coast from Hurricane Katrina. This idea was also included in the Mississippi Governor's which called for restoring the islands to a pre-Camille footprint. This concept was included in the hurricane protection study as LOD-1.



(Source – US Navy)

Figure 2.1-8. The aerial photograph on top shows the islands in 1997 prior to Hurricane George in 1998. The bottom photograph shows the same view of the eroded condition of East and West Ship Island after Hurricane Katrina. Prior to a breach during Hurricane Camille, Ship Island was a single island, although the island has been breached prior to Camille.



Figure 2.1-9. Aerial view of the Gulf Islands National Seashore showing the park boundaries that extend approximately one mile offshore in most areas (National Park Service)

To determine the effects of the islands in reducing the surge damage to the mainland, a number of storms were selected to model against the chain of islands in a pre-Camille and a post-Katrina configuration. The post-Katrina condition can be considered a baseline condition for the modeling and the pre-Camille condition would be an improved condition. The pre-Camille footprint of the islands was obtained from historical records. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. Restoration of Ship Island in a pre-Camille configuration includes closing the post-Katrina, 3-mile long breach to a 2000-foot width and with dunes, along with

some rebuilding of the other islands to a larger land area. Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. This area is the most protected from the restored islands and this protection may result in only up to a 10% reduction in storm surge. The result of the modeling is shown in Figure 2.1-10. The effect of this protection diminishes rapidly to the west from Jackson County.

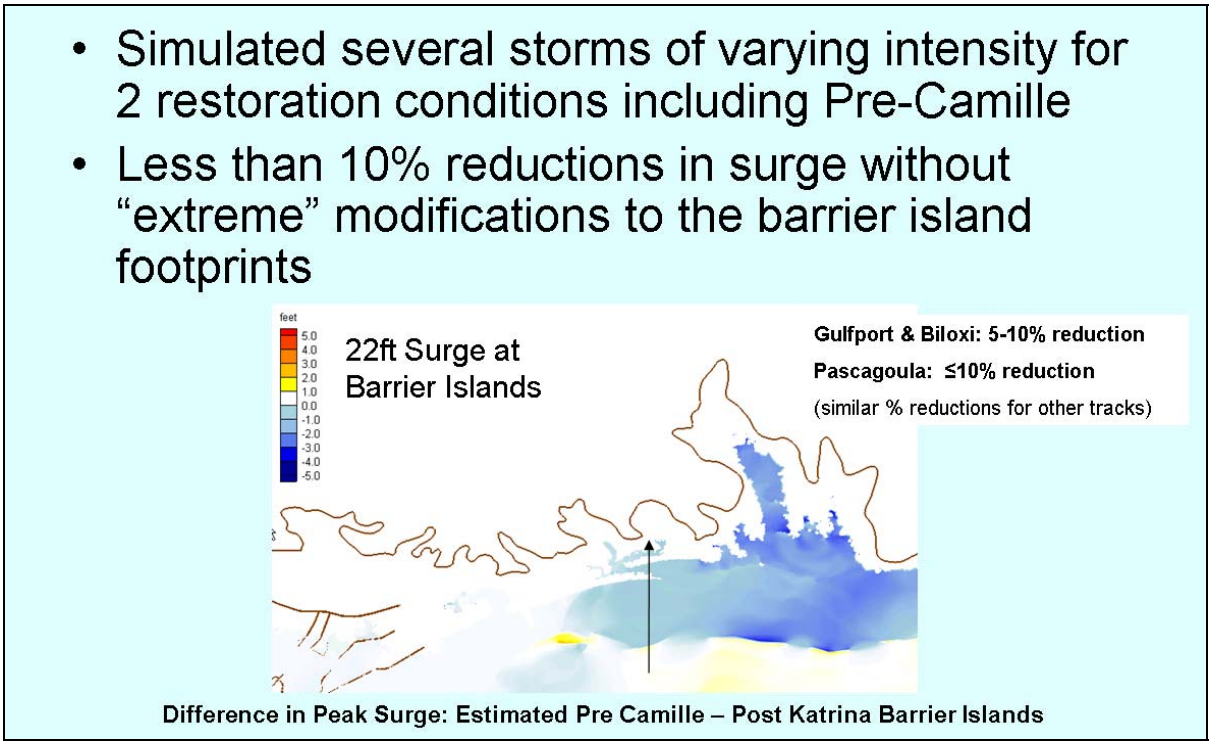


Figure 2.1-10. Sensitivity analysis of barrier island modification to differences in changes in surge heights along mainland

Another positive affect that the islands have is to provide a natural off-shore breakwater for the large sea waves that are generated from hurricanes. The presence of the islands and the relatively shallow water of the Mississippi Sound between the islands and the mainland prevent the sea waves from maintaining their considerable size as they move towards the mainland. Sea waves, often reported at heights of 40 feet and higher in large storms, would break as they approach the chain of islands. The open water between the islands and the mainland, generally ten miles or more, would have enough fetch for waves to regenerate, but at a much lower height due to the shallower water. The generally accepted relationship between water depth and wave height is that the wave can sustain itself at a height that is one half the depth of the water.

An environmental impact of the islands continuing to diminish in size is to allow salinity increases in the Mississippi Sound. Under current conditions, the islands provide a boundary condition between the sea water salinity of the open Gulf of Mexico and the brackish water found in the Sound. Loss of the islands would allow the salinity in the Sound to increase and result in a change of the ecological habitats that exist now. This would impact shellfish and other forms of marine life. This occurred at the Chandeleur Islands near the Mississippi barrier islands when almost the entire island structure was eroded away by Hurricane Katrina (see Figure 2.1-11). Like Cat Island on the Mississippi barrier islands, Chandeleur Islands are a remnant of a delta lobe from the Mississippi River where wave

action created a beach that remained as an island after sea level rise and erosion removed the land mass between the island and the mainland.

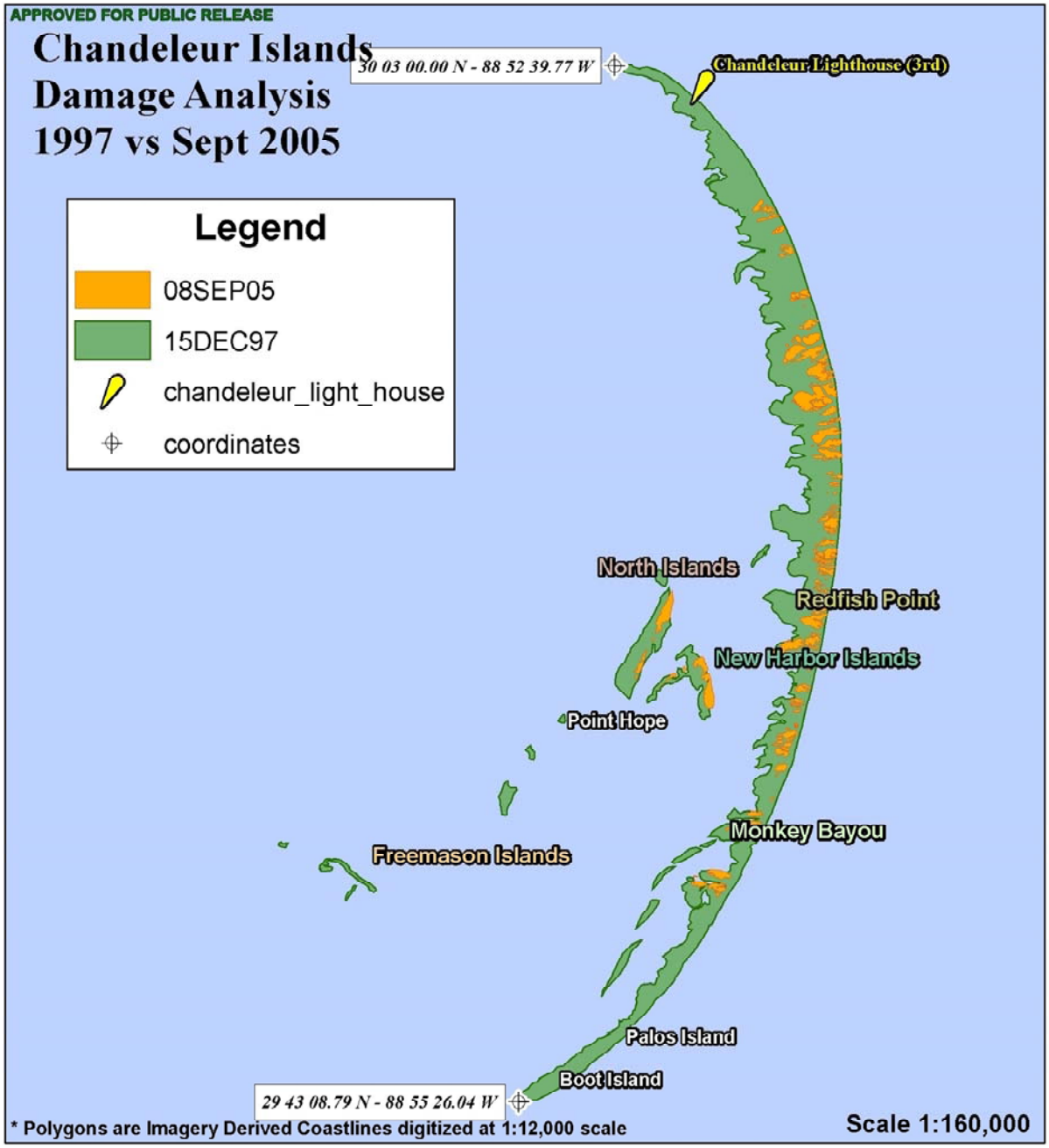


Figure 2.1-11. Loss of land mass from storm erosion at the Chandeleur Islands, 1997 to 2005. (US Navy)

With the consideration that these islands are within the National Park Service and that Petit Bois and Horn Islands are designated Wilderness Areas, any improvements to these islands may be politically difficult. One other consideration to help restore the islands is to supplement the sand in the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where

the natural process of island building could take place. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system.

Another plan could involve environmental restoration of the islands through reshaping dunes on the beaches with planted vegetation, planting of marshes and maritime forests, and planting sea grasses in the near-shore areas of the islands.

2.1.2 Second Line of Defense – Dunes Along Existing Beaches

Essentially all the beaches along coastal Mississippi are man-made. Harrison County has the most beach-front with 26-miles extending from Biloxi Bay to St. Louis Bay. Hancock County has several miles of beach and Jackson County only a short length. In total, the beaches extend along less than half of the Mississippi coastline. Most of the dunes that previously existed along these beaches were destroyed by Katrina and much of the beach was damaged. Reconstruction of the dunes, where beaches exist, will provide reduction of damaging wave action from smaller storms. A project to restore the beaches in Harrison County has been funded and is underway. Other projects to construct dunes to a height of 5-feet in Harrison County and to 2-feet in Hancock and Jackson County has been proposed as an interim projects and has already been designed and are awaiting funding.



Figure 2.1.2-1. View of Harrison County beach looking towards existing seawall at US Highway 90

The beaches, as situated immediately seaward of roads and developed areas, provide a location where elevated dunes could be constructed to provide some protection from smaller hurricanes. Original concepts were to look at crest elevations of 10.0 (NGVD88) and 15.0 (NGVD88) as options for the all dunes. Further discussions focused on the top elevation of the dunes needing to be below the elevation of the adjoining roadway. This was to help mitigate the migration of the sand onto the

roadway as eolian (wind blown) deposits. It was decided to correlate the top of the dune to an elevation that would be 1-foot lower than the adjacent road that would be included in LOD-3. As described in the following section, LOD-3 elevated roadway elevations of 11.0 (NGVD88) were selected for Jackson and Hancock Counties and 16.0 (NGVD88) for Harrison County. These decisions for LOD-3 then dictated dune crest elevations of 10.0 (NGVD88) for Jackson and Hancock Counties and 15.0 (NGVD88) for Harrison County.

Dunes are consistent with public preference for a more natural appearing defense than a hard structure. Construction of dunes will include adding vegetation and sand fencing to help stabilize the dunes. The dunes would be a sacrificial barrier, but could also be important by providing additional protection for the toe of the existing roadway, especially in an elevated seawall or roadway configuration as LOD-3. Placement of the dunes directly against a raised seawall or roadway would also serve aesthetically to mask the appearance of a structural barrier.

While the measure described above joins LOD-2 with the adjoining roadway, consideration could be given to having a stand-alone LOD-2 dune system that is on the existing beach, but separated from the road. The quantity of sand for an option such as this would increase since the northern slope of the dune would go down to a grade elevation of about 5.0 (NGVD88) and not abut against the roadway. By doing so, the top elevation of the dune could vary and be above the roadway as necessary. This may increase the need for maintaining the sand in the designated dune alignment since it would be expected that the sand dune would tend to migrate under the prevailing wind direction. This option was not fully designed as many unanswered questions remain that may have to be simulated with models. This includes the width of the dune crest and the width of the beach berm that might be required in front of the dune. This option would also block any view of the water from the existing roadway in most areas, replacing the view with a dune scene including plantings of sea oats or other beach type vegetation.

2.1.3 Third Line of Defense – Elevated Roadways/Seawalls and Ring Levees

As previously mentioned, all of the beaches described as LOD-2 have a roadway landward of the beach. The roads vary from local or county roads to US Highway 90, a major, four-lane, highway that extends across the entire Harrison County coast. The existing roadways vary in elevation from four to five feet in Jackson and Hancock County and up to about 15 feet above sea level in Harrison County. All of these roads are evacuation routes and all have been damaged in past hurricanes. In a damaged or destroyed condition, these roads make re-entry to the area difficult after a hurricane has passed. Raising and using these roadways as barriers or having an associated seawall defines a portion of the 3rd line of defense, LOD-3. This line will be the first hard engineered structure that will not be affected by erosion from a storm such as a dune system.



Figure 2.1.3-1. Photo of existing beach-front roadway and sea wall in Hancock County, June 2006. Equipment in the background is moving sand from the area just off-shore back onto the beach after being eroded by Hurricane Katrina.

Initial strategy was to study three elevations for the structure, elevations 12.0 (NGVD88), 18.0 (NGVD88) and 24.0 (NGVD88). It was understood that due to limited heights, it would only provide protection from more frequent, smaller storms, but would be overtopped by some large storms. This coastal barrier will coincide with the beaches where they exist. Raising the beach-front road did present some engineering challenges due to the numerous intersections with other streets and roads. With several feet of elevation, the intersecting roads would require ramps that would be extremely long to have a reasonable grade. Each of these ramps would also create areas where rainfall would collect and have to be removed during a storm. It also soon became apparent that public opinion was against any structure that would block the view of the beaches and water from the adjoining properties immediately north of the roads. This was voiced in public meetings and also from agencies that were involved in the study. To maintain some level of support for this defense, it was decided to raise the roadways an average of six feet. This allowed reasonable road intersection construction and allowed the aesthetic view of the water to be maintained and would not be perceived as a high seawall along the coast.



Figure 2.1.3-2. Photo of existing beach and seawall/US Highway 90 in Harrison County, 13 June 2007.

Review of the typical roadway elevations allowed raising the roadways in Jackson and Hancock County to Elevation 11.0 (NGVD88) and Highway 90 in Harrison County to Elevation 16.0 (NGVD88). It was decided to study these elevations without other options as the main part of LOD-3 with the understanding that these structures would not provide protection from large storms. As describe above, the LOD-2 dunes could also be constructed against the elevated roadway to help protect the toe of the structural wall associated with the road.

This line of defense would be connected to Line 4, described below, at the mouth of Biloxi Bay and St. Louis Bay. It would also extend northward to higher ground or to Line 4 in Jackson County and Hancock County. The bays are an inlet for storm surge that will be controlled by surge gates that are a part of Line 4. It was also recognized that if LOD-3 was constructed without LOD-4, surge gates across the bays would have to be included as part of LOD-3.

As the first hard structural defense, Line 3 will exclude some areas that may be considered potential areas of retreat or have other non-structural solutions. This may be due to low population density, ecological sensitivity, areas that contain numerous waterway crossings or areas that could not function with a structural barrier in place. In Jackson County, Line 3 will encompass the southern portion of Ocean Springs, but due to extended marshes and streams, it will extend northeastward from near the eastern end of East Beach Road to higher ground. Areas east of this location contain numerous marshes, streams, and scattered development. Ring levees will be evaluated for housing developments in some areas. Further east in Jackson County are the cities of Gautier, Pascagoula and Moss Point. The presence of numerous streams and inlets will make a continuous barrier very difficult and these areas are also envisioned to have individual ring levees.

At the western end of LOD-3, the barrier will extend down North Beach Boulevard for several miles to near Bayou Caddy and then turn north to tie in with higher ground. By following this path, the existing roadway will provide an alignment and it will encompass much of the developed waterfront from Bay St. Louis to Waveland, MS. Further west, the town of Pearlington will be evaluated for construction of a ring levee.

As with the main portion of LOD-3, the ring levees were initially considered with the same three elevations of 12.0 (NGVD88), 18.0 (NGVD88) and 24.0 (NGVD88). Closer study revealed that in many cases, the elevation 12.0 (NGVD88) was too low based on existing ground surfaces and the elevation 24.0 (NGVD88) may not be high enough to be certified by FEMA for a 100-year storm event. The elevations to be studied for the ring levees then was changed to 20.0 (NGVD88) and 30.0 (NGVD88) with the assumption that the 100-year event would fall between these elevations and that the elevation 30.0 (NGVD88) design would be sufficiently high for even a 500-year event. A 100-year minimum event is necessary for levee certification by FEMA. Having a conceptual design with cost estimates for these two elevations would allow for a cost curve to help predict the costs for certain storm events once the modeling studies were complete and stage frequency curves developed.

Initial alignments were set for the levees that tried to enclose most of the development. These alignments were used to estimate quantities of materials required for construction. After these alignments had been analyzed, the results of the surge modeling indicated that large reductions in the quantities of material could be realized by moving the alignments to higher ground in some areas to exclude some properties that facing or near the edges of marsh or water. Placing the levee behind the structures on these properties would not provide any type of protection, but would greatly decrease the cost of construction and at the same time preserve the aesthetic valve that brought the residents there. An example of this is shown in Figure 2.1.3-3. It was also noted that some of these properties were within potential non-structural zones that were identified as potential flood-proofing areas, either by raising or buyouts.

Another consideration is the presence of multiple large drainages or tidal inlets. Enclosing these drainages within the levee system will require pumping stations to remove rainfall during storm events. Depending on the area to be drained during a storm, these pumping stations can be very large items, both in space required to construct them as well as initial cost and future maintenance. These pumping facilities require a design that can withstand large storm events as they must stay operational during and after the hurricane passes. Depending on topography, some areas such as the interior of the potential Pascagoula – Moss Point levee (see Figure 2.1.3-4) would have numerous drainages that would require water removal.

Using these stations in Mississippi has both advantages and disadvantages over their popular use in Louisiana. In Louisiana, the pumps are required to keep large areas dry because parts of the city are below sea level and the Mississippi River. This condition does not allow many areas to drain by gravity flow. In Mississippi, operation of the pumps are only required when a hurricane has caused a storm surge to push against the levee and gravity flow structures are closed. In most cases, this drainage will be through culverts with flap gates that will not require any type of mechanically assisted closure. This can also present a problem in many cases since the pumps will be in drainages that will be dry unless there is rainfall occurring. Without a supply of water, exercising the pumps as part of a maintenance program may be a problem. During this initial phase of design, most drainages had pumping stations assigned to remove rainfall. Additional studies should allow for the siting and design of storm water retention areas in many of the drainages that will negate the need for pumps, but will require the acquisition of some property.



Figure 2.1.3-3. Bell Fountaine Ring levee alignments. The alignment inside the outer line is being considered for cost savings due to being located on a higher base elevation. This alternate alignment would place any structures between the lines into a non-structural solution.

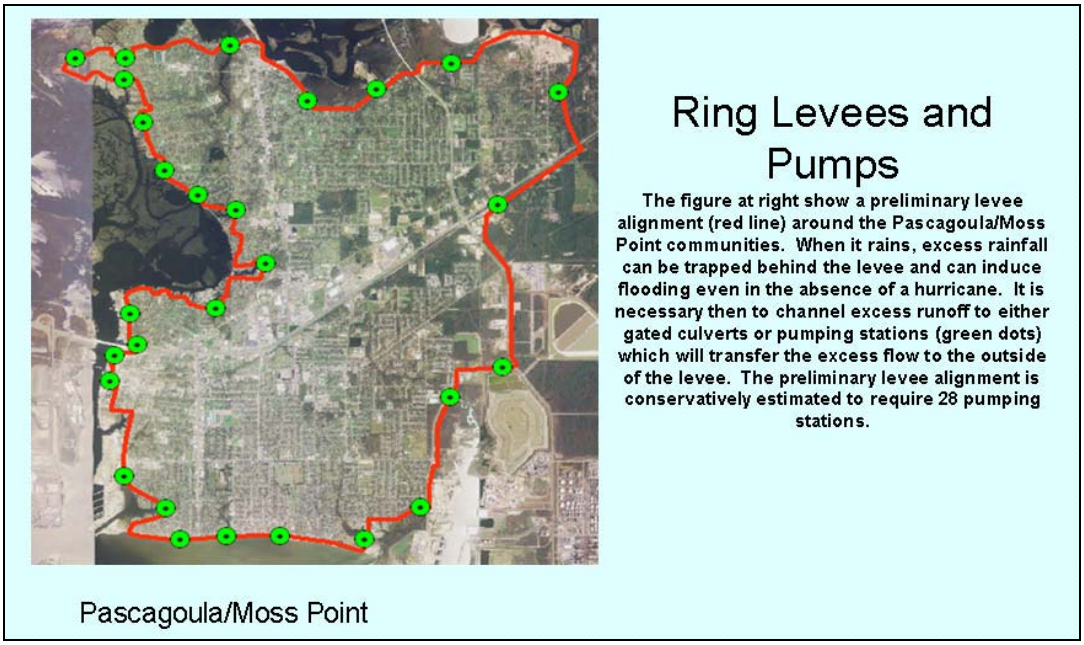


Figure 2.1.3-4. Required Pumping Stations for the Pascagoula-Moss Point Ring Levee

Modeling for storms that could impact the Mississippi Coast will define the predicted return frequency for these storms. The LOD-3 structures that might be used in Mississippi will not provide protection from large storms and this level of protection will vary based on the location and type of structure. While many options were reviewed for the type of structure to be used along the roadways, a simple elevated roadway associated with an extension of the existing seawall was chosen for reliability reasons. A structure that did not mainly rely on powered systems or with multiple moving systems was deemed more suitable for the purposes of this line of defense. As previously described, numerous conceptual designs were considered including inflatable barriers, concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall, sliding panel gates within a seawall, and structural concrete seawalls. The ring levees were all designed as earthen structures. It should be understood that all of these LOD-3 structures would provide much less protection than would be required for a Camille or Katrina-like storm. LOD-3 storm damage reduction levels are limited and will be determined based on public and local government acceptance and the amount of risk that Mississippi is willing to accept.

As previously mentioned, this line is dependent on having the ability of closure across the two bays to prevent the storm surge from running inside the mouths of the bays. While the plan calls for surge gates to be associated with Line 4, surge gates would also have to be incorporated with Line 3 if Line 4 was not selected as an alternative. The top elevation of surge gates used solely for Line 3 would be of an elevation that would be compatible with the rest of that barrier. To develop a cost curve for the barriers, cost estimates for elevations of 20.0 (NGVD88), 30.0 (NGVD88) and 40.0 (NGVD88) have been completed and will be used in conjunction with both LOD-3 and LOD-4. More detailed discussion of the surge gates is found below under the LOD-4 section.

Interior drainage behind these barriers must be considered. Any large rainfall event would require that the water trapped behind the barrier have a means to drain or even be mechanically pumped. The amount of storage that a given watershed could provide behind a barrier during surge conditions will vary. The means to block surge but allow drainage as the surge passes may include conduits with flap valves or gated culverts up to surge gates across large bodies of water. The areas where pumping is required are numerous, but necessary to prevent residual damages associated with this blockage of normal drainage.

The pumping stations, where required, must survive any storm damage and continue to operate until the storm event has passed. Elevated pump housing and power systems would be constructed to a height commensurate with the risk associated with that line of defense. In some instances, housings may need to be hardened to ensure protection from wind related damage.

2.1.4 Forth Line of Defense – Inland Barrier

To preserve the shoreline environment as much as possible, a 4th line of defense for very large storms is envisioned that would be inland from the coast. This line of defense would be the highest line and could contain a larger storm surge up to that associated with a “Maximum Possible Intensity” (MPI) hurricane. LOD-4 was to be modeled as an infinitely high barrier with the screening storms defining a surge elevation against the barrier. The top elevation could then be defined based on selected protection from a selected screening storm. Storms that will be modeled against this line will vary up to the MPI.

As the requirements of the MsCIP project studies were developed it became apparent early on that several massive gate structures would be required to protect the large inlets from tidal surges during larger storm events. In order to protect much of the developed areas around Biloxi and St. Louis Bays, LOD-4 would have to include a structural surge barrier that would also cross the mouth of these bays. These surge barriers would prevent storm surge from moving in through the inlets of the

bays. The structural barriers across the bays could be similar to designs used in Europe for storm surge protection.

Initially it was thought that some adaptation of our customary tainter or vertical lift gate assemblies might serve this purpose, but as the water levels to be resisted and the required length of the structures were developed it became apparent that much more massive construction than we had heretofore experienced would be required. This was further complicated by the need to minimize the visual impact, obstruction to small vessel traffic, and normal tidal flow.

The search for a method of construction that would be efficient and effective while optimizing freedom of tide flow and minimizing visual and physical obstruction under normal conditions led us to the Netherlands, Italy, Russia, and the River Thames in the United Kingdom, where several very massive and large scale projects of this type have been constructed or are presently in the planning stages. While many types of barriers were reviewed, the rising sector design used on the Thames River in London, England was selected

The Thames River Barrier was constructed during the 1980's to protect portions of historic London and the surrounding area from tidal flooding. At this site there is a naturally wide variation in the "spring tides" resulting in frequent very high tides, the maximum observed to date being +3.2 meters (i.e. 3.2 meters above the normal tide influenced water level). Also at this site storm surges of as much as +3.66 meters have been experienced. In the event that a storm surge equivalent to the maximum experienced to date and a very high spring tide were to occur at the same time, the water level could conceivably reach as much as +6.86 meters at this site. Based on this possibility, the top of the gates at the Thames River barrier was set at +6.9 meters. This elevation is sufficient to fully contain the 100-year flood event which would yield a water elevation of approximately +5.5 meters. The design flood event was estimated as being the 2000-year flood.

The Barrier constructed includes a series of reinforced concrete piers and sills, supporting massive steel gates. Each main pier is 11 meters wide and extends to a point slightly above the top of the gates, with the operating machinery and machinery housings mounted atop each pier. Protective and decorative machinery housings were constructed consisting of large curved coverings made of wood and clad with stainless steel. The lowest pier foundations were sunk some 17 meters into the chalk beneath the river bottom.

The barrier includes four main navigation openings measuring 61 meters (approximately 200 feet) in width and two 31.5 meter (approximately 103-foot) openings for passage of smaller vessels. Each of these openings is fitted with a rising sector gate. To allow for free water flow for practically the full width of the river, four more 31.5 meter openings were included each having a falling radial gate, similar to the tainter type gates common to our inland waterway control structures, as a barrier against flood waters.

The rising sector gates are hollow stainless steel structures with the downriver side curved. Each gate is mounted at either end to large steel disks giving the entire gate structure the appearance of a cut-away cylinder. The gates are supported on trunnion shafts which rotate in bearings mounted in the piers. They are operated by means of reversible hydraulic rams and operating arms mounted on the top of the piers. Under normal conditions the gates lie flat in curved concrete sill recesses in the river bed. Each can be operated upward and stopped at four positions, partially closed (1/8 turn of the disk upward), fully closed (1/4 turn of the disk upward), underspill position (3/8 turn of the disk upward), and maintenance position (1/2 turn of the disk upward). To facilitate operation of the gate the interior of each gate chamber is evacuated of water resulting in a partially buoyant structure.

The facilities are operated from a Control Tower located on one bank of the river with a backup control room on the opposite bank. Two service tunnels pass through the foundation of the barrier beneath the river to connect between the two control rooms and to provide power and other utility

service access to each pier. In case of extreme emergency each gate can be operated from the individual pier engine rooms. Operating power is provided by three 1.5 MW on-site power generating units, with backup connection to the local electrical grid.

Since its commissioning the Thames River Barrier has been operated 4 to 5 times per year, for a total of 276 times as of 29 April 2002. Each closing cycle takes approximately 15 minutes, though the operation time is greatly extended because of the coordination required with operation of the port facilities.

The Thames River Barrier was constructed between 1972 and 1982 and was formally opened in 1984. The total project construction cost was approximately $760 million. The annual operating and maintenance cost for the Barrier and appurtenant facilities is approximately $13 million.

In considering the rising sector gate design for application to the MsCIP barrier structures several points of advantage were identified. Under normal conditions the gates rest out of view at river bottom level. This is appealing in that it would offer a minimum of obstruction to view, to tidal ebb and flow, and to navigation through the structure. The piers, while substantial, are placed wide enough apart that they should be no more obtrusive than the existing bridge structures. The speed of operation would minimize the time the gates would be required to be in place before and after a storm event, and the fact that the gates can be rotated to a full up position for maintenance completely in the dry without installation of unwatering devices or dismantling of the structure is a great maintenance advantage. The maintenance aspect is further enhanced by the fact that the gate surface material is all stainless steel.

Readily observable disadvantages or questionable considerations include the very high construction cost, the relatively small design head required at the Thames River installation as compared to those for the MsCIP sites, the considerably weaker foundation materials existing at the Mississippi Gulf Coast sites, and the relative lengths of the barrier structures required for the MsCIP project sites compared to the Thames River site.

This type of structure would allow the least restriction to natural tidal flow and with gates flush with the natural bottom, provide the least environmental concern.

The general alignment of line 4 is envisioned along the path of a railway that crosses the coast of Mississippi. In Harrison County, this pathway is through heavily populated and commercial zones. To the east in Jackson County, a decision was made not to cross the Pascagoula River and associated marshes. To do so would have both technical and environmental concerns. Crossing this major river system would create environmental problems as well as interior flooding. Constructing barriers or levees across the marshes will change the surface water flow, restrict tidal exchange and could alter existing salinity conditions leading to major ecosystem changes. Blocking the rivers with surge gates, even for short periods could cause extensive flooding due to water backing up behind the gates during storms as rain falls inland. This could cause more flooding than the storm surge. The Pascagoula River system is also habitat to the endangered Gulf Sturgeon and any approved construction or modifications in the river would be unlikely.

For these reasons, the first major watershed divide west of the Pascagoula River was selected to turn the barrier north and extend it to a location beyond the extent of the storm surge associated with a MPI event. Similarly to the west in Hancock County, LOD-4 follows the railway to a watershed divide that is located east of the Pearl River where it follows the divide north to the MPI line. Both of these northward extensions will cross the path of Interstate 10 and may dictate some modifications to the highway depending on the selected top elevation of the line.

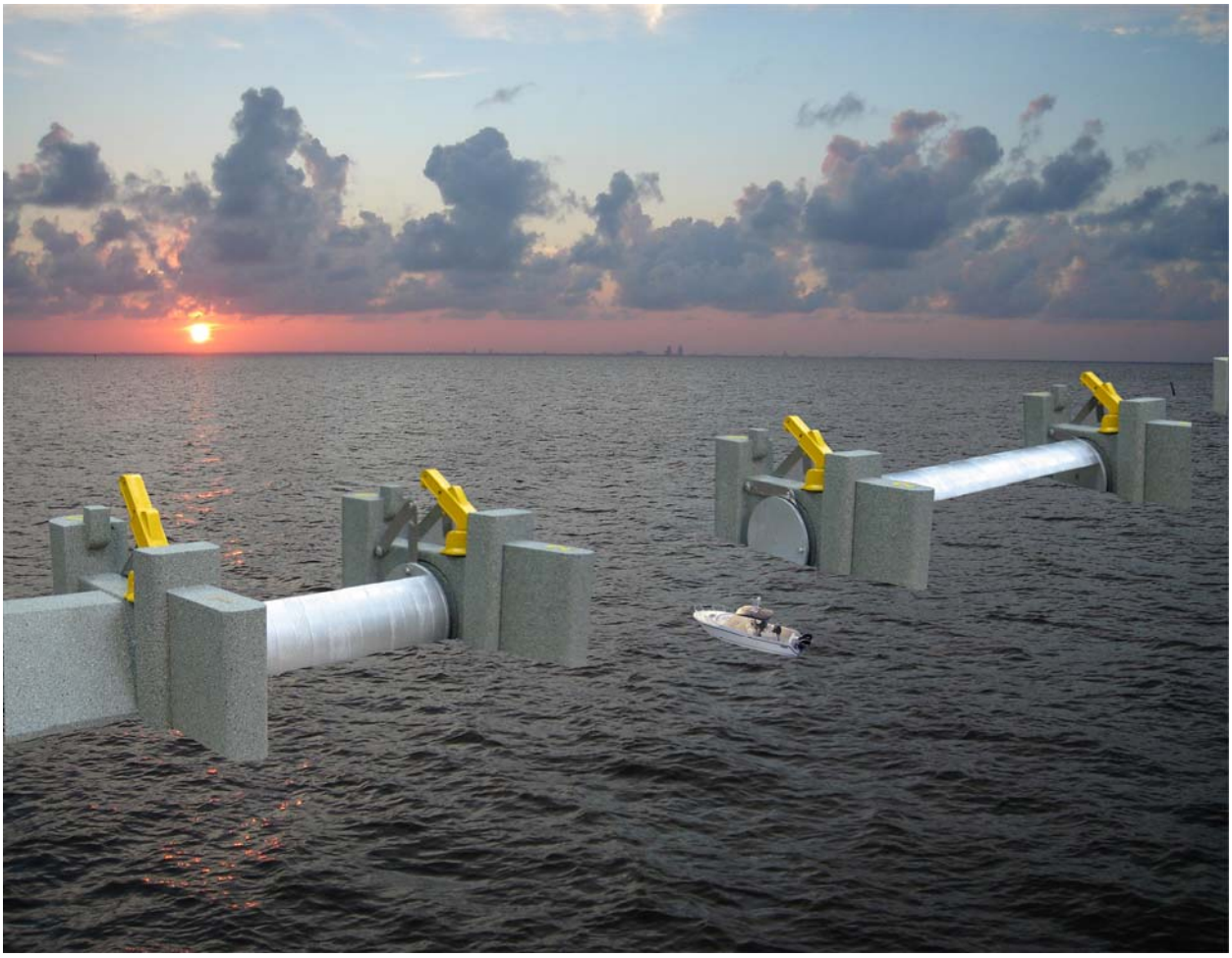


Figure 2.1.4-1. Conceptual graphic of rising sector gate used to close the mouths of the bays in Mississippi during a storm surge. This would be of similar design to what was used on the Thames River in London. The gate to the left of the boat is in the raised position, the gate in front of the boat is in the down or open position and the gate to the right of the boat is in the up or maintenance position.

LOD-4 could also be designed to have roadways, even major highways on top if desired. This line would be the highest defense, but would not protect structures seaward from the larger storms that might overtop Line 3. All facilities seaward of Line 4 would be prone to flooding in a large storm, so flood-proofing would be necessary in this zone. As described prior, this barrier would extend from high ground east of the Pearl River to high ground west of the Pascagoula River for a distance of approximately 57 miles. It would not cross either of these river systems.

Like Line 3, interior drainage behind this barrier must also be considered. The watersheds may be large and large rainfall events would require substantial structures designed to allow the water to drain or be pumped over the structure in a storm.

2.1.5 Fifth Line of Defense – Beyond the Surge Limits

Computer simulations have predicted how far inland storm surge will extend if the worse-case hurricane or maximum possible intensity (MPI) event hits the Mississippi coast. This line represents a line of safety where homes, facilities or transportation routes north of this line should not be affected by any storm surge. This would be an area where hospitals, schools, emergency response

and management facilities might be located. Present predictions based on modeling sets this line near elevation 40 feet.

2.2 Hydrodynamic and Coastal Process Modeling

Part 2 documents the hydrodynamic and coastal processes modeling required to evaluate the lines of defense. The coastal processes modeling analysis employed the engineering-economic model Beach-*fx* (Gravens et al. 2007) is discussed first. Beach-*fx* relies on a shore response database to evaluate the beach and dune line of defense (line of defense two). The beach and dune analysis is primarily concerned with levels of protection below a 50-year return period and therefore the shore response database was developed with an existing surge database commonly applied for beach studies. The statistical methodology for computing the frequency relationships necessary for the evaluation of the no project condition and lines three and four is then introduced. The numerical models and methodology for providing the data to the statistical analysis is detailed including wind and atmospheric pressure modeling, offshore wave modeling, nearshore wave modeling, and storm surge modeling. The resulting frequency relationships are presented and discussed. The part concludes with documentation of various sensitivity analyses, including sensitivity to barrier island configuration (an evaluation of line of defense one), and wetlands.

2.2.1 Introduction

Part 2 documents the hydrodynamic and coastal processes modeling required to evaluate the lines of defense. The coastal processes modeling analysis employed the engineering-economic model Beach-*fx* (Gravens et al. 2007) is discussed first. Beach-*fx* relies on a shore response database to evaluate the beach and dune line of defense (line of defense two). The beach and dune analysis is primarily concerned with levels of protection below a 50-year return period and therefore the shore response database was developed with an existing surge database commonly applied for beach studies. The statistical methodology for computing the stage-frequency curves necessary for the evaluation of the no project condition and lines three and four is then introduced. The numerical models and methodology for providing the data to the statistical analysis is detailed including wind and atmospheric pressure modeling, offshore wave modeling, nearshore wave modeling, and storm surge modeling. The resulting stage-frequency curves are presented and discussed. The part concludes with documentation of various sensitivity analyses, including sensitivity to model inputs, barrier island configuration (an evaluation of line of defense one), and wetlands.

2.3 Shore Response Database

2.3.1 Purpose

The coastal processes modeling analysis employed the engineering-economic model Beach-*fx* as the primary analysis tool. The purpose of this analysis is to evaluate the physical performance of the beach and dune system for anticipated future without-project and alternative with project conditions and to estimate the economic costs and benefits of each. This section of the report documents development of the coastal processes input data and physical performance results of the Beach-*fx* analysis, the economic results of the Beach-*fx* analysis are documented elsewhere in this report. Central to the application of Beach-*fx* is development of the Shore Response Database (SRD). The SRD is a relational database that stores results of beach profile change simulations of a historically based suite of plausible storms impacting a pre-defined range of anticipated beach profile configurations, as defined by ranges of berm width, dune width, and dune height. The SRD contains the primary coastal morphology change data that is one of the basic elements of Beach-*fx,* a

comprehensive analytical framework for evaluating the physical performance and economic benefits and costs of shore-protection projects, particularly, beach nourishment along sandy shores. The SRD is site- and study-specific; that is, it is developed uniquely for each shore protection project study area. Results stored in the SRD for each storm/profile combination are changes in berm width, dune width, dune height and upland width, and cross-shore profiles of erosion, maximum wave height, and total water elevation. The morphology changes (berm width, dune width, dune height and upland width changes) are used to update the simplified pre-storm beach profile to obtain the post-storm profile. Hence, through Monte Carlo simulations of the project lifecycle the morphological evolution of the study area is estimated along with project costs and infrastructure damage estimates. Simulation of multiple project lifecycles allows for the quantification of average expected project evolution, project costs, and infrastructure damages together with statistical distributions of these quantities. The damage driving parameters (cross-shore profiles of erosion, maximum wave height, and total water elevation) are used to estimate damages within reaches associated with that representative profile. The SRD is thus a pre-generated set of beach profile responses to storms and a range of profile configurations that are expected to exist under different scenarios of storm events and management actions (beach nourishment). The SRD, once generated, serves as a look-up table by the Monte Carlo simulation model. The Monte Carlo simulation has available to it the same set of storms used in populating the SRD.

2.3.2 Computational Models

The models applied to evaluate beach profile response to storms and project induced shoreline change are model SBEACH (Larson and Kraus 1989) and GENESIS (Hanson and Kraus 1989). SBEACH is a numerical model for simulating storm-induced beach change that has been applied at numerous projects. SBEACH takes as input the storm time series (wave heights, wave periods, and total water elevations) and the initial profile definition, as well as other descriptors of the beach (e.g., grain size) and model parameters, and produces as output, the estimated beach profile at the end of the storm, as well as cross-shore profiles of erosion, maximum wave height, and total water elevation including wave setup. This information is extracted from the SBEACH output by post-processing routines and stored in the SRD. The storm time series input is derived from a pre-computed surge response database developed by the Dredging Research Program (DRP) and the Wave Information Studies (WIS) database.

Estimates of the project-induced shoreline change rate are obtained through application of a one-line shoreline change model such as GENESIS (Hanson and Kraus 1989). The GENESIS model has been applied to numerous engineering projects and has demonstrated favorable capability to predict long-term shoreline change. GENESIS was designed to simulate long-term shoreline change produced by temporal and spatial differences in the longshore sand transport at coastal engineering projects. The beach profile is assumed to remain in a state of quasi-equilibrium over the long-term. The accretion or erosion of the beach is realized as a seaward or landward translation of the entire profile so that only one point of the profile, taken as the shoreline, is required to model the evolution of a sandy coast. Project-induced shoreline change rates are computed for each of the planned beach nourishment cycles which accounts for the improved performance of beach nourishment projects that comes with project maturation. That is, theory and beach nourishment experience has shown that dispersion losses at a beach nourishment project tend to decrease with the number of project renourishments. This information is stored in the database by reach and nourishment cycle. Project-induced shoreline changes capture the “spreading out” of a nourishment project on a long straight shoreline. In this phase of the analysis, potential improvements along the Mississippi Sound shoreline are assumed to be continuous along the Harrison and Hancock County shorelines. The project in Harrison County is assumed to extend from Biloxi Bay in the east to Saint Louis Bay in the west. In Hancock County the project is assumed to extend from Saint Louis Bay to Bayou Caddy.

Consequently, project-induced shoreline changes were assumed negligible because as the project is continuous across the study domain.

2.3.3 Surge Database

The DRP tropical storm database consists of surge data hydrographs recorded at 486 discrete locations corresponding to selected WIS and nearshore stations along the east and Gulf of Mexico Coasts and Puerto Rico. The database was constructed by numerically simulating historically based hurricanes that have impacted the east and Gulf coasts. The source of data for the simulations was the National Oceanic and Atmospheric Administration's National Hurricane Center's HURDAT (HURicane DATabase).

For this study, a storm suite containing 71 historical storms from the year 1886 to 2001 with at least a foot of storm surge along the Mississippi coast were identified. Storm surge hydrographs were extracted from the DRP database for these 71 historical events at stations 509 and 510. The storm surge hydrographs were subsequently combined with statistically representative astronomical tides corresponding to high, mean, and low tidal ranges and the peak storm surge was aligned with four tidal phases (high tide, mean tide falling, mean tide rising and low tide) to expand the historical storm suite by a factor of 12 resulting in a plausible storm suite of 852 unique storm events. Time series of wave heights and periods were obtained from WIS station 144 for those storms coinciding with the WIS database. For storms not included in the WIS database wave heights and periods were estimated based on methods outlined in the Shore Protection Manual.

2.3.4 Methodology

The methodology for generating the SRD involves a series of steps. First, representative beach profiles are generated based on available measured beach profiles. Then the expected range of upper beach profile configurations (dune height, dune width, and berm width) are surmised and combined with the representative submerged beach profile. SBEACH simulations of beach profile response are then performed for each unique beach profile and plausible storm combination. Finally, a data extraction routine extracts upland width, dune height, dune width and berm width changes as well as cross-shore profiles of erosion, total water elevation and maximum wave height from the SBEACH output files and writes these data to the SRD. The SRD, once generated, serves as a look-up table by the Beach-*fx* Monte Carlo simulation model. The Monte Carlo simulation has available to it the same set of storms used in populating the SRD. As a given storm from the simulated sequence takes place, the current profile (defined by representative profile, dune width, dune height and berm width) is used to look up the results that are associated with that storm in the SRD for the profile that is closest to the pre-storm profile as tracked in the simulation. The SRD results define the post-storm profile to track volume changes and to determine within-storm erosion, and wave heights and water elevations associated with the storm along the cross-shore profile. Within Beach-*fx*, storm-based morphology change includes a representation of scarping of the seaward dune face. Dune scarping takes place when the berm retreat is calculated to invade the seaward toe of the dune.

In this study, SRD databases were separately generated for Harrison and Hancock counties because the representative profiles, design conditions and storm surge hydrographs differ between the two counties. Unique SRD databases were generated for existing and future without-project conditions and for the with-project conditions. In Harrison County the existing and future without-project condition SRD is comprised of beach profile responses for a total of 10,224 beach profile – storm combinations (12 beach profiles by 852 storms). The Harrison County with-project SRD is comprised of beach profile responses for a total of 127,800 beach profile – storm combinations (150 beach profiles by 852 storms). In Hancock County the existing and future without-project condition SRD is comprised of beach profile responses for a total of 6,816 beach profile – storm combinations

(8 beach profiles by 852 storms). The Hancock County with-project SRD is comprised of beach profile responses for a total of 58,788 beach profile – storm combinations (69 beach profiles by 852 storms).

The SRD also includes an applied shoreline change rate, project-induced shoreline change rate, and post-storm berm width recovery. The user-specified applied shoreline change rate is a reach level calibration parameter and is specified in feet per year, for each reach. The applied shoreline change rate is set so that the combination of the applied shoreline change rate and storm-induced change returns on average over multiple lifecycle simulations the historical shoreline change rate for the reach. The target historical shoreline change rate is determined based on a separate analysis of the available historical beach profile and or shoreline position data. In this study, the applied shoreline change rate for Harrison County was assigned a value of -0.244 ft/year to cause Beach-fx to return the estimated historical shoreline change rate of -3.00 ft/year, based on available historical shoreline position data. In Hancock County the applied shoreline change rate was assigned a value of -2.116 ft/year to cause Beach-fx to return the estimated historical shoreline change rate of -4.85 ft/year.

Post-storm recovery of eroded berm width after passage of a major storm is recognized by the coastal engineering community although the present state of coastal engineering practice has not yet developed a predictive capability for estimating this process. Consequently, the post-storm recovery is represented in an ad hoc procedure in which the user specifies the percentage of the estimated berm width loss during the storm that is recovered over a user specified recovery interval. In this study the post-storm recovery factor was assigned a value of 80 percent and a recovery interval of 21 days. That is, 80 percent of the berm width loss caused by a storm in the simulation is restored over the 21 days following the storm event. If a second storm event occurs prior to full berm width recovery (within 21 days) berm width recovery for the first storm is suspended. The post-storm recovery factor in combination with the applied shoreline change rate serve as calibration factors in Beach-*fx*. The basis for the selected recovery factor was made based on engineering judgment and the expectation that, in the absence of storm activity, the Mississippi mainland shoreline should be either stable or modestly erosional, selection of an 80 percent recovery factor resulted in an applied erosion rate of -0.244 ft/year to achieve the long-term historical shoreline change rate of -3.00 ft/year, which satisfies the assumption of a mostly stable shoreline in the absence of storm activity.

2.3.4.1 Treatment of Future Sea Level Rise

The analysis described above was repeated three times for three different potential sea level rise scenarios corresponding to the existing rate of sea level rise, a potential future moderate rate of sea level rise and a potential future high rate of sea level rise. Incorporating potential future sea level rise in the coastal processes analysis involved adding an increment of water elevation to the total water elevation input to SBEACH. For the potential moderate future rate of sea level rise input water levels were increased 2.4 ft and for the potential high future rate of sea level rise input water levels were increased 3.8 ft. The potential future sea level rise scenarios significantly change the predicted morphology evolution, the required nourishment fill volumes, and the predicted damages. For example, in Harrison County the average long-term shoreline change rate of -3.00 ft/year for the existing rate of sea level rise increases to -5.83 ft/year for the moderate rate of future sea level rise and to -5.18 ft/year for the high rate of future sea level rise. The reason for the decrease in the average annual rate of shoreline change between the moderate rate of sea level rise and the high rate of sea level rise is due to more frequent complete inundation of the beach berm for the high rate of sea level rise which results in less berm erosion and consequently less shoreline change. In Hancock county the average long-term shoreline change rate of -4.85 ft/year for the existing rate of sea level change increases to -5.18 ft/year for the moderate rate of future sea level rise and to -5.98 ft/year for the high rate of future sea level rise.

As mentioned, the future potential sea level rise scenarios result in much more frequent inundation of the beach system. The potential moderate rate of future sea level rise increases the peak total water elevation of 48 percent of the historical storms by more than a factor of 2. Similarly, the potential high rate of future sea level rise increases the peak total water elevation of 78 percent of the historical storms by more than a factor of 2, the peak total water elevation of 20 percent of the historical storms is increased by more than a factor of 3.

2.3.5 Results

The results of the coastal processes analysis are presented in the context of the with- and without-project simulations. All Beach-*fx* simulations involved consideration of 300 potential future lifecycles of 105 year duration. The sequence and number of storm events in each lifecycle was randomly selected from the plausible storm suite of 852 historically-based storm events. The sequence and number of storms encountered in each lifecycle simulation is unique. However, the series of lifecycles used in the evaluation of the with- and without-project alternatives are identical. On average, 65 storms were encountered in each of the 105-year lifecycle simulations whereas the maximum and minimum number of storms per lifecycle is 90 and 45 storms, respectively. The standard deviation in the number of storms per lifecycle is 8. To illustrate the stochastic character of the Beach-*fx* simulations Hurricane Camille, the most intense event in the suite of historically-based plausible storms, is encountered a total of 267 times in the 300 105-year lifecycle simulations. In 96 lifecycles Camille is encountered just once, in 54 lifecycles Camille is encountered twice, in 14 lifecycles Camille is encountered three times, in four lifecycles Camille is encountered four times and in one lifecycle Camille is encountered five different times. In 33 of the 300 simulated lifecycles Hurricane Camille is never encountered.

2.3.5.1 Future Without-Project Simulations

The future without-project simulations assumed continuation of existing shore protection activities and two alternative scenarios of the future shore protection activities were examined. The first alternative examined continued maintenance of the existing berm project in Harrison and Hancock counties. The second future without project alternative involved not only maintenance of the existing berm project but also construction and maintenance of the "interim dune" feature, which involves a 2.9 yd^3/ft dune feature positioned 50 ft seaward of the Hwy. 90 seawall with a 10 ft (NAVD 88) dune elevation and a 10 ft dune crest width in Harrison County. In Hancock County the interim dune feature is comprised of approximately 1.6 yd^3/ft of sand with a 7 ft (NAVD 88) dune elevation and a 10 ft dune crest width. The berm project in Harrison County involves a 230 ft wide berm extending seaward from the Hwy. 90 seawall to the Sound. The berm elevation varies from an elevation of approximately 7.2 ft (NAVD 88) at the seawall to 3.5 ft at the slope break to the Sound. The Hancock County berm project involves a 150 ft wide berm extending from the seawall to the Sound. The berm elevation varies from approximately 5.0 (NGVD88) ft at the seawall to 3.5 ft at the slope break to the Sound.

Maintenance of the future without project alternatives in Harrison County occurs on a 12 year interval at which time the without project alternative template is restored by hydraulic placement of fill material obtained from offshore sand sources. In Hancock County maintenance of the future without project alternatives occurs on an annual basis by truck haul placement. These differences in the frequency of beach maintenance in Harrison and Hancock Counties significantly influence the volume requirements of maintaining the beaches in the two counties. The magnitude of the influence of the maintenance cycle on with and without project volume requirements is discussed further in section 2.3.4.

Table 2.3-1 summarizes the results of the Harrison County without-project Beach-*fx* simulations. The data in Table 2.3-1 indicate that existing beach maintenance practices will require approximately 130 yd^3/ft of beach over a 100 year project life assuming the existing rate of sea level rise persists into the future. If however, future rate of sea level rise increases the simulations indicate that the potential moderate rate of future sea level rise will result in about a 90 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about a 115 percent increase in project volume requirements.

Table 2.3-1.
Harrison County Without-Project Summary

Alternative Name[1]	Number of Nourishments				Nourishment Volume (yd^3/ft)			
	mean	SD	max	min	mean	SD	max	min
Berm_ESLR	6	1	8	4	142.3	22.0	214.7	85.6
Interim Dune & Berm ESLR	7	1	8	5	124.9	22.1	208.6	72.5
Berm_MSLR	8	1	8	5	278.1	36.6	385.3	179.6
Interim Dune & Berm MSLR	8	0	8	7	229.2	26.1	310.4	169.4
Berm_HSLR	8	0	8	6	324.4	39.2	437.7	211.3
Interim Dune & Berm HSLR	8	0	8	7	248.9	28.5	338.9	192.1

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

Table 2.3-2 summarizes the results of the Hancock County without-project Beach-*fx* simulations. The data in Table 2.3-2 indicate that existing beach maintenance practices will require approximately 304 yd^3/ft of beach over a 100 year project life assuming the existing rate of sea level rise persists into the future. If however, future rate of sea level rise increases the simulations indicate that the potential moderate rate of future sea level rise will result in about a 51 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about a 69 percent increase in project volume requirements.

Table 2.3-2.
Hancock County Without-Project Summary

Alternative Name[1]	Number of Nourishments				Nourishment Volume (yd^3/ft)			
	mean	SD	max	min	mean	SD	max	min
Berm_ESLR	100	0	100	100	297.7	28.1	379.7	250
Interim Dune & Berm ESLR	100	0	100	100	310.3	31.6	396.9	250
Berm_MSLR	100	0	100	100	443.7	47.0	581.7	302.9
Interim Dune & Berm MSLR	100	0	100	100	473.1	53.5	607.0	285.7
Berm_HSLR	100	0	100	100	497.2	53.1	654.8	351.9
Interim Dune & Berm HSLR	100	0	100	100	531.5	32.1	619.7	452.1

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

2.3.5.2 Future With-Project Simulations

The future with-project simulations involved evaluation of four alternative design cross-sections in both Harrison and Hancock counties. The maintenance or renourishment of the design cross-sections are the same as those used in evaluation of the future without-project alternatives: renourishment every 12 years by hydraulic placement in Harrison County and annual reconstruction

of the design cross-section, as required, by truck haul placement in Hancock County. The design cross-sections in Harrison County involved a 15 ft dune height, 35 ft dune crest width and a 160 ft berm width (Alternative 1); a 15 ft dune height, 25 ft dune crest width and a 170 ft berm width (Alternative 2); a 13 ft dune height, 45 ft dune crest width and a 160 ft berm width (Alternative 3); and a 13 ft dune height, 15 ft dune crest width and a 160 ft berm width (Alternative 4). Dune volumes for the four Harrison County design alternatives are 17.2 yd^3/ft, 13.9 yd^3/ft, 14.2 yd^3/ft, and 6.7 yd^3/ft for Alternatives 1, 2, 3, and 4, respectively. The design cross-sections in Hancock County involved a 10 ft dune height, 40 ft dune crest width and 80 ft berm width (Alternative 1); a 10 ft dune height, 20 ft dune crest width and 100 ft berm width (Alternative 2); an 8 ft dune height, 50 ft dune crest width and 80 berm width (Alternative 3); and an 8 ft dune height, 30 ft dune crest width and 100 ft berm width. Dune volumes for the four Hancock County design alternatives are 10.7 yd^3/ft, 6.6 yd^3/ft, 7.3 yd^3/ft, and 4.7 yd^3/ft, for Alternatives 1, 2, 3, and 4, respectively.

Table 2.3-3 summarizes the results of the Harrison County with-project Beach-*fx* simulations. The data in Table 2.3-3 indicate that, in general, nourishment is required at the end of every nourishment cycle (the maximum number nourishments is 9) for the moderate and high potential future sea level rise rate. However, for the existing rate of sea level rise on average 2 nourishment cycles can be skipped for Alternative 1 and one nourishment cycle can be skipped for Alternatives 2 and 4. Nourishment volume requirements over the 100-year project life are approximately 197 yd^3/ft of beach assuming the existing rate of sea level rise persists into the future. If however, the future rates of sea level rise increases the simulations indicate that the potential moderate rate of future sea level rise will result in about a 65 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about an 86 percent increase in project volume requirements.

Table 2.3-4 summarizes the results of the Hancock County without-project Beach-*fx* simulations. The data in Table 2.3-4 indicate that with-project nourishment volumes for the existing rate of sea level rise are approximately 369 yd^3/ft of beach over a 100-year project life. If however, future rate of sea level rise increases the simulations indicate that the potential moderate rate of future sea level rise will result in about a 75 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about a 102 percent increase in project volume requirements.

Table 2.3-3.
Harrison County With-Project Summary

Alternative Name[1]	Number of Nourishments				Nourishment Volume (yd^3/ft)			
	mean	SD	Max	min	mean	SD	max	min
Alternative 1 ESLR	7	1	9	4	202.6	37.5	334.7	116.6
Alternative 2 ESLR	8	1	9	4	199.9	37.3	360.2	99.4
Alternative 3 ESLR	8	1	9	4	203.7	38.0	351.9	122.8
Alternative 4 ESLR	8	1	9	4	180.7	35.5	321.3	82.8
Alternative 1 MSLR	9	1	9	7	366.7	48.5	506.6	240.8
Alternative 2 MSLR	9	0	9	7	360.9	47.9	488.6	243.1
Alternative 3 MSLR	9	1	9	7	351.5	46.7	483.7	235.0
Alternative 4 MSLR	9	0	9	7	296.9	40.1	396.2	203.8
Alternative 1 HSLR	9	0	9	7	421.4	49.1	531.2	312.0
Alternative 2 HSLR	9	0	9	7	411.2	49.4	539.9	278.1
Alternative 3 HSLR	9	0	9	7	418.0	44.7	540.8	294.9
Alternative 4 HSLR	9	0	9	7	335.5	36.8	437.1	247.8

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

Table 2.3-4.
Hancock County With-Project Summary

Alternative Name[1]	Number of Nourishments				Nourishment Volume (yd^3/ft)			
	mean	SD	max	min	mean	SD	max	Min
Alternative 1ESLR	100	0	100	100	384.1	68.3	829.8	283.6
Alternative 2 ESLR	100	0	100	100	352.9	61.8	758.5	272.0
Alternative 3 ESLR	100	0	100	100	380.6	65.8	748.8	294.7
Alternative 4 ESLR	100	0	100	100	358.1	75.7	1,117.7	279.3
Alternative 1MSLR	100	0	100	100	690.1	121.9	1,034.5	445.8
Alternative 2 MSLR	100	0	100	100	587.5	93.0	877.4	404.7
Alternative 3 MSLR	100	0	100	100	674.1	136.3	1,059.4	410.3
Alternative 4 MSLR	100	0	100	100	587.4	100.1	887.6	371.6
Alternative 1HSLR	100	0	100	100	835.8	107.6	1,252.4	624.3
Alternative 2 HSLR	100	0	100	100	682.1	77.3	883.9	490.9
Alternative 3 HSLR	100	0	100	100	704.0	80.5	1,012.8	549.6
Alternative 4 HSLR	100	0	100	100	599.9	63.7	853.2	449.3

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

2.3.6 Summary

The coastal processes analysis conducted as a part of this study has provided a number of useful insights with respect to morphology change, coastal evolution, and the primary drivers for storm-induced damages along the Mississippi Sound shoreline. First, the Mississippi Sound shoreline is primarily a stable, low energy coast that is dramatically impacted by tropical storm events. In the absence of tropical storm events the shoreline is expected to be only slightly erosive with shoreline change rates on the order of -1 ft/year. In general, moderate storm events produce more coastal erosion and volumetric beach change along the Mississippi Sound shoreline than do major hurricanes. This is because the large storm surge associated with the very intense storms completely inundates the beach system and protects it from the high energy dissipation associated with wave breaking, which results in less overall shoreline change and volumetric erosion of the beach. Damages to upland infrastructure are largely driven by inundation and direct wave attack as opposed to erosion, partly because most of the infrastructure is located landward of the sea wall that runs along Hwy 90 Harrison County and Beach Boulevard in Hancock County.

As a result of the difference in maintenance cycles in Harrison and Hancock counties the project volume requirements in Hancock County exceed those in Harrison County by approximately 225 percent for without project conditions under existing sea level rise conditions, for the potential future sea level rise scenarios the increase in volume requirement is about 180 percent. For with project conditions the volume requirements in Hancock County exceed those in Harrison County by approximately 190 percent. The reason the volume requirements are so much higher in Hancock County is because the beach is restored to design conditions every year if needed, whereas in Harrison County the beach is restored to design conditions once every 12 years. If the beach in Harrison County is damaged by a major storm in the year following reconstruction of the design template the beach remains vulnerable for the remainder of the 11 year nourishment cycle. Essentially, the present analysis indicates that the nourishment cycle in Harrison County should be shortened or augmented with a provision for emergency dune reconstruction after the occurrence of a major storm event.

2.4 Statistical Methodology

A team of Corps of Engineers, FEMA, NOAA, private sector and academic researchers have been working toward the definition of a new system for estimating hurricane inundation probabilities. The findings and recommendations of this group are documented in a White Paper on Estimating Hurricane Inundation Probabilities (Resio 2007). The approach recommended by the group was a modified Joint Probability Method (JPM) referred to as the JPM with Optimal Sampling (JPM-OS). The JPM-OS methodology was applied for this study and is summarized here. For a full description, see Resio (2007).

2.4.1 JPM-OS

The JPM was developed in the 1970's (Myers, 1975; Ho and Meyers, 1975) and subsequently extended by a number of investigators (Schwerdt *et al.*, 1979; Ho *et al.*, 1987) in an attempt to circumvent problems related to limited historical records. In this approach, information characterizing a small set of storm parameters was analyzed from a relatively broad geographic area. The underlying concept of the JPM-OS methodology is to provide a good estimate of the surges in as small a number of dimensions as possible, while retaining the effects of additional dimensions by including an ε term within the estimated Cumulative Distribution Function (CDF) for surges. The ε term is considered to include, at a minimum, tides, random variations in the Holland B parameter, track variations not captured in storm set, model errors (including errors in bathymetry, errors in model physics, etc.), and errors in wind fields due to neglect of variations not included in the PBL winds. It is evident that the overall distribution of ε can only be approximated from ancillary information on errors in comparisons to high water marks and comparisons of results from runs with the "best-estimate" wind fields and PBL wind fields. Tides are factored into the analysis assuming linear superposition, with some degree of error introduced. Based on the best available approximations to all of these terms, assuming that all the "error" contributions are independent, and a loose application of the Central Limit Theorem, it is assumed that the "error" term can be represented as a Gaussian distribution with a mean of zero (assuming that the model suite is calibrated to this condition) and a standard deviation equal to some percentage of the modeled surge.

The JPM-OS treats geographic variation by using the Chouinard et al. (1997) method for determining optimal spatial size for estimating hurricane statistics. In this method, the optimal size for spatial sampling is estimated in a manner that balances the opposing effects of spatial variability and uncertainties related to sample size. It can be shown that the optimal spatial sample (kernel) size is in the range of 160 km for frequency analyses, and that the optimal spatial size for intensities reaches a plateau above about 200 km and does not drop off substantially at higher spatial kernel sizes. For developing the JPM-OS for the Mississippi and Louisiana coasts, a basic data set of 22 hurricanes, which had central pressures less than 955 mb, were analyzed. The hurricane sample set covers the interval 1941 through 2005.

A "line-crossing" frequency analysis methodology was applied since the frequency of landfalling storms is inherently better posed in this context. Sensitivity studies showed that the results for spatial samples for spatial kernels above 250 km do not vary markedly and a sample size of ±3 degrees (333 km) along this line was selected. Results from this analysis were converted into an estimate of the frequency of hurricanes (which attain a minimum central pressure of 955 mb or less) making landfall within contiguous 1-degree increments along the reference line. For each 1-degree increment along the coast, pressure differentials at the time of landfall for all storms making landfall within the ±3-degree distance along the reference line were used to define a best-fit (conditional) Gumbel distribution, i.e. the distribution of hurricane intensity given that a hurricane (with central pressure less than 955 mb) does occur. Combining the storm frequency estimates with the Gumbel

coefficients for the pressure differentials, estimates of the omni-directional probability of intensity along the Gulf coast at the time of landfall can be made.

Storm size is not independent of storm intensity. Recently, Shen (2006) has shown that the potential intensity achievable by a hurricane is very sensitive to the size of a hurricane eye. Figures 2.4-1a and 2.4-1b show the relationships between the pressure scale radius (R_p) (i.e storm size) and central pressure of all storms exceeding Category 2 within the Gulf of Mexico at their time of maximum strength (52 storms –shown in Figure 2.4-1a) and the 22-storm sample of landfalling storms (Figure 2.4-1b). The following equation gives an estimate of the conditional probability of storm size as a function of central pressure:

$$P(R_p \mid \Delta p) = \frac{1}{\sigma(\Delta p)\sqrt{2\pi}} e^{-\frac{x^2}{2}}$$

where E2.4-1

$$x = \left(\frac{R_p - \overline{R}_p(\Delta p)}{\sigma(\Delta p)} \right)$$

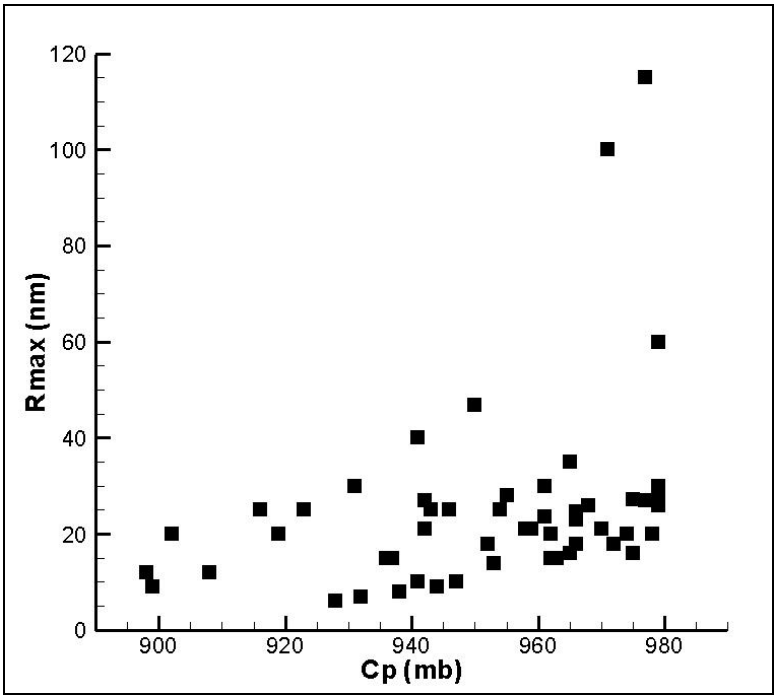


Figure 2.4-1a. Relationship between size scaling parameter (Rp) versus Central Pressure for 52 storm set in Gulf of Mexico (all storms > Cat 2). For reference, Hurricane Camille is characterized as Cp=909 mb and Rmax=11 nm. Hurricane Katrina is characterized as Cp=920 mb and Rmax=19 nm.

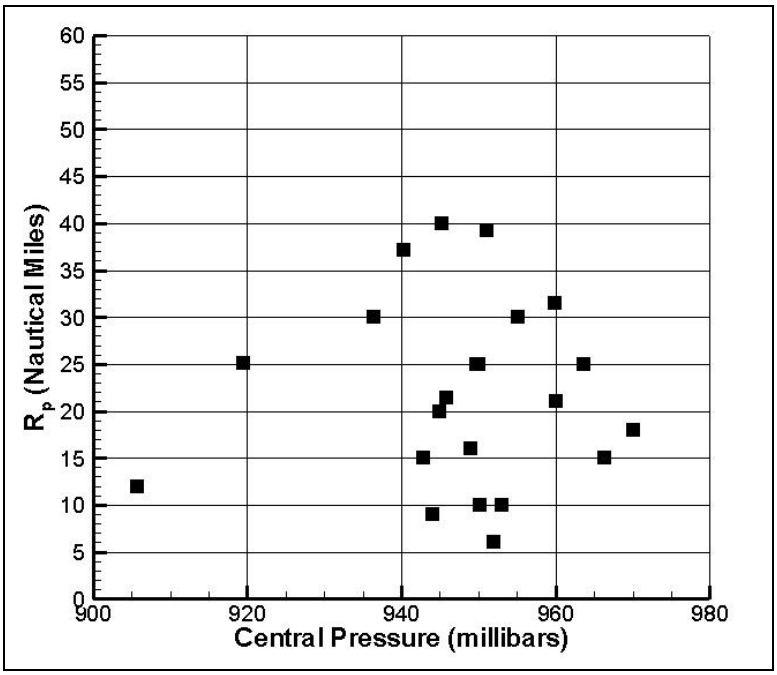


Figure 2.4-1b. Relationship between size scaling parameter (Rp) versus Central Pressure for 22 storm set in Gulf of Mexico (all storms with central pressure < 955)

Figure 2.4-2 gives the mean angle of storm heading as a function of distance along the reference line shown in Figure 2.4-3, along with the standard deviation of the heading angles around this mean value. The direction convention used here is that a heading of due north represents an angle of zero degrees. Storms heading more westerly than due north will have positive angles, while storms heading more easterly will have negative angles. These estimates were derived by the same spatial averaging procedure used in deriving the central pressures and frequencies. A circular normal distribution is used to represent the storm heading probability distribution as a function of location along the reference line.

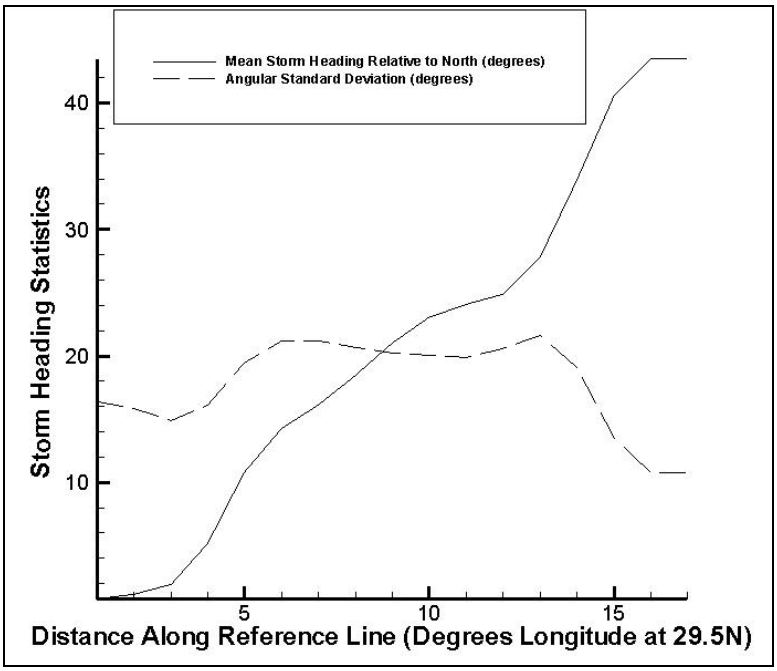


Figure 2.4-2. Plot of mean storm heading angle and standard deviation around this angle as a function of location along reference line. Distance along the x-axis can be taken as equivalent to 1-degree increments along the coast.

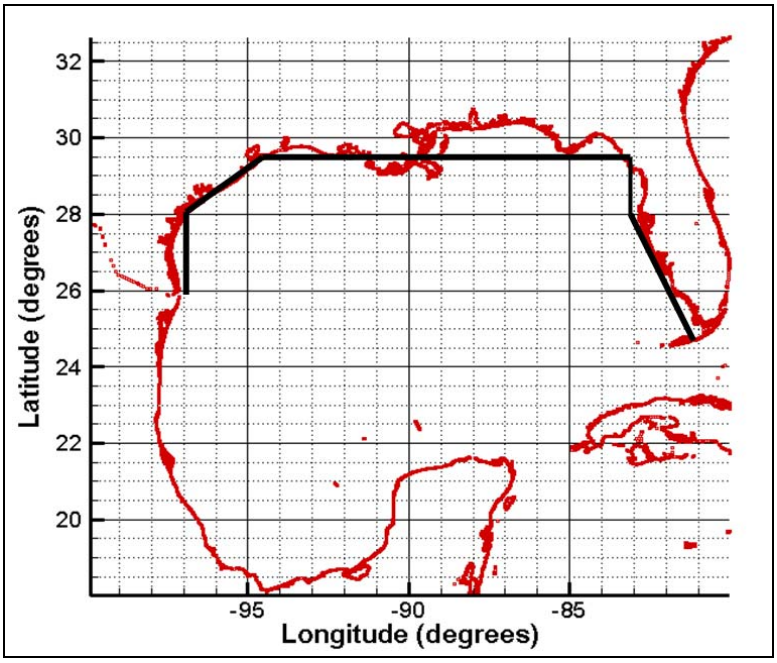


Figure 2.4-3. Location of line for analysis of hurricane landfalling characteristics

Figure 2.4-4 presents the estimated forward storm speed as a function of central pressure. This figure suggests that storm intensity and the forward speed of the storm are approximately independently distributed. Forward storm speed is plotted as a function of storm heading at landfall for the 14 storm subset that intersect with the 29.5-degree latitude portion of the reference line in Figure 2.4-3 and for the entire 22-storm sample of landfalling storms (shown in Figures 2.4-5a and 2.4-5b). These figures show that there is a tendency for higher forward speeds to be associated with lower storm heading angle (a correlation of 0.52 which is significant at the 0.05 level of significance with 21 degrees of freedom in a "Student's *t*" test). This is consistent with the expected behavior of re-curving storms that become swept up in stronger westerly circulations. The primary exception to the overall relationship is Hurricane Betsy, represented by the point in the upper right-hand corner of Figure 2.4-5b. This storm moved rapidly into the New Orleans area after crossing the lower portion of the Florida peninsula.

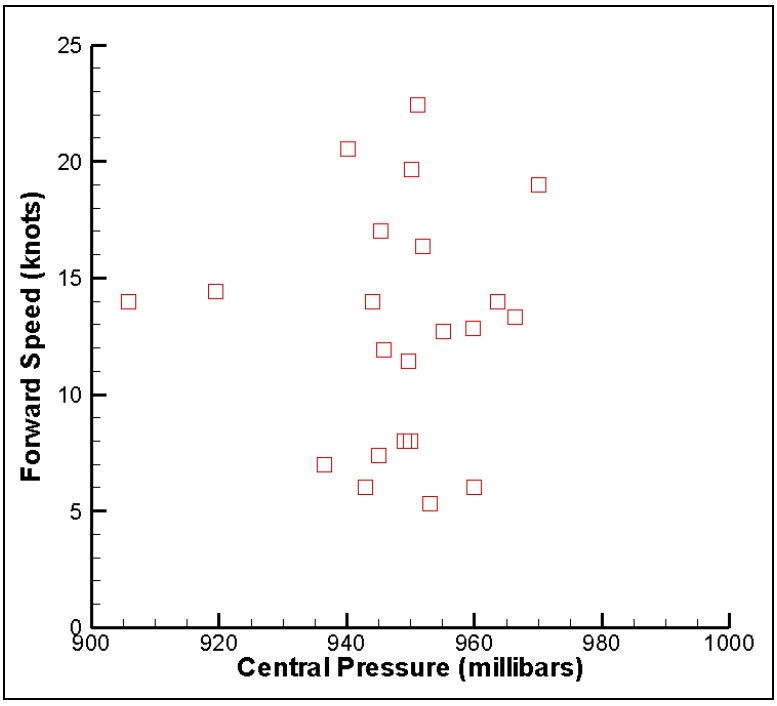


Figure 2.4-4. Plot of forward speed of storm at landfall versus central pressure at landfall

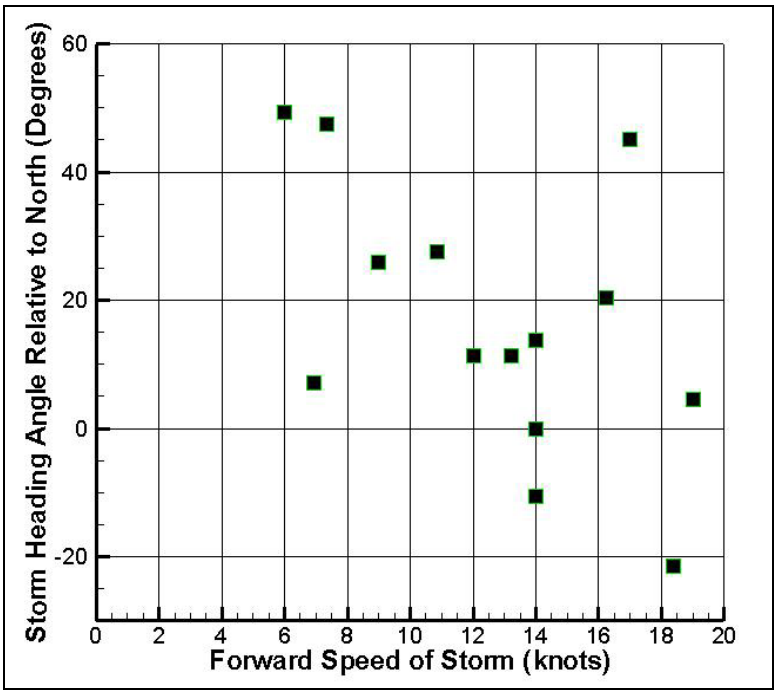


Figure 2.4-5a. Plot of storm heading and forward speed at time of landfall for only central Gulf landfalling storms

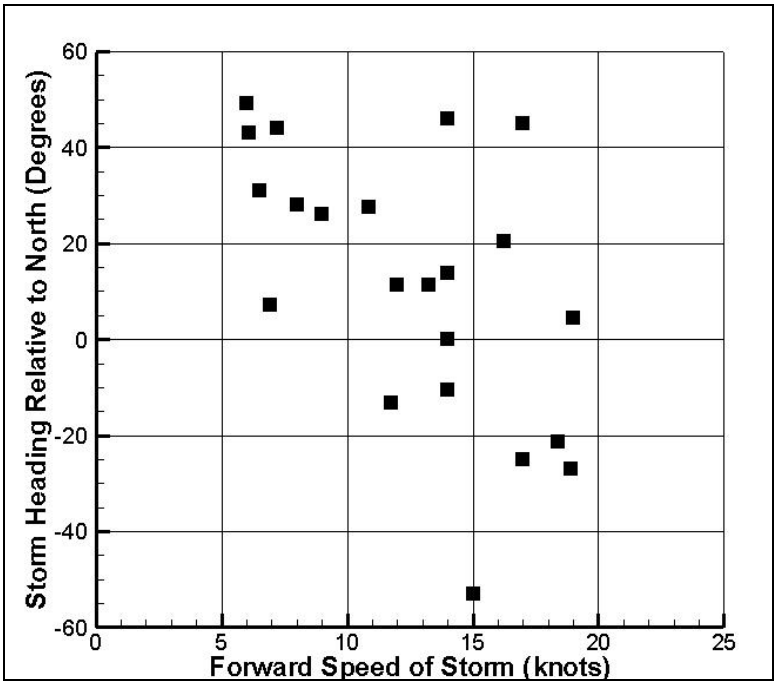


Figure 2.4-5b. Plot of storm heading and forward speed at time of landfall for the entire 22-storm sample

Consolidating this information, for any point in the five-dimensional parameter space (retaining appropriate interrelationships among parameters), the final estimates of joint probability densities can be written as

$$p(c_p, R_p, v_f, \theta_l, x) = \Lambda_1 \cdot \Lambda_2 \cdot \Lambda_3 \cdot \Lambda_4 \cdot \Lambda_5$$

$$\Lambda_1 = p(c_p \mid x) = \frac{\partial F[a_0(x), a_1(x)]}{\partial c_p} = \frac{\partial}{\partial x}\left\{\exp\left\{-\exp-\left[\frac{c_p - a_0(x)}{a_1(x)}\right]\right\}\right\} \text{ (Gumbel Distribution)}$$

$$\Lambda_2 = p(R_p \mid c_p) = \frac{1}{\sigma(\Delta P)\sqrt{2\pi}} e^{-\frac{(\bar{R}_p(\Delta P) - R_p)^2}{2\sigma^2(\Delta P)}}$$

E2.4-2

$$\Lambda_3 = p(v_f \mid \theta_l) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(\bar{v}_f(\theta_l) - v_f)^2}{2\sigma^2}}$$

$$\Lambda_4 = p(\theta_l \mid x) = \frac{1}{\sigma(x)\sqrt{2\pi}} e^{-\frac{(\bar{\theta}_l(x) - \theta_l)^2}{2\sigma^2(x)}}$$

$$\Lambda_5 = \Phi(x)$$

where the overbars denote average values of the dependent variable for a specified value of an independent variable in a regression equation, $a_0(x)$ and $a_1(x)$ are the Gumbel coefficients for the assumed Gumbel form of the central pressures, and $\Phi(x)$ is the frequency of storms per year per specified distance along the coast (taken as one degree in examples presented here).

2.4.1.1 Estimation of the ε term

Although there may be some degree of nonlinearity in the superposition of tides and storm surges, numerical experiments have shown that for the most part linear superposition provides a reasonable estimate of the (linearly) combined effects of tides and surges. Thus, the tidal component of the ε term, represents the percentage of time occupied by a given tidal stage and can be directly derived from available tidal information along the coast.

Careful analyses appropriate for formulating Holland B parameters for ocean response modeling have shown that this parameter falls primarily in the range of 1.1–1.6 offshore and 0.9–1.2 at the coast. For Gulf of Mexico hurricanes, a mean value of 1.27 in offshore areas is assumed with a standard deviation of 0.15, while at the coast the corresponding mean and standard deviation is 1.0 and 0.10, respectively. Via numerical experiments, the maximum storm surge generated by a hurricane has been found to vary approximately linearly with variations in the Holland B parameter, at least for changes of the Holland B parameter in the range of 10–20%.

Off-coast track variations affect surges at the coast primarily through the effects of these track variations on wave fields, rather than by their effects on direct wind-driven surges. Wave fields tend to integrate wind field inputs over tens of hours; consequently, off-coast track variations tend to shift the wave fields somewhat while maintaining the general form and magnitude of the wave height contours. Near-coast radiation stresses are approximately proportional to gradients in wave energy fluxes, which, in turn, can be related to the square of the wave height gradient. In shallow water, where contributions of radiation stresses to surges are most important, wave heights tend to be depth limited. It is only in the incremental region, where larger waves make additional contributions due to increased energy losses offshore, that larger wave conditions affect the total wave set-up at

the coast. Numerical sensitivity studies suggest that once incident waves become much larger than about 10 meters, most of the additional energy loss is in depths that do not contribute very much to wave set up. For this reason plus the fact that in general the wave set-up term tends to be only about 15-30% of the total surge, we expect the effect of storm track variations on wave set-up at the coast to be fairly small (due to the fact that surge response is on a much faster scale than wave generation, where we noted that the "straight-track" approximation was not very good). It is assumed that the deviations around the mean surge will be approximately Gaussian. A standard deviation of 20% of the calculated wave-set up contributions to the total surge (determined by subtracting the direct wind-only surge from the total surge due to winds and waves combined) will be used within this distribution.

Model errors combined in calibration/verification runs of ADCIRC have shown that this combination of model and forcing in the Louisiana-Mississippi coastal area provides relatively unbiased results with a standard deviation in the range of 1.75–2.50 ft. Relative errors associated with the use of PBL winds increase the value of the standard deviation to 2.00 to 3.50 ft. This is not too surprising, since the accuracy of HWM's (the primary measurements to which the model results are compared) are quite variable.

Combining all of these terms, under the assumption that they are each independently distributed, gives

$$p(\varepsilon) = \iint\iint \delta(\varepsilon_1 + \varepsilon_2 + \varepsilon_3 + \varepsilon_4 - \varepsilon)\, p(\varepsilon_1)\, p(\varepsilon_2)\, p(\varepsilon_3)\, p(\varepsilon_4)\, d\varepsilon_1 d\varepsilon_2 d\varepsilon_3 d\varepsilon_4 \qquad \text{E2.4-3}$$

where

ε_1 is the deviation between a storm at a random tide phase and a zero tide level;

ε_2 is the deviation created by variation of the Holland B parameter;

ε_3 is the deviation created by variations is tracks approaching the coast; and

ε_4 is the deviation created primarily by errors in models and grids.

Three of the terms ε_1, ε_3 and ε_4 are treated here as though they are approximately independent of the magnitude of the surge, while the remaining term, ε_2 has been found to depend essentially linearly with the magnitude of the surge. For a monochromatic tide, the tidal elevation distribution, ε_1, is known to be bimodal distributed around its zero value; however, in nature, the effect of combining several tidal components with varying phases is to force the distribution toward a unimodal distribution. The probabilities of terms ε_3 and ε_4 are assumed to be normally distributed; thus, the probability distribution of the sum of these two terms will also be a normal distribution with the variance given by the sums of the individual variances of the two terms.

Figure 2.4-6 gives a numerical example of the combination of all four terms assuming a storm surge of 15 ft, as might be associated with a particular deterministic model execution based on a set of track and PBL parameters. As can be seen in this figure, the overall magnitude of these effects can add or subtract substantially to the total water depth. In this case, the distribution appears similar to a Gaussian distribution, since it is dominated by the term with the largest variance (deviations due to the omission of the Holland B parameter); however, the other terms have been included within the integral for $p(\varepsilon)$. Table 2.4-1 shows an example of the effect of adding this term on expected surge levels for selected return periods. In this example, a Poisson frequency of 1/16 was used in combination with a Gumbel distribution, with parameters $a_0 = 9.855$ and $a_1 = 3.63$. For this example, the effect of adding the ε-term is less than ½ ft for return periods up to 175 years and only exceeds1 ft at return periods greater than 400 years. However, for risk-based calculations which

often include very large return periods (1000-10000 years), this term can become as large as 2-3 ft, even for the case where the effects of all neglected factors are assumed to be distributed around a mean deviation of zero. The effect could of course be larger if the deviations were biased.

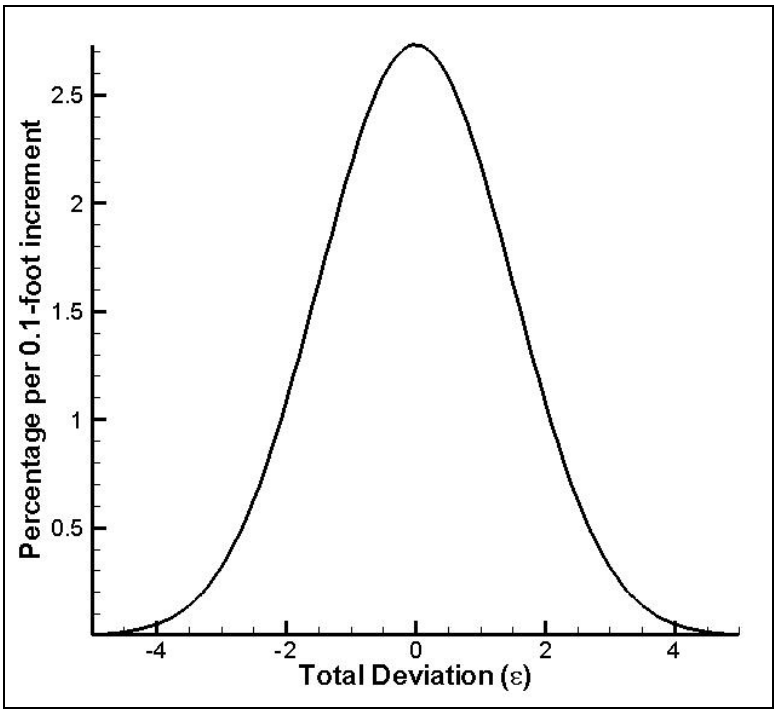


Figure 2.4-6. Percentage of deviations per 0.1-foot class as a function of deviation in feet

Table 2.4-1.
Example of Expected Surge Values as a Function of Return Period With and Without ε-Term

Return Period (years)	Without ε-Term (ft)	With ε-Term (ft)
50	11.98	12.06
100	14.82	15.21
200	17.67	18.35
300	19.33	20.18
400	20.52	21.49
500	21.43	22.50

From Table 2.4-1 and the above discussion, we see that the effect of the ε-term becomes much more pronounced at large return periods. Thus, older applications of the JPM that neglected this term were probably reasonably accurate at the 100-year return period, but were likely to have been progressively biased low at higher return periods. The important points to stress here are twofold. First, any neglect or suppression of natural variability in a procedure to estimate extremes will lead to some degree of underestimation of the estimated extremes; therefore, it is important to recognize and attempt to quantify all significant factors affecting surge heights at the coast. Second, to avoid making the number of dimensions in the JPM unmanageable, the estimated effects of the neglected factors contributing to extreme surges should be addressed statistically, such as done here via the addition of the ε-term to the JPM integral.

2.4.1.2 Sampling of Storm Parameters for the JPM-OS

In the conventional JPM, each simulation was typically treated as representative of its entire discrete probability range (i.e. all of the probability for each multi-dimensional box centered on its mean position). In these applications, the computational burden was considerably less than what is considered appropriate for surge simulations. Even in the original JPM, however, a scaling relationship between the pressure differential of a storm and computed surge levels was used to reduce the number of computer runs. This relationship, based on theoretical considerations and confirmed numerically in several studies, shows that surges are linearly proportional to the pressure differential of a storm at all areas close to the area of maximum storm impact. This information can be used effectively to interpolate between two different numerical results within the JPM integral. Such an interpolation provides added resolution along the pressure differential axis in this integral, which is very important due to the highly nonlinear characteristics of the probability of pressure differentials [$p(\Delta P)$].

In addition to the scaling relationship between surge levels and pressure differentials, the JPM-OS attempts to sample the parameter space in a fashion that can be used to estimate surges (develop the response surface) in an optimal manner. This method has been developed via hundreds of simulations on relatively straight coasts, as well as on coasts with other simple geometries, and is in the process of being extended to more complex coasts. It attempts to alleviate the need for very closely spaced parameter values in numerical simulations (essentially track spacing and number of storm sizes, forward speeds, and track angles considered); thereby potentially greatly reducing the total number of computer runs required for JPM execution. The storm suite for this study is discussed in section 2.4.2.

2.4.1.3 Specification of Variations in Pre-landfalling Hurricanes

Whereas the original JPM considered storm size, intensity, and wind field distribution to be constant in storms approaching the coast, the new JPM uses information from recent storms to estimate the rate of change of these parameters for pre-landfall conditions. In general these trends show that storms tend to fill by about 10-15 millibars, become slightly (15-30%) larger and have less peaked wind speed distributions (Holland B parameter decreasing from about 1.27 to around 1.0) over the last 90 nautical miles of coastal water before landfall. Since all of our probabilities have been developed based on landfalling characteristics, the offshore characteristics must be estimated from a generalized transform

$$p(\Delta P, R_p, v_f, \theta_l, x)_{offshore} = p(\Delta P, R_p, v_f, \theta_l, x)_{landfall} J^{-1} \qquad \text{E2.4-4}$$

where *J* is the Jacobian for the transform from nearshore to offshore conditions. However, since 1) storm heading during approach to the coast is relatively constant, 2) the forward speeds are assumed to be constant during approach to land and 3) the points of intersection (x) are identical for each offshore and landfall case, the transform can be viewed in only two dimensions, ΔP and R_p.

2.4.2 Storm Suite

Figures 2.4-7a to 2.4-7d show the synthesized primary tracks used in the study. The central tracks essentially mimic the behavior of intense landfalling historical storms in the record, while preserving the geographic constraints related to land-sea boundaries. These storms preserve the historical pattern of the tracks better than simply shifting the same storm tracks east or west along the coast, since they capture the observed variations in mean storm angles along the coast.

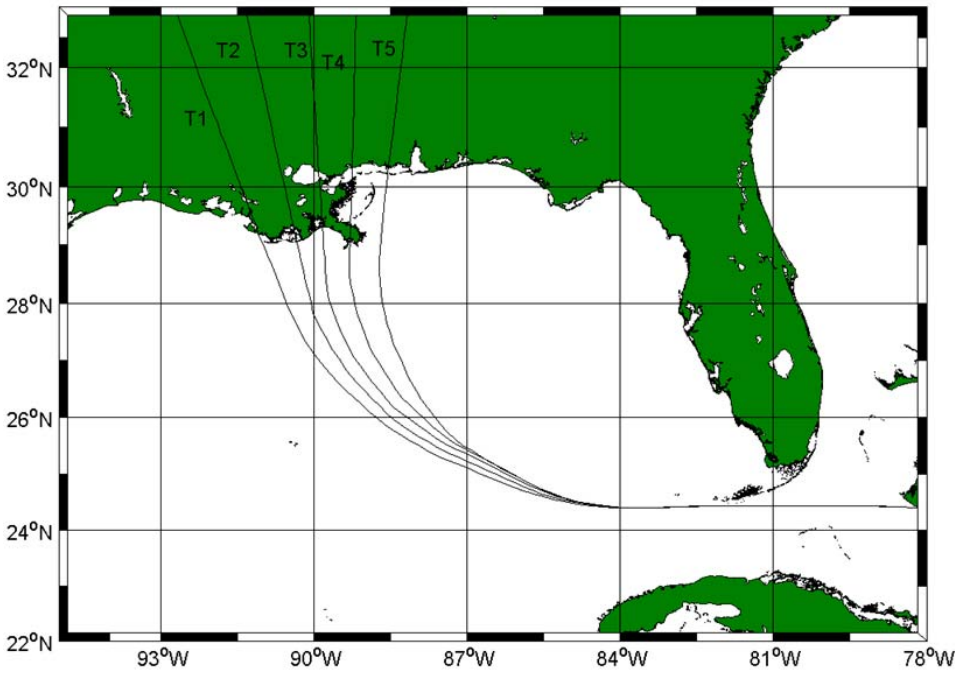


Figure 2.4-7a. Synthesized Tracks Used in the Study

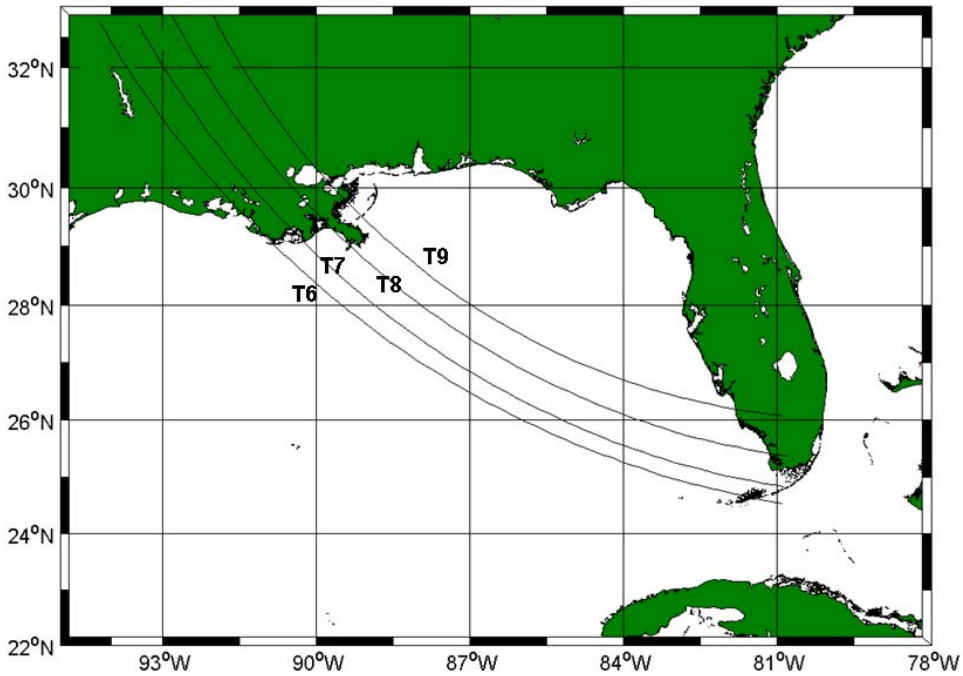


Figure 2.4-7b. Synthesized Tracks Used in the Study

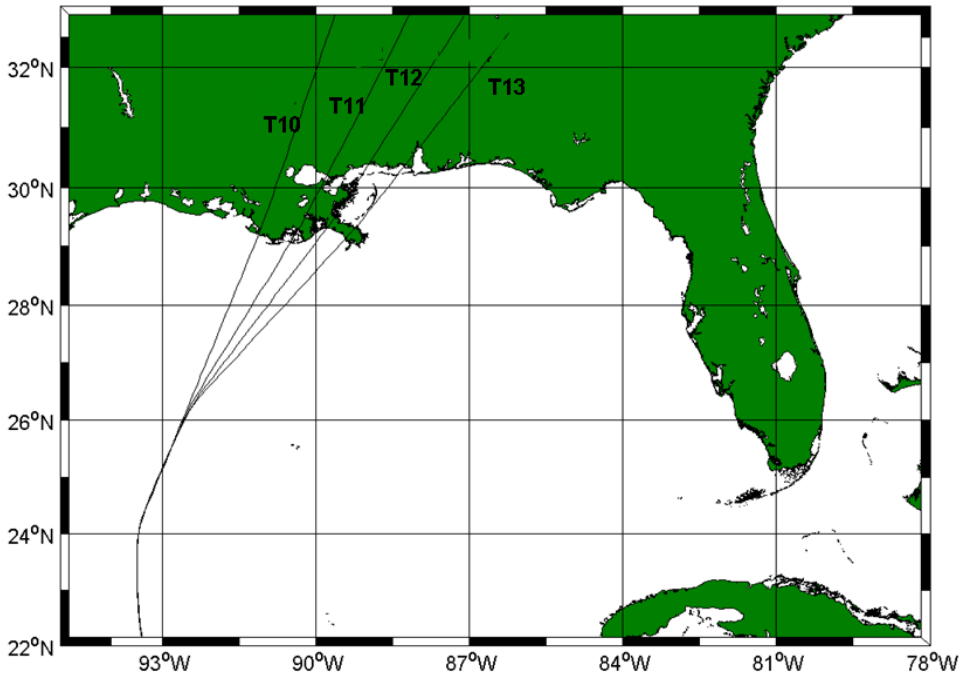


Figure 2.4-7c. Synthesized Tracks Used in the Study

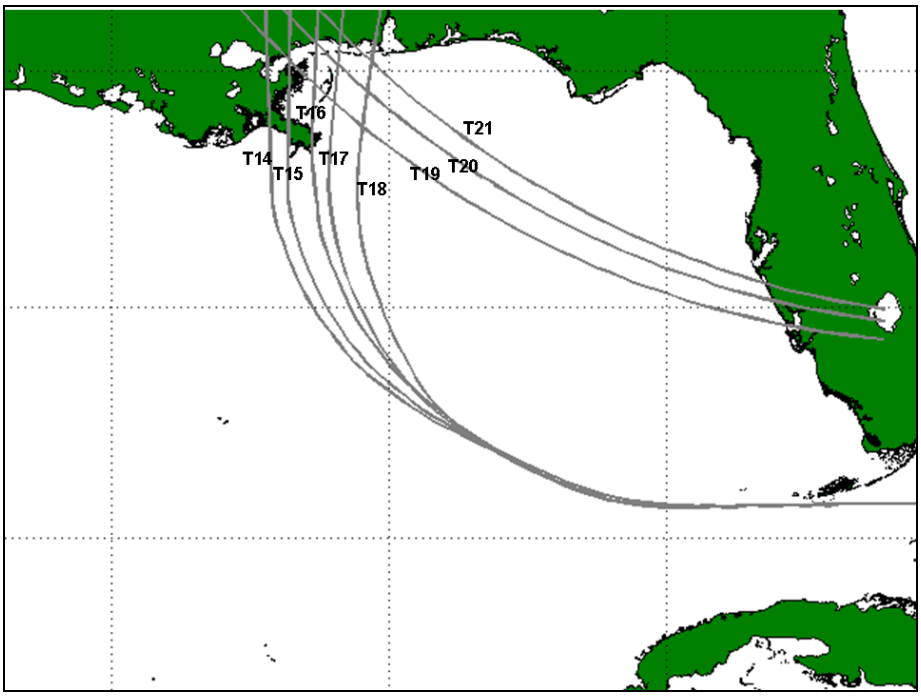


Figure 2.4-7d. Synthesized Tracks Used in the Study

Along each of the tracks modeled, the central pressure is allowed to vary during a simulated intensification interval until its intensity reaches a plateau. This plateau is maintained until the storm comes within 90 nautical miles of the coast at that time, the pressures decay according to the (linear interpolation) relationship

$$C_p(s) = \lambda_0 C_p(s_0) - (1-\lambda_0)\Delta P_{decay}$$

where

C_p is the central pressure at s

s is the distance along the storm track, with s_0 located 90 nm from landfall

λ_0 is an interpolation multiplier (=1 at 90 nm from landfall and =0 at landfall)

ΔP_{decay} is the total change in central pressure over 90 nm approach to landfall

E2.4-5

The pressure decay term is somewhat dependent on storm size, so the following relationship was used to represent this term

$$\Delta P'_{decay} = R_p - 6 \quad \text{(with } R_p \text{ given in nautical miles)}$$

constrained by $\Delta P_{decay} = Max(\Delta P'_{decay}, 18); Min(\Delta P'_{decay}, 5)$

E2.4-6

Once a storm is one hour past landfall the pressure decay factor according to Vickery is applied

$$C_p = P_\infty - \delta P$$

E2.4-7

where

$$\delta P = \delta P_0 e^{-a\Delta t}$$

where

δP is the local pressure differential

δP_0 is the pressure differential one hour after landfall

a is an empirical constant

Δt is time after landfall minus 1 hour

Rmax and the Holland B parameter are allowed to vary linearly over the same distance as Cp for all storms except the smallest storm class used in this application. For that class (Rmax = 6 nm), the storm is assumed to retain its intensity, its size, and its Holland B parameter all the way to landfall. Table 2.4-2 summarizes the central pressure / size scaling radius combinations used to define the storm suite.

Table 2.4-2.
Central Pressure/Size Scaling Radius Combinations

Central Pressure (mb)	Rmax (nm)					
900	6.0	12.5	14.9	17.7	18.4	21.8
930	8.0	17.7	25.8			
960	11.0	17.7	18.2	21.0	24.6	35.6

Defining three angles covers the important range for estimating the response surface of the surges. With the secondary variables (tidal phases, Holland B variations, wind field variations around the PBL central estimate, etc.) added to the integral, this provides a reasonable estimate of the surge CDF. The tracks approaching the Mississippi/Louisiana coast from the southeast are similar to the tracks of the 1947 Hurricane, Betsy, and Andrew. During the 1941-2005 interval, no tracks approached from the southwest; however, other storms such as the 1893 storm did approach eastern Louisiana from this direction. The 1893 track is fairly similar to one of the hypothetical tracks out of the southwest. A track from this direction represents the fact that these storms have to become caught up in the more westerly flow (winds blowing toward the east). For a storm to maintain its strength it cannot move too far west or too close to land; consequently, the track of a major storm is constrained somewhat to come from the region from which all the hypothetical (+45 degree) tracks emerge in order for these storms to strike the Mississippi coast.

The effect of storm heading angle on surges at the coast appears to be twofold. First, the overall along-coast pattern is broadened; since the storm moves along the coast at the same time that it moves toward landfall. Second, there is a relatively slow variation in the maximum surges produced by a storm as a function of the angle of the storm track with the coast. Sensitivity studies have shown that the maximum surge is relatively weakly dependent on the angle of storm intersection with the coast. In general, the hurricane approaching slightly (15-30 degrees) from west of perpendicular to a straight east-west coast produces a somewhat higher surge (5% or so) than hurricanes moving perpendicularly to the coast. On the other hand, hurricanes approaching the straight east-west coast from a more easterly direction will tend to produce lower surges than hurricanes moving perpendicular to such a coast. This appears to be a fairly broad pattern that can be represented via interpolation.

The effect of forward storm speed is addressed by considering three different forward velocities Vf=(11,6,17) knots, where 11 is around the mean and the 6-kt and 17-kt speeds span almost the entire range of Vf values at landfall for storms with Cp's less than 950. Increased forward storm speed contributes to higher wind speeds in the hurricane PBL model. Consequently, one effect of increasing forward storm velocity is to increase the surge at the coast by a factor, which is similar to increasing the wind speeds within the hurricane, i.e.

$$\eta_1 = \eta_2 \left(\frac{v_{\max} + 0.5 v_{f_1}}{v_{\max} + 0.5 v_{f_2}} \right)^2$$

where

η_1 is the surge at the coast in storm 1, with forward speed = v_1 E2.4-8

η_2 is the surge at the coast in storm 2, with forward speed = v_2

$v_{\max}$ is the maximum wind speed of a stationary storm

v_{f_i} is the forward storm velocity of the ith storm

A second effect of storm speed is to change the duration that a flood wave has to propagate inland. Thus, a slowly moving storm may produce more extensive inland flooding than a faster moving storm. By covering essentially the entire range of forward storm speeds observed in major storms within the Gulf (see Figures 2.4-5a and 2.4-5b), the range of the effects of storm speed on surges can be quantified. Table 2.4-3 identifies the various parameters for the entire 197-storm suite. Tracks denoted with a and b are secondary tracks that fall between the primary tracks plotted in Figure 2.4-7.

Table 2.4-3.
Storm Suite

Run Number	Central Pressure (mb)	Rmax (nm)	Track (see Figure 1-7)	Forward Speed (knots)
Run001	960	11	1	11
Run002	960	21	1	11
Run003	960	35.6	1	11
Run004	930	8	1	11
Run005	930	17.7	1	11
Run006	930	25.8	1	11
Run007	900	6	1	11
Run008	900	14.9	1	11
Run009	900	21.8	1	11
Run010	960	11	2	11
Run011	960	21	2	11
Run012	960	35.6	2	11
Run013	930	8	2	11
Run014	930	17.7	2	11
Run015	930	25.8	2	11
Run016	900	6	2	11
Run017	900	14.9	2	11
Run018	900	21.8	2	11
Run019	960	11	3	11
Run020	960	21	3	11
Run021	960	35.6	3	11
Run022	930	8	3	11
Run023	930	17.7	3	11
Run024	930	25.8	3	11
Run025	900	6	3	11
Run026	900	14.9	3	11
Run027	900	21.8	3	11
Run028	960	11	4	11
Run029	960	21	4	11
Run030	960	35.6	4	11
Run031	930	8	4	11
Run032	930	17.7	4	11
Run033	930	25.8	4	11
Run034	900	6	4	11
Run035	900	14.9	4	11
Run036	900	21.8	4	11
Run037	960	11	5	11
Run038	960	21	5	11
Run039	960	35.6	5	11
Run040	930	8	5	11
Run041	930	17.7	5	11
Run042	930	25.8	5	11
Run043	900	6	5	11
Run044	900	14.9	5	11

1

Table 2.4-3.
Storm Suite (continued)

Run Number	Central Pressure (mb)	Rmax (nm)	Track (see Figure 1-7)	Forward Speed (knots)
Run045	900	21.8	5	11
Run046	960	18.2	6	11
Run047	960	24.6	6	11
Run048	900	12.5	6	11
Run049	900	18.4	6	11
Run050	960	18.2	7	11
Run051	960	24.6	7	11
Run052	900	12.5	7	11
Run053	900	18.4	7	11
Run054	960	18.2	8	11
Run055	960	24.6	8	11
Run056	900	12.5	8	11
Run057	900	18.4	8	11
Run058	960	18.2	9	11
Run059	960	24.6	9	11
Run060	900	12.5	9	11
Run061	900	18.4	9	11
Run066	960	18.2	10	11
Run067	960	24.6	10	11
Run068	900	12.5	10	11
Run069	900	18.4	10	11
Run070	960	18.2	11	11
Run071	960	24.6	11	11
Run072	900	12.5	11	11
Run073	900	18.4	11	11
Run074	960	18.2	12	11
Run075	960	24.6	12	11
Run076	900	12.5	12	11
Run077	900	18.4	12	11
Run078	960	18.2	13	11
Run079	960	24.6	13	11
Run080	900	12.5	13	11
Run081	900	18.4	13	11
Run082	960	17.7	1	6
Run083	900	17.7	1	6
Run084	960	17.7	2	6
Run085	900	17.7	2	6
Run086	960	17.7	3	6
Run087	900	17.7	3	6
Run088	960	17.7	4	6
Run089	900	17.7	4	6
Run090	960	17.7	5	6
Run091	900	17.7	5	6

Table 2.4-3.
Storm Suite (continued)

Run Number	Central Pressure (mb)	Rmax (nm)	Track (see Figure 1-7)	Forward Speed (knots)
Run092	930	17.7	6	6
Run093	930	17.7	7	6
Run094	930	17.7	8	6
Run095	930	17.7	9	6
Run097	930	17.7	10	6
Run098	930	17.7	11	6
Run099	930	17.7	12	6
Run100	930	17.7	13	6
Run101	930	17.7	1	17
Run102	930	17.7	2	17
RuN103	930	17.7	3	17
Run104	930	17.7	4	17
Run105	930	17.7	5	17
Run106	930	17.7	6	17
Run107	930	17.7	7	17
Run108	930	17.7	8	17
Run109	930	17.7	9	17
Run111	930	17.7	10	17
Run112	930	17.7	11	17
Run113	930	17.7	12	17
Run114	930	17.7	13	17
Run115	960	17.7	1b	11
Run116	900	17.7	1b	11
Run117	960	17.7	2b	11
Run118	900	17.7	2b	11
Run119	960	17.7	3b	11
Run120	900	17.7	3b	11
Run121	960	17.7	4b	11
Run122	900	17.7	4b	11
Run123	960	17.7	6b	11
Run124	960	17.7	7b	11
Run125	960	17.7	8b	11
Run126	900	17.7	6b	11
Run127	900	17.7	7b	11
Run128	900	17.7	8b	11
Run131	960	17.7	10b	11
Run132	900	17.7	10b	11
Run133	960	17.7	11b	11
Run134	900	17.7	11b	11
Run135	960	17.7	12b	11
Run136	900	17.7	12b	11
Run137	960	17.7	1	6
Run138	900	17.7	1	6
Run139	960	17.7	2	6

Table 2.4-3.
Storm Suite (continued)

Run Number	Central Pressure (mb)	Rmax (nm)	Track (see Figure 1-7)	Forward Speed (knots)
Run140	900	17.7	2	6
Run141	960	17.7	3	6
Run142	900	17.7	3	6
Run143	960	17.7	4	6
Run144	900	17.7	4	6
Run145	930	17.7	6b	6
Run146	930	17.7	7b	6
Run147	930	17.7	8b	6
Run149	930	17.7	11b	6
Run150	930	17.7	12b	6
Run151	930	17.7	13b	6
Run152	930	17.7	1	17
Run153	930	17.7	2	17
Run154	930	17.7	3	17
Run155	930	17.7	4	17
Run156	930	17.7	6	17
Run157	930	17.7	7	17
Run158	930	17.7	8	17
Run160	930	17.7	10b	17
Run161	930	17.7	11b	17
Run162	930	17.7	12b	17
Run801	960	11	18	11
Run802	960	21	18	11
Run803	960	35.6	18	11
Run804	930	8	18	11
Run805	930	17.7	18	11
Run806	930	25.8	18	11
Run807	900	6	18	11
Run808	900	14.9	18	11
Run809	900	21.8	18	11
Run810	960	11	14	11
Run811	960	21	14	11
Run812	930	8	14	11
Run813	930	17.7	14	11
Run814	900	6	14	11
Run815	900	14.9	14	11
Run816	960	11	15	11
Run817	960	21	15	11
Run818	930	8	15	11
Run819	930	17.7	15	11
Run820	900	6	15	11
Run821	900	14.9	15	11
Run822	960	11	16	11
Run823	960	21	16	11

Table 2.4-3.
Storm Suite (continued)

Run Number	Central Pressure (mb)	Rmax (nm)	Track (see Figure 1-7)	Forward Speed (knots)
Run824	930	8	16	11
Run825	930	17.7	16	11
Run826	900	6	16	11
Run827	900	14.9	16	11
Run828	960	11	17	11
Run829	960	21	17	11
Run830	930	8	17	11
Run831	930	17.7	17	11
Run832	900	6	17	11
Run833	900	14.9	17	11
Run846	960	18.2	19	11
Run847	960	24.6	19	11
Run848	900	12.5	19	11
Run849	900	18.4	19	11
Run850	960	18.2	20	11
Run851	960	24.6	20	11
Run852	900	12.5	20	11
Run853	900	18.4	20	11
Run854	960	18.2	21	11
Run855	960	24.6	21	11
Run856	900	12.5	21	11
Run857	900	18.4	21	11

2.4.3 Measure Evaluation

To evaluate the lines of defense 3 and 4, a subset of the 197-storm suite was simulated with the structures in place. Storms 019 to 045 were selected for this purpose. The deviation of the surge and wave response from the no project condition with the lines of defense in place was computed for each storm in the measure evaluation suite. It is assumed that the rank order of the storms does not change from the no project condition such that for a given station location

$$\eta'(T) = \eta(T) + \zeta(T) \qquad \text{E2.4-9}$$

where η' is the surge/waves with the line of defense in place, T is return period, η is surge/waves for the no project condition, and ζ is the deviation from the no project condition. The deviation as a function of return period ($\zeta(T)$) is computed from the subset of 27 storms. Figure 2.4-8 is an example plot showing the deviation between line 3 and the no project condition for a save station in St. Louis Bay. With a shape preserving interpolation, the deviation at each return period is computed and applied to adjust the stage frequency relationships for the proposed lines of defense.

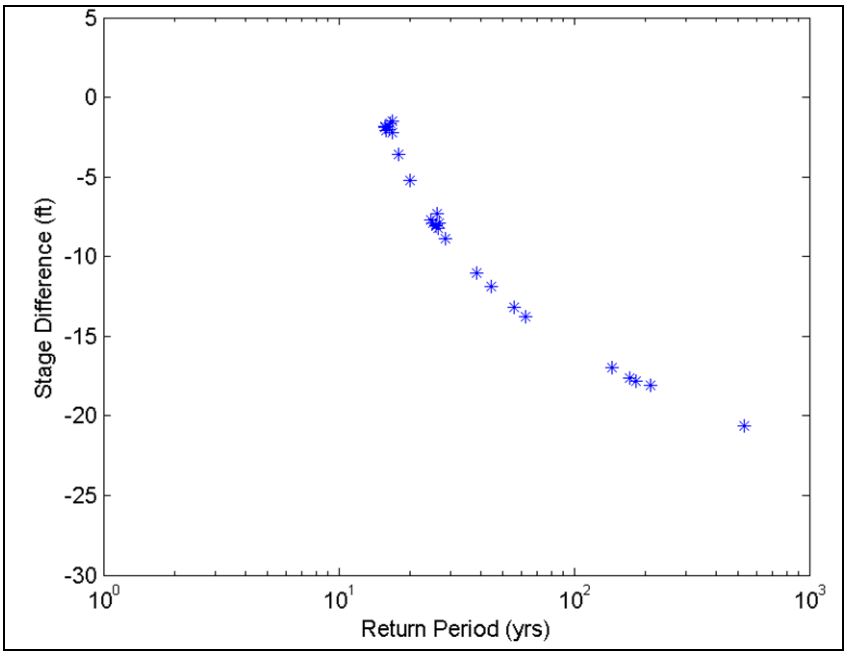


Figure 2.4-8. Plot of difference in storm surge between line of defense 3 and the no project condition as a function of return period at a save location in St. Louis Bay.

2.5 Wind and Atmospheric Pressure Modeling

Accurate modeling of wave and storm surge levels requires accurate wind and pressure field input to the model. This section describes the methodology to generate wind and pressure fields for the 197 storms in the JPM-OS suite. The wind fields specified with this methodology drive the storm surge simulations and the offshore and nearshore wave simulations.

2.5.1 Computational Model

The wind and pressure fields are generated with an Oceanweather Inc (OWI) highly refined meso-scale moving vortex formulation developed originally by Chow (1971) and modified by Cardone et al. (1992). The model is based on the equation of horizontal motion, vertically averaged through the depth of the planetary boundary layer. The numerical modeling grid is represented by a series of nests defined on a rectangular system; the highest resolution residing in the center of the vortex (about 2-km) decreasing in resolution by a factor of two to the outer extremities. It is assumed a tropical system changes structure relatively slowly (over a period of one or more hours). Hence, the spatial and temporal evolution of this system can be represented by a series of *snapshots* representing distinct phases in the storm's process. One added feature of this model is to conserve the integrity in storm's structure so that the horizontal velocity components can be linearly interpolated without loss in energy.

This model computes the surface wind and pressure field in tropical cyclones and is referred to as the Planetary Boundary Layer Model, or TC-96 (Thompson and Cardone, 1996). For each simulation in the suite a unique set of input conditions is defined. The data file includes the track position in space and time, the forward speed (V_f) and direction, central pressure, pressure scale radius (R_p), a rotation angle and a pressure profile peakedness parameter termed the *Holland B* factor (Holland, 1980). The wind and pressure field is generated and positioned on a fixed longitude/latitude grid system covering the Gulf of Mexico. Using continuity of the storm center, these snapshots are

placed in time generating a complete account of the temporal and spatial evolution of a given hurricane. It should be noted that all storm simulations are synthetic conditions based on input criteria of the TC-96 model. Hence, no validation of the results can be pursued. This method has been used successfully for the past decade over a wide range of tropical storm scenarios for a number of studies (Cox and Cardone, 2000). Replacing the validation of the final wind and pressure fields, extensive quality control products (QA/QC) were generated to assure consistency and correctness of the forcing functions used for the wave and surge modeling efforts.

2.5.2 Methodology

The final wind and pressure fields resulting from TC-96 are targeted on a grid domain covering the entire Gulf of Mexico. The lateral boundaries are at -98º to -80º Longitude; 18º to 31º Latitude with a grid resolution of 0.05º (or 3´). The temporal variation in these fields is set to 1800-s, (30-min average wind) with lengths of storms ranging from 47- to 144-hr. All wind-fields are *marine-exposure* (no effective roughness variations for land/sea changes), generated at a 10-m elevation. The marine-exposure assumption will have implications as each of the tropical systems make landfall altering their state because of differences in the roughness lengths between open water and vegetated states. Each simulation retained consistent time of landfall at the identical date-time stamp of 080100 (month, day, hour). This effectively assured the surge and nearshore wave modeling efforts were synchronized in time. In addition each simulation has a unique name and internally a unique date-time stamp (incrementing the year for each run). The wind and pressure fields were generated for the entire 197-storm suite.

2.5.3 Results

The 197-storm suite was simulated with the TC-96 PBL model and the results were applied as forcing for the surge and wave modeling. Example results for storm 821 of the wind and pressure field generation are given in Figures 2.5-1 to 2.5-5. A series of seven individual graphical products are used in the evaluation of the wind and pressure fields. These identify any inconsistencies that would be attributed to incorrect input conditions to TC-96 since the model itself is very robust. These products include track position and maximum wind speed; maximum (wind magnitude) and minimum (pressure) field conditions over the entire simulation duration; wind and pressure field snapshot at landfall, wind field snapshot at the overall maximum speed in the simulation; and time variation of input.

Figure 2.5-1 plots the maximum wind speed found at each snapshot and the storm track position. For each individual snapshot (at 1800-s time step intervals) the maximum wind speed is determined. In general the wind maxima must be to the right of the storm track. If at any time the maximum wind speed location falls to the left of the track a potential error in the input to TC-96 is flagged. As in the case of storm 821 the locations of all maxima are to the right of the storm track. As this storm approaches the coastline and makes landfall, the wind speed decreases from nearly 60-m/s at its maximum to around 40-m/s indicative of filling of the pressure field.

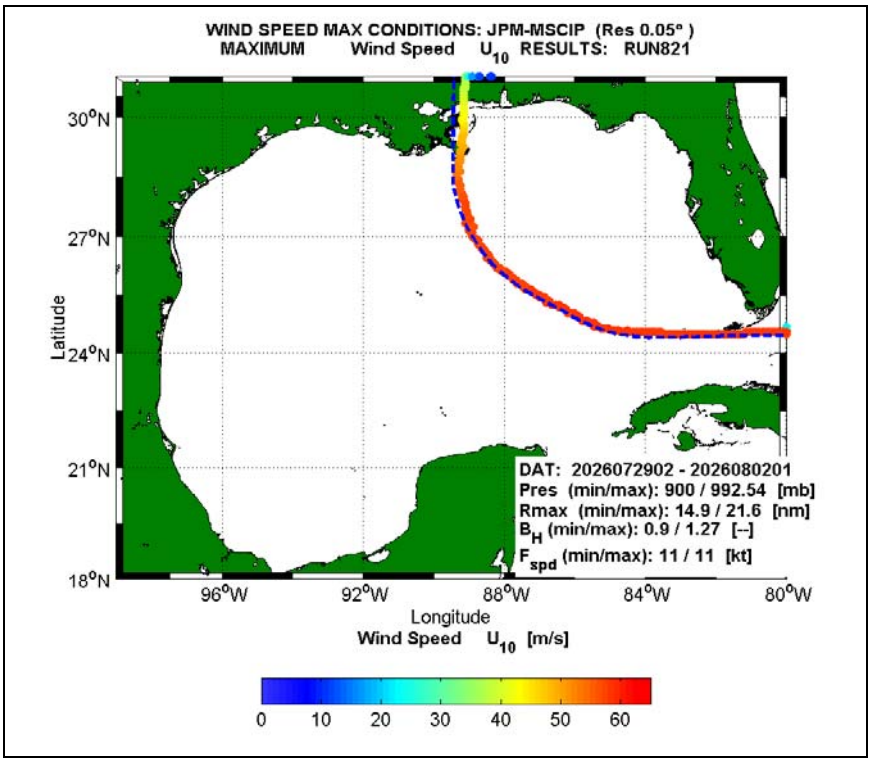


Figure 2.5-1. Location and value of maximum individual wind magnitude at every snapshot along with the storm track position for storm 821

Figure 2.5-2 represents the spatial variation of the maximum wind speed, and Figure 2.5-3 is the minimum overall pressure distribution. The wind field product (Figure 2.5-2) reflects the storm's path and displays the spatial coverage of high winds (for this case above 50-m/s), an indication of the breadth in the hurricane core. Figure 2.5-2 also shows the decay in the wind speed magnitude as it makes landfall. The minimum pressure distribution (Figure 2.5-3) clearly shows the storm track position, R_{max}, and where the filling of the pressure field occurs.

An example plot of the wind speed and wind direction vectors is shown in Figure 2.5-4. The wind direction vectors have been sub-sampled every 4 grid points, and are pointing toward which the winds are blowing. The directions also tend to reflect the base vortex in the TC-96 methodology. This is clearly evident as you move from the extremities of the storm to its center. The wind speed contouring clearly shows near continuous lines from the land to sea. This is indicative of generating an exclusive set of marine exposure wind fields. The wind speed maximum is found in the right front quadrant of the storm rotated about 45º counterclockwise from the orthogonal to the storm track.

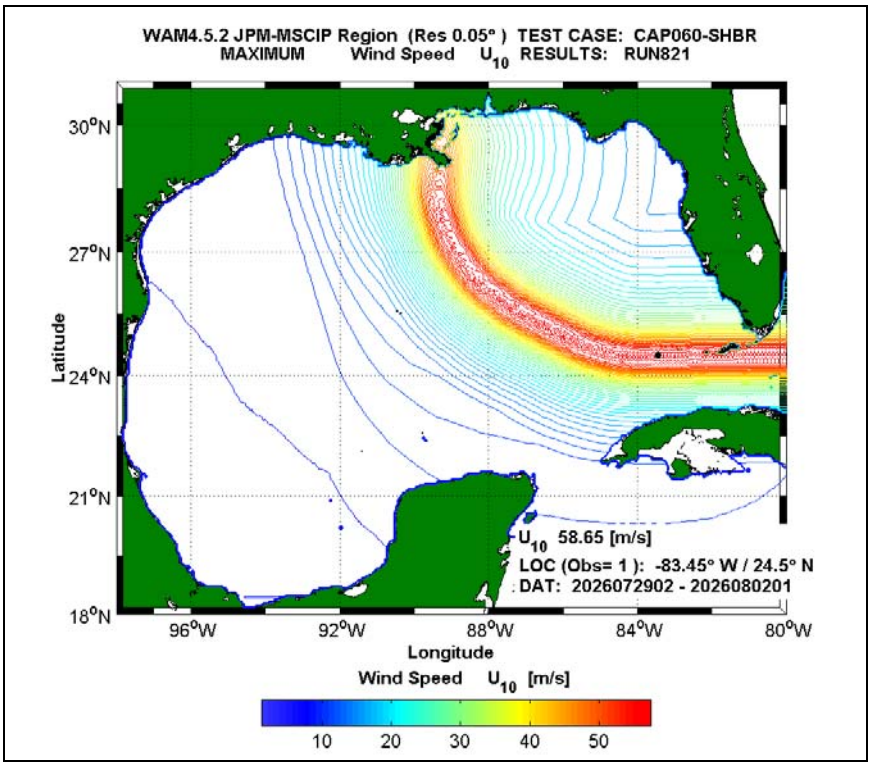


Figure 2.5-2. Maximum overall wind speed color contour for storm 821

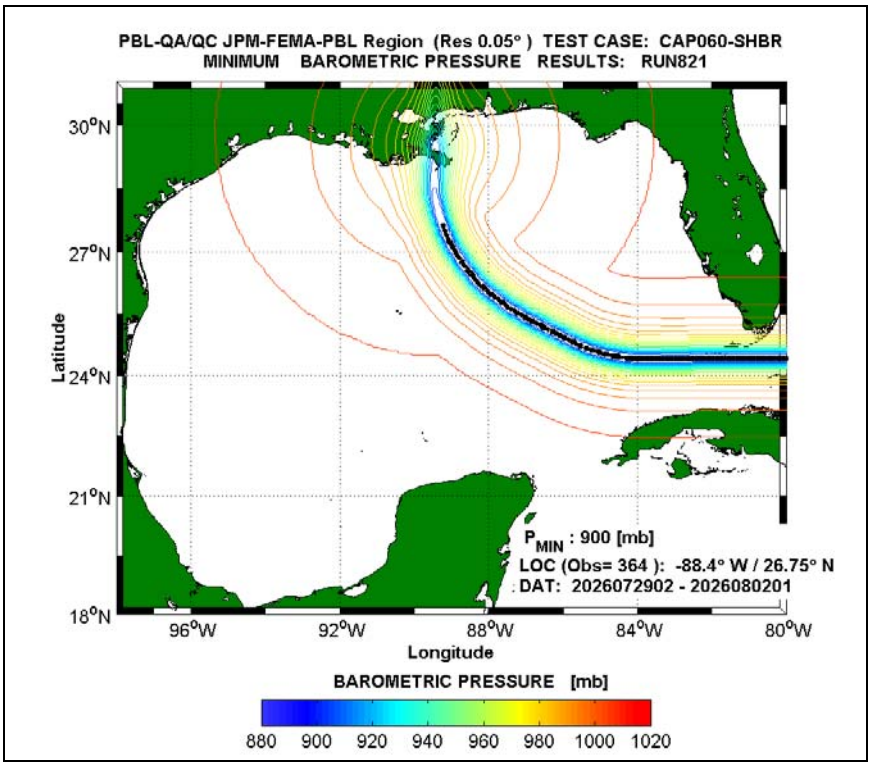


Figure 2.5-3. Minimum overall pressure field color contour for storm 821

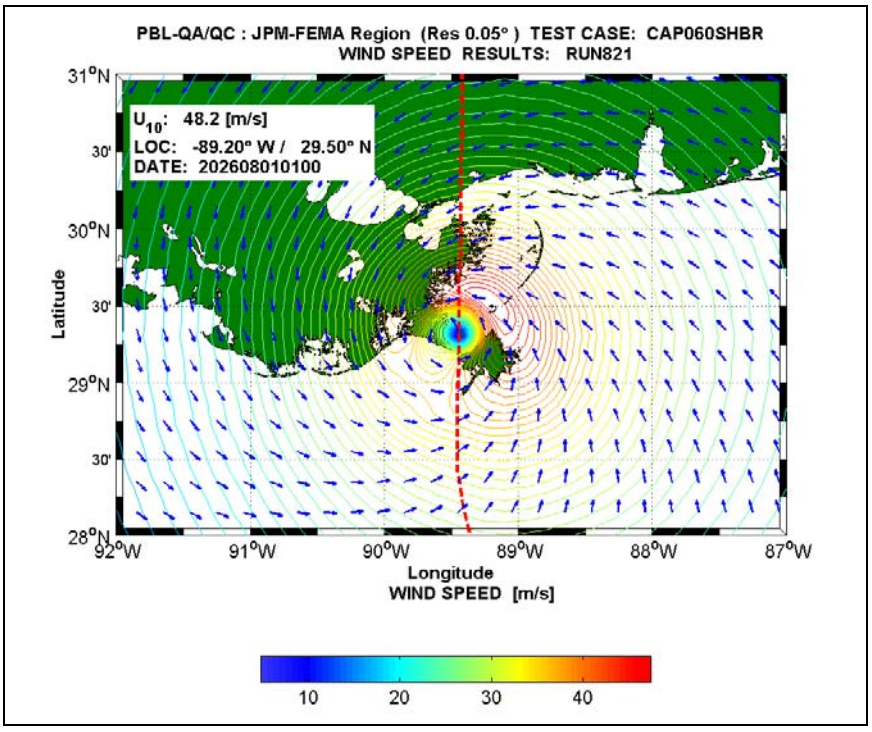


Figure 2.5-4. Snapshot of the wind speed (color contoured) and wind direction at the landfall time for storm 821

Figure 2.5-5 displays time plots and comparisons between the input files used to build the wind and pressure fields for TC-96 and results obtained from the resulting fields. It displays the minimum pressure from the input and output, the maximum wind speed (only from the output wind fields to check consistency); a comparison between R_p and a computed radius to maximum wind speed (R_{max}); the input Holland B (for consistency checks); and a comparison between the input forward speed and one computed from the field information. There are a few identifiable differences and similarities found in this product. The top panel of Figure 2.5-5 shows a large difference between the input and output minimum pressures. These differences will not influence any of the surge modeling efforts since they lie outside of the ADCIRC simulation times. These differences are attributed to the input file containing minimum pressures that are located outside of the defined grid domain. This also holds true for the comparison between the pressure scale radius (R_p) and the computed R_{max} at the start and end of the simulation. One must also note that R_p and R_{max} are not equivalent variables, but are relatively similar. In addition, the estimate of R_{max} is dependent on the modeled grid resolution of 0.05º or roughly 5.5-km. The value of R_p is a defined finite input value. In general though, despite these differences, any large deviation (more than 20-percent of the value) would be considered as questionable. The fourth panel displays the time variation in Holland B parameter analyzed directly from the input file. This variable is either constant (a value of 1.0) over time, or decreases as it does in this example just prior to landfall. This reflects the filling in the pressure field, as well as a decrease in the wind maximum. For all no constant cases, the Holland B is equal to 1.0 at landfall. The lower panel checks for the proper forward speed. The solid line is derived from the input file, while the symbols represent a computed forward speed derived from the output results. The noted oscillations result from the specified grid resolution used with accuracy levels on the order of about 5.5-km. Strong deviations from the input would suggest a phase error in the resulting wind fields and subject to either further testing or evaluation.

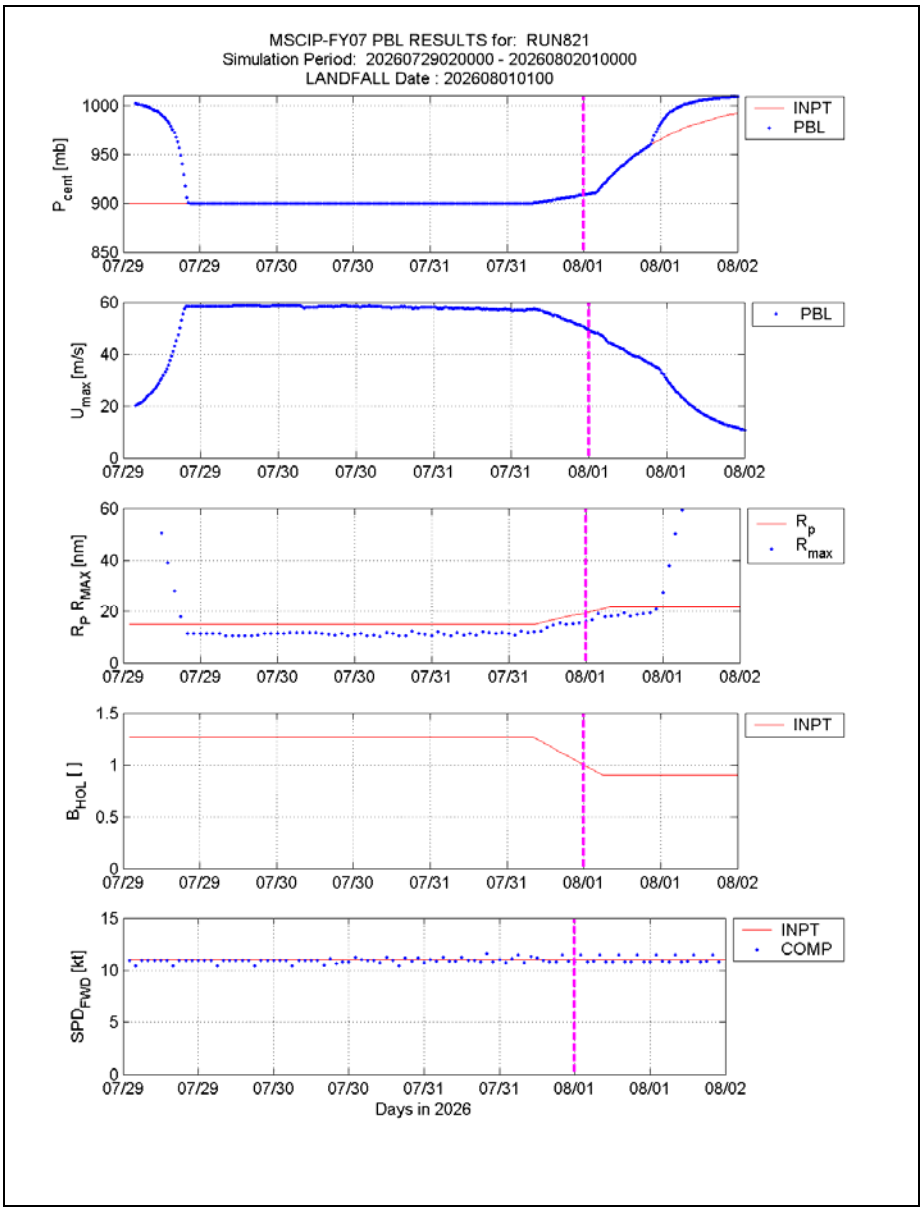


Figure 2.5-5. Time plot of input to TC-96 and output derived from the wind and pressure field files for storm 821

2.6 Offshore Wave Modeling

Offshore waves are required as a boundary condition for the nearshore wave modeling. This section describes the methodology to generate the offshore waves for the 197 storms in the JPM-OS suite. The offshore wave model is forced with the wind fields discussed in section 2.5.

2.6.1 Computational Model

The generation of the wave field and directional wave spectra for the various hurricane storm tracks is based on the implementation of a third generation discrete spectral wave model called WAM (Komen et al, 1994). This model solves the action balance equation:

$$\frac{\partial N}{\partial t} + \overrightarrow{c_G} \cdot \frac{\partial N}{\partial \vec{x}} = \omega^{-1} \cdot \sum_i S_i \qquad \text{E2.6-1}$$

where N is the action density defined by $F(f,\theta,x_i,t)/\omega$, where F is the energy density spectrum defined in frequency, (f) direction (θ) over space, (x_i)and time, (t) and the radial frequency ω is equal to $2\pi f$. S_i represent the source-sink terms:

$$\sum_i S_i = S_{in} + S_{nl} + S_{ds} + S_{w-b} + S_{bk} \qquad \text{E2.6-2}$$

S_{in} is the atmospheric input, S_{nl} represents the nonlinear wave-wave interactions, S_{ds} is the high frequency breaking (white-capping), $S_{w\text{-}b}$ is wave bottom effects (bottom friction), and S_{bk} is depth limited wave breaking. The solution is solved for the spatial and temporal variation of action in frequency and direction, over a fixed grid defined in x_i (generally a fixed longitude latitude geospatial grid).

Computationally E2.6-1 is solved in two steps. The advection term (second term in E2.6-1) is solved first accounting for the propagation of wave energy. Each packet of energy in frequency and direction is moved based on the group speed of that particular frequency band and water depth. This assumes linear theory and superposition of wave packets. In a fixed longitude latitude grid system curvature effects are resolved where the energy is propagated in a spherical coordinate system. As the water depth decreases, the full dispersion relationship is applied. Wave shoaling and refraction effects the propagation of the energy packets.

After every propagation step the solution to the time rate change of the action density is solved including the source term integration. The wind field is read, and the atmospheric input source (S_{in}) is applied. The nonlinear wave-wave interaction source term is the mechanism that self-stabilizes the spectral energy, transferring portions of the energy to the forward face and high frequency tail. Dissipation (S_{ds}) removes portions of energy that become too energetic for the given frequency band. For application in arbitrary depths energy is removed via the wave-bottom sink ($S_{w\text{-}b}$) and ultimately in very shallow water the spectrum releases much of its available energy due to breaking (S_{bk}). A more complete theoretical derivation and formulation of the source terms can be found in Komen et al. (1994).

2.6.2 Methodology

The goal of the offshore wave modeling was to provide two-dimensional wave spectra in the coastal area to be used as input boundary condition to the nearshore wave modeling (STWAVE, Smith et al. 2001). The spectral estimates contain all energy derived from the synthetic storm simulations.

Initial sensitivity tests (and past hurricane simulations) indicated that only one grid at a nominal resolution of 0.05º was required to provide quality wave estimates. The target domain is shown in Figure 2.6-1. Figure 2.6-2 identifies the save locations for the boundary conditions for the nearshore transformation modeling STWAVE (Smith et al 2001). Two sets are used in this study. The Alabama-Mississippi set (AL-MS, ST001-ST025) consist of the line parallel to the Alabama and Mississippi coastline. The second set is the diagonal line running from the northeast to southwest intersecting the AL-MS boundary at ST011 and ending at ST046. There are many distinct features that can affect the incoming wave energy, however most all, with exception to the Mississippi Canyon are landward of the defined output boundary for STWAVE. The Mississippi Canyon because of its deep water acts as a filter, attenuating wave energy.

Two time steps are applied in the wave model simulations. The propagation time step is set so that numerical stability is attained. The second time step the source term integration is set to the physical processes and relaxation times of S_{in} , S_{nl} , S_{ds} , $S_{w\text{-}b}$. In addition the time steps are required to be integer multiples of the wind input, and for the fine-scale grid also evenly divisible of the basin-scale propagation time step.

All simulations are initiated from simple fetch laws using the first wind field. Wave field information files are built for quality assurance, quality control graphical products displaying the temporal and spatial evolution of various wave related parameters for each of the 197 storms. The offshore WAM wave simulations supply the nearshore wave modeling effort supported by STWAVE (Smith, et al, 2001). The WAM directional wave spectra are output every 15-min at 28 discrete frequency bands (exponential distribution where $f_{n+1} = 1.1 \cdot f_n$ and $f_0 = 0.031384$), and 24 direction bands centered every 15-deg starting at $\theta_0 = 7.5$). The location of these special output locations are found in Figure 2.6-2.

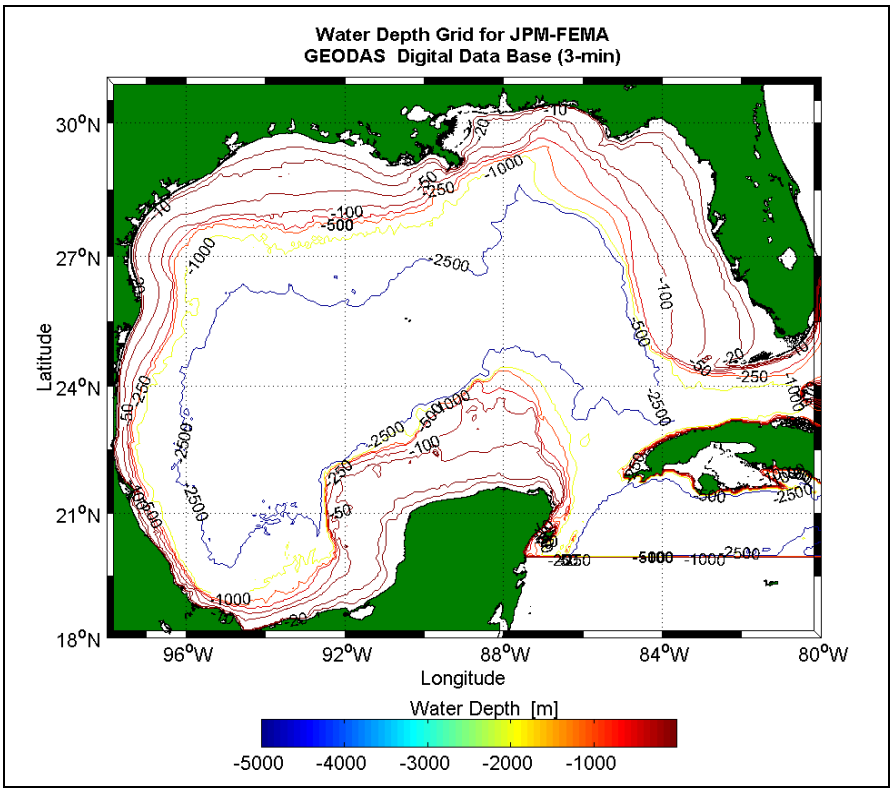


Figure 2.6-1. Water depth contours for offshore wave model simulations. Depths are in meters.

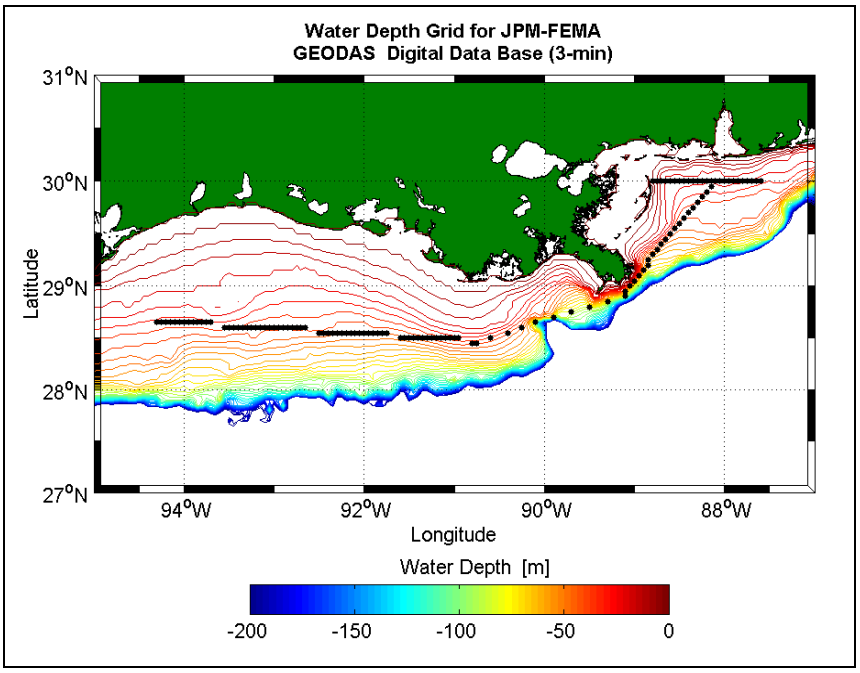


Figure 2.6-2. Refined version of the water depth grid used in offshore wave model simulations. Boundary points closed symbols, and depths are in meters.

2.6.3 Results

Generation of wave estimates based on synthetic storm simulations must be substantiated with verification/validation of the modeling results based on not only the technology used, but also the methods applied. This effort has been documented in previous studies (Interagency Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Project (IPET), https://ipet.wes.army.mil/) and more recently a Joint Coastal Surge Modeling Effort for the New Orleans District. These two reports focus on the verification of the WAM results using highly defined wind fields and also the PBL methods. A series of historical storms (Betsy, 1965, Rita 2005, Ivan 2004, Camille 1969, Katrina 2005 and Andrew 2002) were selected and analyzed.

Two-dimensional wave spectra in the coastal area were calculated and output by WAM to be applied as the input boundary condition to the nearshore wave model STWAVE for the entire 197-storm suite. Example results of the maximum total significant wave height field for RUN801 are given in Figure 2.6-3. The envelope of high waves coincides with that of the wind core (see Figure 2.5-2). The maximum overall H_{mo} for this simulation is 17-m and falls far south of any of the boundary points. However, there is an area of 10-m maxima running all along the SE-LA boundary extending well into the Mississippi coastline. The distribution is skewed toward the east sending what appears to be more energy into the coastline. In the nearshore area, the H_{mo} results diminish to a range near 8-m.

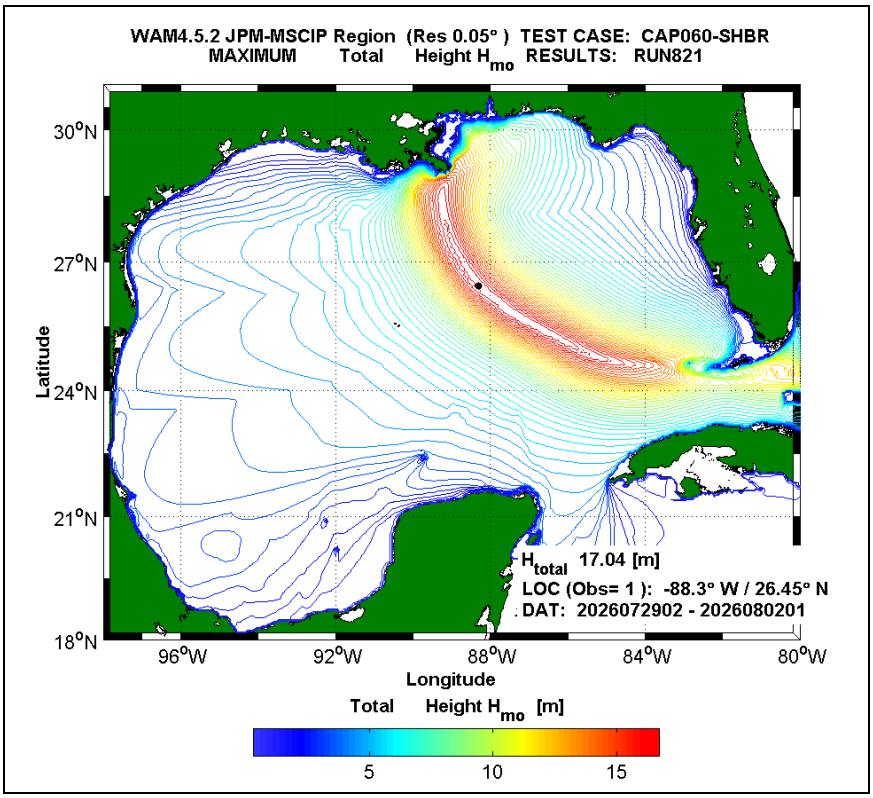


Figure 2.6-3. Maximum overall total significant wave height (in meters) color contour for storm 821

Figure 2.6-4 is an example color contour plot generated to depict the spatial (x axis) and temporal (y-axis) variation of the significant wave heights at each of the 119 output locations designated for STWAVE input boundary information. ST001 through ST046 are the points located along the Mississippi coast. Figure 2.6-4 represents the significant wave heights (integrated from the directional wave spectra of the STWAVE boundary conditions) for storm 821. Rather than isolate only station information (ST001 through ST046) along the Mississippi coast, all 119 output locations are contoured. This aids in the overall evaluation of the wave model's performance, and isolates any potential problems, not only in the local domain (along the Mississippi-Alabama coastline) but the entire shoreline reach. The well defined discontinuity around ST025 requires some explanation. The location of ST001 through ST025 represented in Figure 2.6-2 as the horizontal line seaward Mississippi Sound and extending to the west to the Chandelier Islands. The water depth decreases to about 5-m at the western extent. This causes the wave heights to diminish to near zero. ST026 is the start of the SE-LA boundary (Figure 2.6-2) and starts just offshore of ST012, and is oriented in a NE/SW direction extending to the tip of Louisiana. For storm 821, there is a distinct lobe of high energy values (upwards of nearly 16-m) along the SE-LA boundary. Along the Mississippi coast the wave climate is diminished to 10-m. Despite this reduction in energy level the duration of these high waves occurs over a 12-hour time span. One must realize some of the energy contained in the spectrum may not reach the coast, propagating outside of a ±90º directional plane at the boundary. These conditions emulate that found in the maximum wave height graphic (Figure 2.6-3). The skewed nature of the maximum H_{mo} distribution is evident in this plot, where the Mississippi coastline is affected despite the landfall being located well to the west.

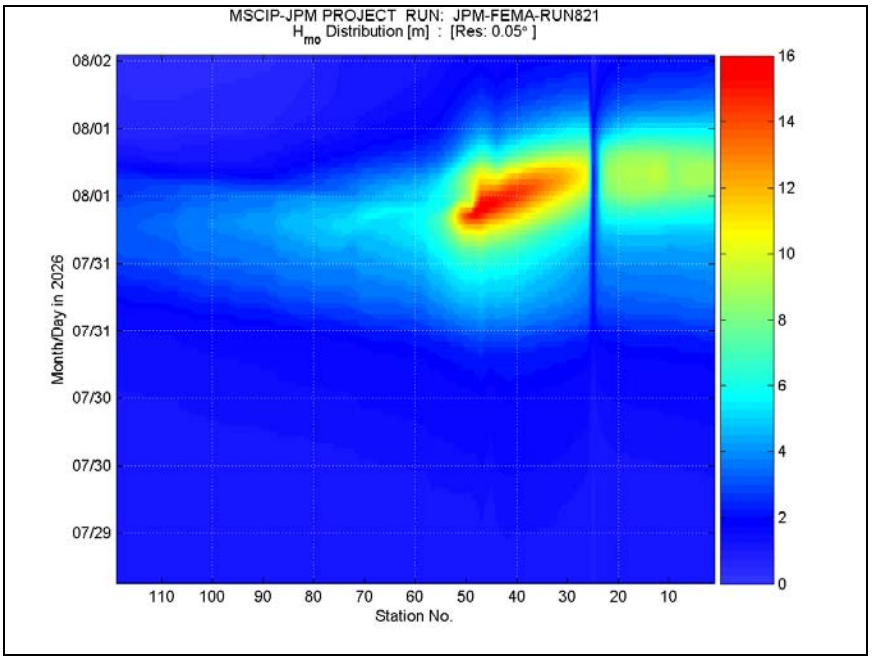


Figure 2.6-4. Spatial and temporal variation in the H_{mo} (in meters) for the 119 boundary output locations for storm 821

Directional spectral wave estimates were generated based on the 28 frequency and 24 direction bands at the 46 nearshore locations in the WAM grid domain for the entire 197-storm suite. This information consists of time (900-s) and spatial (0.05-deg) varying energy density (defined here as m^2-s) for the entire storm simulation period. This information is used as input criteria for STWAVE to estimate the nearshore wave environment.

2.7 Nearshore Wave Modeling

This section describes the numerical modeling of nearshore wave transformation and generation. Nearshore waves are required to calculate wave runup and overtopping on structures, and the wave momentum (radiation stress) contribution to elevated water levels (wave setup). First the nearshore wave model STWAVE and the Boussinesq wave model COULWAVE are briefly described, then the modeling methodology is outlined. Finally, example results are presented.

2.7.1 Computational Models

2.7.1.1 STWAVE

The numerical model STWAVE (Smith 2000; Smith, Sherlock, and Resio 2001; Smith and Smith 2001; Thompson, Smith, and Miller 2004; Smith and Zundel 2006; Smith and Sherlock in publication) was used to generate and transform waves to the shore. STWAVE numerically solves the steady-state conservation of spectral action balance along backward-traced wave rays:

$$(C_{ga})_x \frac{\partial}{\partial x}\frac{C_a C_{ga}\cos(\mu-\alpha)E(f,\alpha)}{\omega_r} + (C_{ga})_y \frac{\partial}{\partial y}\frac{C_a C_{ga}\cos(\mu-\alpha)E(f,\alpha)}{\omega_r} = \sum\frac{S}{\omega_r} \quad \text{E2.7-1}$$

where

C_{ga} = absolute wave group celerity

x,y = spatial coordinates, subscripts indicate x and y components

C_a = absolute wave celerity

μ = current direction

α = propagation direction of spectral component

E = spectral energy density

f = frequency of spectral component

ω_r = relative angular frequency (frequency relative to the current)

S = energy source/sink terms

The source terms include wind input, nonlinear wave-wave interactions, dissipation within the wave field, and surf-zone breaking. The terms on the left-hand side of E2.7-1 represent wave propagation (refraction and shoaling), and the source terms on the right-hand side of the equation represent energy growth and decay in the spectrum.

The assumptions made in STWAVE include mild bottom slope and negligible wave reflection; steady waves, currents, and winds; linear refraction and shoaling, and depth-uniform current. STWAVE can be implemented as either a half-plane model, meaning that only waves propagating toward the coast are represented, or a full-plane model, allowing generation and propagation in all directions. Wave breaking in the surf zone limits the maximum wave height based on the local water depth and wave steepness:

$$H_{mo_{\max}} = 0.1L\tanh kd \quad \text{E2.7-2}$$

where

H_{mo} = zero-moment wave height

L = wavelength

k = wave number

d = water depth

STWAVE is a finite-difference model and calculates wave spectra on a rectangular grid. The model outputs zero-moment wave height, peak wave period (T_p), and mean wave direction (α_m) at all grid points and two-dimensional spectra at selected grid points. Recent upgrades to STWAVE include an option to input spatially variable wind and surge fields. The surge significantly alters the wave transformation and generation for the hurricane simulations in shallow areas (such as Lake Pontchartrain) and where low-laying areas are flooded.

The inputs required to execute STWAVE include the bathymetry grid (including shoreline position and grid size and resolution); incident frequency-direction wave spectra on the offshore grid boundary; current field (optional), surge and/or tide fields, wind speed, and wind direction (optional); and bottom friction coefficients (optional). The outputs generated by STWAVE include the fields of energy-based,

zero-moment wave height, peak spectral wave period, and mean direction; wave spectra at selected locations (optional); fields of radiation stress gradients to use as input to ADCIRC (optional).

2.7.1.2 COULWAVE

Numerical results based on the standard Boussinesq equations or the equivalent formulations have been shown to give predictions that compared quite well with field data (Elgar and Guza 1985) and laboratory data (Goring 1978, Liu *et al*. 1985). COULWAVE (Cornell University Long and Intermediate Wave model) is based on the Boussinesq-type equations, which are known to be accurate for inviscid wave propagation from fairly deep water (wavelength/depth ~2) all the way to the shoreline (Wei *et al*, 1995).

The model consists of a fairly complex set of partial differential equations that are integrated in time to solve for the free surface elevation. Fundamentally, the Boussinesq equations solved by COULWAVE are inviscid. To accommodate frictional effects, viscous submodels are integrated. To simulate the effects of wave breaking, the eddy viscosity model of Kennedy *et al* (2000) is used here with some modification as given in Lynett (2006b). Energy dissipation is added to the momentum equation when the wave slope exceeds some threshold value, and continues to dissipate until the wave slope reaches some minimum value when the dissipation is turned off.

The moving shoreline condition has been shown to capture shoreline motion due to a wide range of wave frequencies, wave heights, and beach slopes. The shoreline algorithm has been extensively compared with empirical runup laws and existing experimental data for runup due to regular waves. (Korycansky & Lynett, 2005). The model results have also been compared to time-averaged experimental data of overtopping of sloping structures (e.g. Kobayashi & Wurjanto, 1989; Dodd, 1998; Hu et al, 2000) with good agreement. The Boussinesq model results were compared with well-established empirical formulas such as those given by Owen (1984) and Van der Meer & Janssen (1995). A noteworthy result of these comparisons is the conclusion that, when using the wave height and water level at the toe of the last simple slope of the structure, there is no accuracy preference between the empirical formulas and the detailed hydrodynamics (Boussinesq). Thus, for relatively simple profiles where the wave height at the structure toe can be estimated with high confidence, the empirical formulas provide the same level of accuracy as the Boussinesq with significantly less computational expense. On the other hand, if the levee is fronted by a series of slopes or an arbitrary shaped protecting structure, some method must be used to provide the wave height at the toe of the last simple slope. For this situation, the Boussinesq can be used to provide this wave height; however the Boussinesq can also provide the overtopping for such a configuration and would be the logical choice for estimating overtopping, provided the computational resources and expertise required by the modeling are available.

2.7.2 Methodology

STWAVE was applied on two grids with 200 m resolution for the Mississippi coast: Eastern Mississippi/Alabama grid and Western Mississippi/Eastern Louisiana grid. The input for each grid includes the bathymetry (interpolated from the ADCIRC domain), surge fields (interpolated from ADCIRC output), and wind (interpolated from ADCIRC output). The wind applied in STWAVE is spatially and temporally variable for all domains. STWAVE was run at 30-min intervals for 93 quasi-time steps (46.5 hrs). The model output includes wave parameters (height, peak wave period, and mean direction) to provide wave parameters for the calculation wave runup and overtopping on structures and radiation stresses to be applied as forcing in ADCIRC to calculate wave setup.

The bathymetry grids cover the entire Gulf of Mexico coastline of Mississippi and extend east into Alabama and west into Louisiana at a resolution of 656 ft (200 m). The East MS-AL grid domain covers Eastern Mississippi and Alabama The domain is approximately 70 by 75 miles (112.6 by 121

km). The West MS-Southeast LA grid is approximately 85 by 92 miles (136.6 by 148.8 km) and extends from Mississippi Sound to the Mississippi River. The domain was broken into two parts to capture the transformation of offshore waves from approximately the 100 ft (30 m) depth contour to the shoreline. Figure 2.7-1 shows the bathymetry for the MS-AL grid and Figure 2.7-2 shows the bathymetry for the MS-SE LA grid. Brown areas in the bathymetry plots indicate land areas at 0 ft or higher elevation. These simulations are forced with both the local winds interpolated from ADCIRC and waves interpolated on the offshore boundary from the regional WAM model. The simulations were run with the half-plane version of STWAVE for computational efficiency.

The STWAVE model cannot resolve the wave setup that occurs near structures such as levees and seawalls due to the resolution of the grid and the assumption of negligible wave reflection. Local wave setup very near structures such as levees and seawalls can increase the water level at the structure. To capture the additional wave setup near the line of defense structures, COULWAVE was applied. COULWAVE was used to generate a lookup table that, given input wave boundary condition information from STWAVE and a representative profile, computes the additional wave setup and wave height at the toe of the structure.

Representative profile data was collected at Hancock, west Harrison, east Harrison, and Jackson counties. Profile data that extended from the mainland into Mississippi Sound at locations near Waveland, Pass Christian, Harrison County just west of the western end of Deer Island, and in the Pascagoula area were used to develop the representative profiles for the Mississippi coast. To evaluate both a levee and seawall structure, the structures were incorporated into the 4 representative profiles, giving a total of 8 profiles to be simulated. The seawall had a 15 ft (NAVD88 2004.65) elevation for all four profiles. The levee was modeled with a 30 ft elevation for the Waveland, Pass Christian, and west of Deer Island profiles; and modeled with a 15 ft elevation on the Pascagoula profile.

To develop the lookup table a set of independent parameters and their ranges were specified. The independent parameters are levee slope, levee crest height, incident wave height, peak wave period, and surge water elevation. All of the hydrodynamic parameters are specified at 600 ft from the levee toe, and represent information provided from STWAVE and ADCIRC runs. The levee slope evaluated was 1:3. The seawall was approximated as a very steep slope (5:1). The other parameters used to develop the lookup table are given in Table 2.7-1. For each parameter combination, a Boussinesq simulation was run for the 8 profiles. Save stations near proposed structures were associated with the most appropriate representative profile. For the Mississippi coast, a total of 8 x 3 x 3 X 3 = 216 simulations were run to create the lookup table.

For each simulation, time series of free surface elevation, depth-averaged velocity, and mass flux are recorded. Each time series is distilled to a significant wave height, a mean water level (from which the local wave setup is obtained), and a mean flux. Note that mean flux, when measured on the crest of a levee, is identical to the overtopping rate in units of water volume/time per unit length of crest. Using interpolation routines, the wave height, wave setup, and overtopping values for any combination of input conditions bracketed by the independent parameter ranges shown above can be obtained. The lookup table script outputs the wave setup at the structure toe, the wave height at the toe, and the overtopping rate predicted by COULWAVE.

The entire 197 storm suite was simulated with STWAVE forced with input boundary conditions calculated by the offshore wave model WAM and water level supplied by the surge model. All storms were run on both STWAVE grids. STWAVE was run for approximately a two-day period for each storm to capture the peak wave conditions. Radiation stress gradients were calculated and applied as a forcing condition to the surge model. To provide the wave height and period for boundary conditions to COULWAVE, the STWAVE output was processed to extract the significant wave height at the surge peak for save stations near the proposed structures.

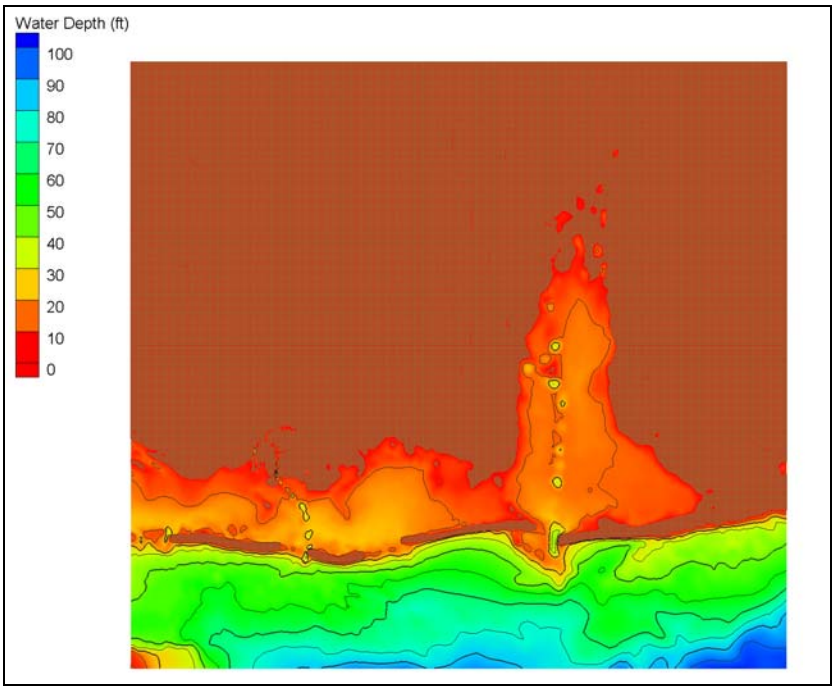


Figure 2.7-1. MS-AL Bathymetry Grid (depths in feet)

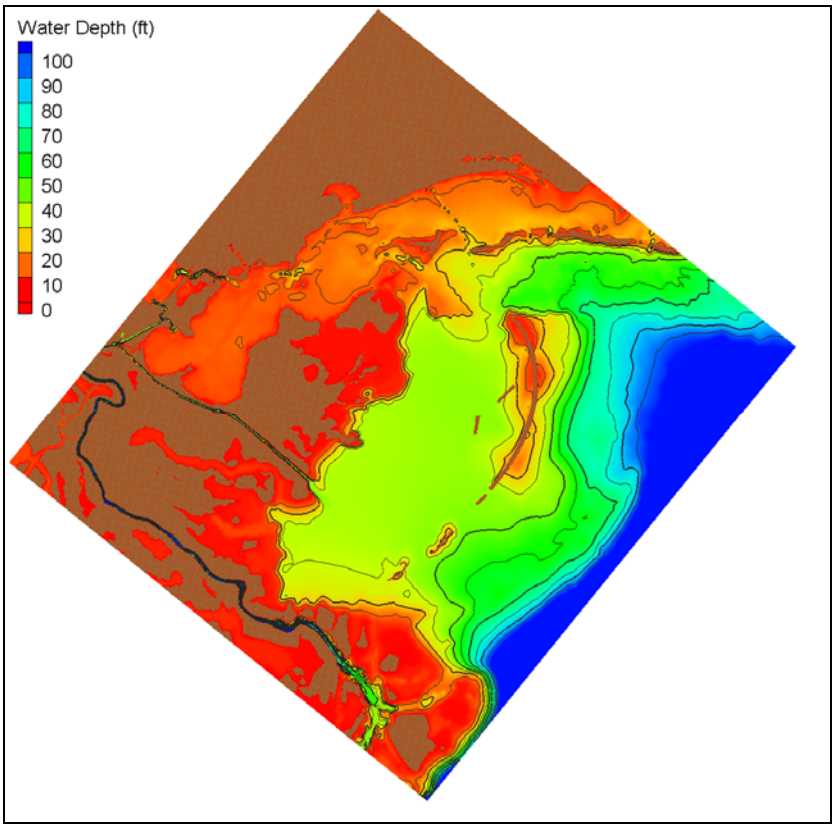


Figure 2.7-2. West MS-SE LA Bathymetry Grid (depths in feet)

Table 2.7-1.
Water Levels and Wave Parameters Modeled with COULWAVE

Water Level Relative to Structure Crest (ft)	Wave Heights (ft)	Peak Periods (sec)
0	2, 5, 8	8, 12, 16
-2	2, 5, 8	8, 12, 16
-4	2, 5, 8	8, 12, 16

2.7.3 Results

Example output generated from the STWAVE model results are provided in Figures 2.7-3 to 2.7-6. Figures 2.7-3 to 2.7-4 show the maximum significant wave height and coincident direction produced by storm 027 for the MS-AL and MS-SE LA grids, respectively. Figures 2.7-5 to 2.7-6 are the peak wave periods at the time of maximum wave height. The maximum significant wave heights and periods in representative sections can be selected as boundary conditions for calculating wave runup and overtopping, wave forcing on structures, or other design purposes.

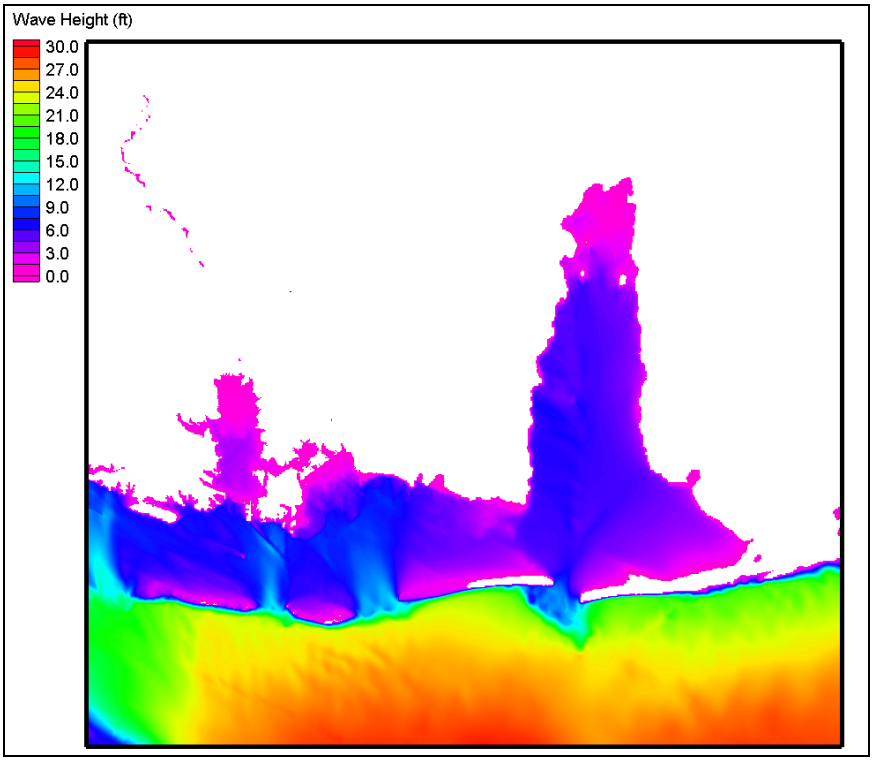


Figure 2.7-3. Maximum significant wave height for the MS-AL grid for storm 027

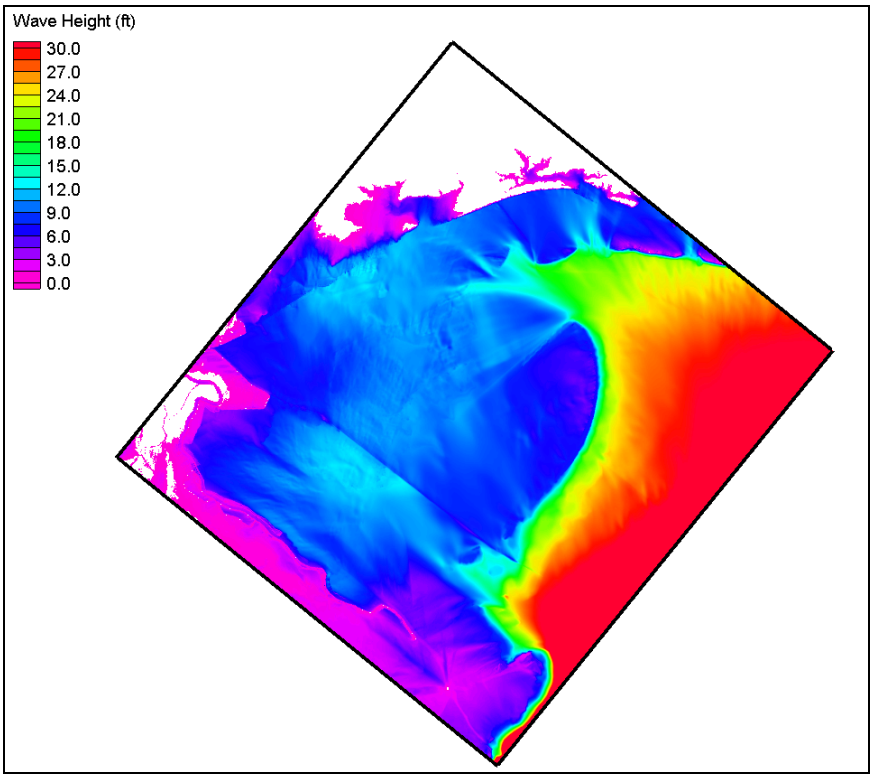


Figure 2.7-4. Maximum significant wave height for the MS-SE LA grid for storm 027

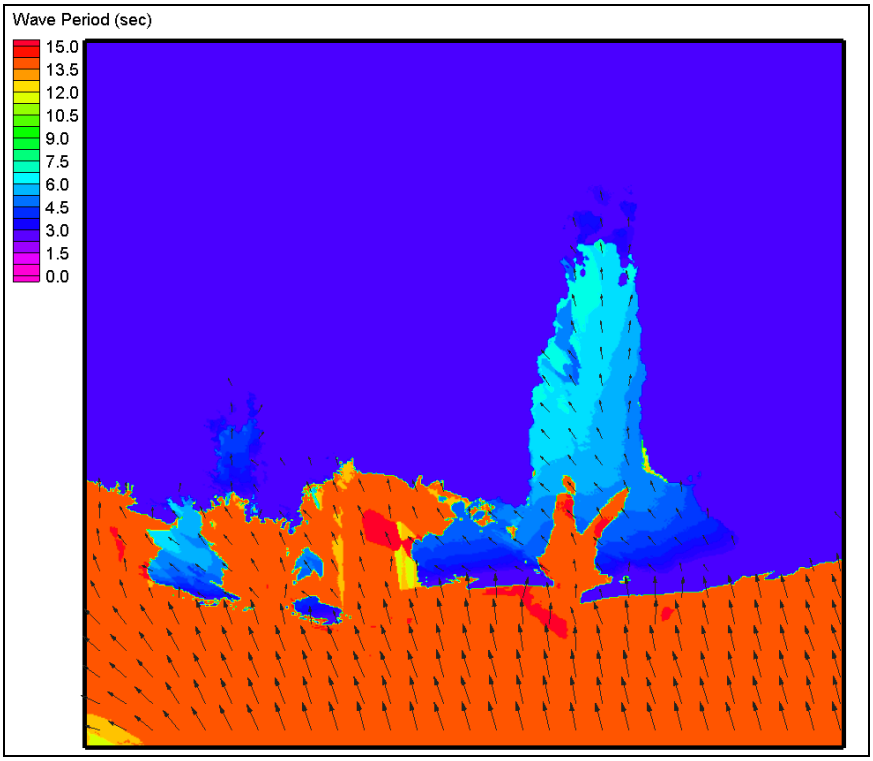


Figure 2.7-5. Peak wave period and direction at the time of maximum wave height for the MS-AL grid for storm 027

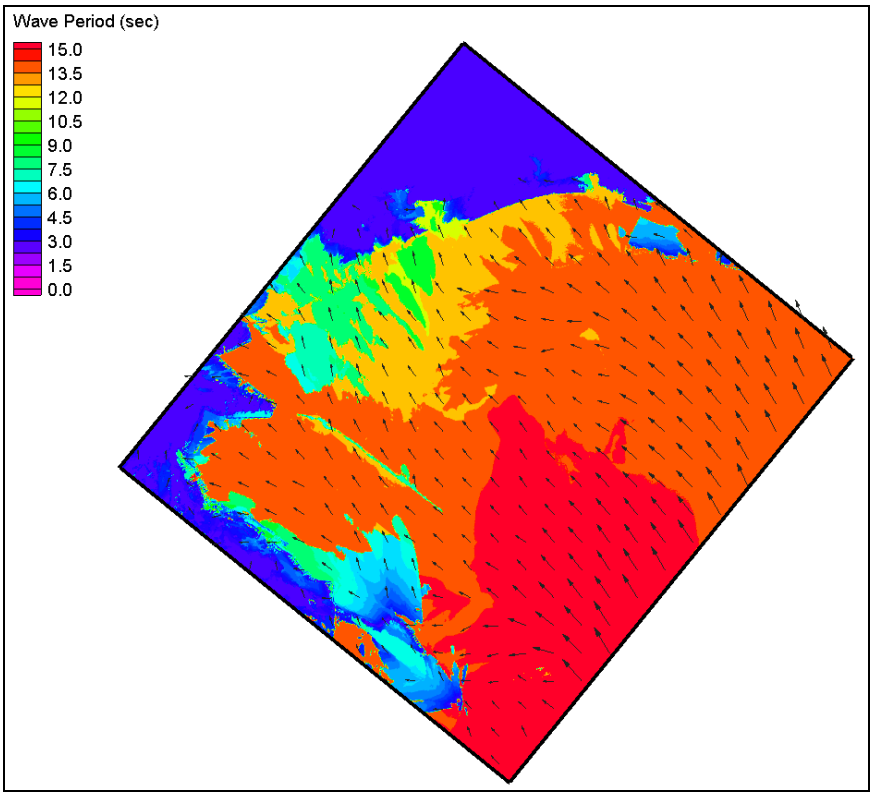


Figure 2.7-6. Peak wave period and direction at the time of maximum wave height for the MS-SE LA grid for storm 027

For storm 027 at a save location near a proposed ring levee in the Pascagoula area, the wave height and period calculated by STWAVE at the peak of the storm was approximately 3.5 ft and 13.5 sec, respectively. With these input parameters, the wave setup at the toe of the structure obtained from the COULWAVE generated lookup table was about 1.3 ft. These calculations were made for all 27 storms in the measure evaluation storm suite and the local wave setup was added to the water level. In general, the additional wave setup calculated near the structure was less than 1 ft, but occasionally was calculated to be as much as approximately 1.75 ft. Note that this additional wave setup was only applied to estimate water levels at the proposed lines of defense to assist in preliminary cost estimation.

2.8 Storm Surge Modeling

The Advanced CIRCulation Model (ADCIRC) was selected as the basis for the surge modeling effort. The domain and geometric/topographic description and resulting computational grid provides for a common domain and grid from the Sabine River to Mobile Bay which extends inland across the floodplains of Southern Louisiana and Mississippi (to the 30 to 75 ft contour NAVD88 2004.65) and extends seaward to the deep Atlantic Ocean. The grid, referred to as SL15, domain boundaries were selected to ensure the correct development, propagation and attenuation of storm surge without necessitating nesting solutions or specifying ad hoc boundary conditions for tides or storm surge. The grid will be used for all coastal analysis for Louisiana and Mississippi to ensure consistency and matching solutions at state line/region boundaries.

2.8.1 Computational Model

ADCIRC-2DDI, the two-dimensional, depth-integrated implementation of the ADCIRC coastal ocean model, was used to perform the hydrodynamic computations in this study (Luettich et al. 1992, Westerink et al. 1992, Westerink et al. 1993, Luettich and Fulcher 2004, Luettich and Westerink 2004). Imposing the wind and atmospheric pressure fields, the ADCIRC model can replicate tide induced and storm-surge water levels and currents. In two dimensions, the model is formulated with the depth-averaged shallow water equations for conservation of mass and momentum. Furthermore, the formulation assumes that the water is incompressible, hydrostatic pressure conditions exist, and that the Boussinesq approximation is valid. Using the standard quadratic parameterization for bottom stress and neglecting baroclinic terms and lateral diffusion/dispersion effects, the following set of conservation equations in primitive, nonconservative form, and expressed in a spherical coordinate system, are incorporated in the model (Flather 1988; Kolar et al. 1993):

$$\frac{\partial U}{\partial t}+\frac{1}{r\cos\phi}U\frac{\partial U}{\partial \lambda}+\frac{1}{R}V\frac{\partial U}{\partial \phi}-\left[\frac{\tan\phi}{R}U+f\right]V=$$

$$-\frac{1}{R\cos\phi}\frac{\partial}{\partial \lambda}\left[\frac{p_s}{\rho_0}+g(\zeta-\eta)\right]+\frac{\tau_{s\lambda}}{\rho_0 H}-\tau_* U \qquad \text{E2.8-1}$$

$$\frac{\partial V}{\partial t}+\frac{1}{r\cos\phi}U\frac{\partial V}{\partial \lambda}+\frac{1}{R}V\frac{\partial V}{\partial \phi}-\left[\frac{\tan\phi}{R}U+f\right]U=$$

$$-\frac{1}{R}\frac{\partial}{\partial \phi}\left[\frac{p_s}{\rho_0}+g(\zeta-\eta)\right]+\frac{\tau_{s\lambda}}{\rho_0 H}-\tau_* V \qquad \text{E2.8-2}$$

$$\frac{\partial \zeta}{\partial t}+\frac{1}{R\cos\phi}\left[\frac{\partial UH}{\partial \lambda}+\frac{\partial (UV\cos\phi)}{\partial \phi}\right]=0 \qquad \text{E2.8-3}$$

where

t = time,

λ and φ = degrees longitude (east of Greenwich is taken positive) and degrees latitude (north of the equator is taken positive),

ζ = free surface elevation relative to the geoid,

U and *V* = depth-averaged horizontal velocities in the longitudinal and latitudinal directions, respectively,

R = the radius of the earth,

$H = \zeta + h$ = total water column depth,

h = bathymetric depth relative to the geoid,

$f = 2\Omega \sin \varphi$ = Coriolis parameter,

Ω = angular speed of the earth,

p_s = atmospheric pressure at free surface,

g = acceleration due to gravity,

η = effective Newtonian equilibrium tide-generating potential parameter,

ρ_0 = reference density of water,

$\tau_{s\lambda}$ and $\tau_{s\varphi}$ = applied free surface stresses in the longitudinal and latitudinal directions, respectively, and

τ = bottom shear stress and is given by the expression $C_f (U^2 + V^2)^{1/2} / H$ where C_f is the bottom friction coefficient.

The momentum equations (Equations 1 and 2) are differentiated with respect to λ and τ and substituted into the time differentiated continuity equation (Equation 3) to develop the following Generalized Wave Continuity Equation (GWCE):

$$\frac{\partial^2 \zeta}{\partial t^2} + \tau_0 \frac{\partial \zeta}{\partial t} - \frac{1}{R \cos\phi} \frac{\partial}{\partial \lambda} \left[\frac{1}{R \cos\phi} \left(\frac{\partial HUU}{\partial \lambda} + \frac{\partial (HUV \cos\phi}{\partial \phi} \right) - UVH \frac{\tan\phi}{R} \right]$$

$$\left[-2\omega \sin\phi \, HV + \frac{H}{R \cos\phi} \frac{\partial}{\partial \lambda} \left(g(\zeta - \alpha\eta) + \frac{p_5}{\int} p_0 \right) + \tau_* HU - \tau_0 HU - \tau_{s\lambda} \right]$$

$$-\frac{1}{R} \frac{\partial}{\partial \phi} \left[\frac{1}{R \cos\phi} \left(\frac{\partial HVV}{\partial \lambda} + \frac{\partial HVV \cos\phi}{\partial \phi} \right) + UUH \frac{\tan\phi}{R} + 2\omega \sin\phi \, HU \right] \qquad \text{E2.8-4}$$

$$+\frac{H}{R} \frac{\partial}{\partial \phi} \left(g(\zeta - alfa\eta) + \frac{p_s}{\rho_0} \right) + \tau_* - \tau_0 HV - \frac{\tau_{s\lambda}}{\rho_0}]$$

$$-\frac{\partial}{\partial t} [\frac{VH}{R} \tan\phi] - \tau_0 [\frac{VH}{R} \tan\phi] = 0$$

The ADCIRC model solves the GWCE in conjunction with the primitive momentum equations given in Equations 1 and 2. The GWCE-based solution scheme eliminates several problems associated with finite-element programs that solve the primitive forms of the continuity and momentum equations, including spurious modes of oscillation and artificial damping of the tidal signal. Forcing functions include time-varying water-surface elevations, wind shear stresses, and atmospheric pressure gradients.

The ADCIRC model uses a finite-element algorithm in solving the defined governing equations over complicated bathymetry encompassed by irregular sea/ shore boundaries. This algorithm allows for extremely flexible spatial discretizations over the entire computational domain and has demonstrated excellent stability characteristics. The advantage of this flexibility in developing a computational grid is that larger elements can be used in open-ocean regions where less resolution is needed, whereas smaller elements can be applied in the nearshore and estuary areas where finer resolution is required to resolve hydrodynamic details.

2.8.2 Methodology

The ADCIRC grid utilized for this study is that which was calibrated and validated for IPET with Hurricane Katrina data and subsequently validated with data from Hurricane Rita for this and other coastal surge studies conducted by USACE. The development of an accurate unstructured grid storm surge model of Southern Louisiana and Mississippi requires appropriate selection of the model domain and optimal resolution of features controlling surge propagation. The SL15 model domain, shown in Figure 2.8-1, has an eastern open ocean boundary that lies along the 60° W meridian, extending south from the vicinity of Glace Bay in Nova Scotia, Canada to the vicinity of Coracora Island in eastern Venezuela (Westerink, Luettich and Muccino 1994, Blain et al. 1994, Mukai et al. 2002, Westerink et al., 2006, Ebersole et al., 2006). This domain has a superior open ocean boundary that is primarily located in the deep ocean and lies outside of any resonant basin. There is little geometric complexity along this boundary. Tidal response is dominated by the astronomical constituents and nonlinear energy is limited due to the depth. The boundary is not located near tidal amphidromes. Hurricane storm surge response along this boundary is essentially an inverted barometer pressure effect directly correlated to the atmospheric pressure deficit in the meteorological forcing; it can therefore be easily specified. This boundary allows the model to accurately capture basin-to-basin and shelf-to-basin physics. Hurricane forerunner and Gulf of Mexico resonant modes can be generated as the hurricane moves from the Atlantic into the Gulf.

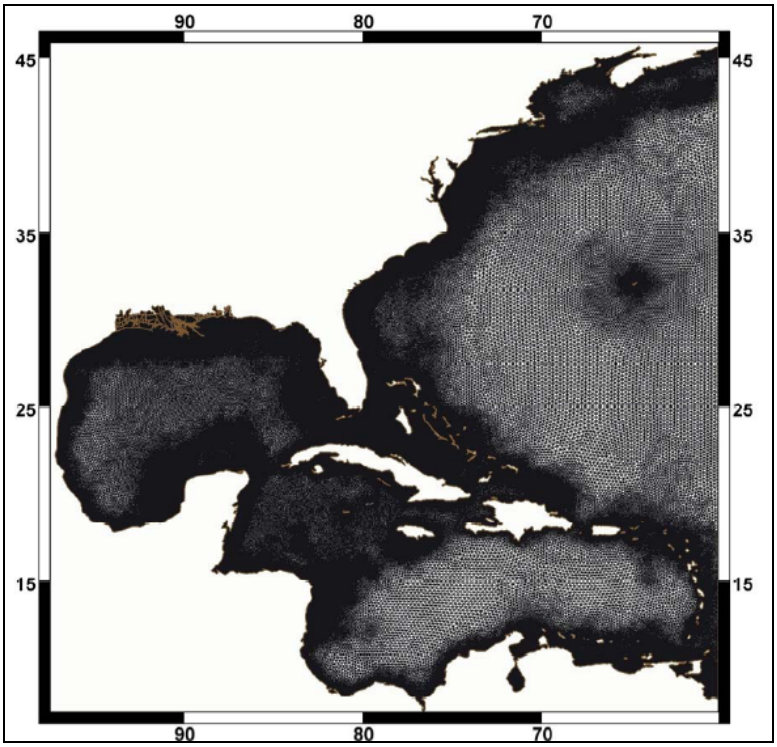


Figure 2.8-1. The ADCIRC SL15 Unstructured Grid

The grid design provides localized refinement of the coastal floodplains of Southern Louisiana and Mississippi and of the important hydraulic features. The level of detail in Southern Louisiana and Mississippi is unprecedented, with nodal spacing reaching as low as 100 ft in the most highly refined areas. Unstructured grids can resolve the critical features and the associated local flow processes with orders of magnitude fewer computational nodes than a structured grid, because the latter is limited in its ability to provide resolution on a localized basis and fine resolution generally extends far outside the necessary area. The SL15 grid is refined locally to resolve features such as inlets, rivers, navigation channels, levee systems and local topography/bathymetry. In addition, wave breaking zones have been identified based on local bathymetric gradients, and a swath of 150 to 700 ft grid resolution has been placed along the coast and over barrier islands to ensure that the grid scale of the flow model is consistent with that of the STWAVE models. The STWAVE forcing function is accommodated by adding a high level of resolution where significant gradients in the wave radiation stresses and forcing of surge through wave transformation and breaking are the largest. The high resolution zones allow for the strong wave radiation stress gradients to fully force the water body in these important regions and ensures that the resulting wave radiation stress induced set up is sufficiently accurate. Barrier islands were in particular very highly resolved to 150 to 250 ft due to the significant wave breaking and the resulting important wave radiations stresses as well as the very high currents that develop over the features. The SL15 computational grid contains 2,137,978 nodes and 4,184,778 elements. Grid resolution varies from approximately 12-15 mi in the deep Atlantic Ocean to about 100 ft in Louisiana and Mississippi. The high grid resolution required for the study region leads to a final grid with more than 90% of the computational nodes placed within or upon the shelf adjacent to Southern Louisiana and Mississippi, enabling sufficient resolution while minimizing the cost of including such an extensive domain. Geometry, topography and bathymetry in the SL15 model were all defined to replicate the prevailing conditions in August 2005 prior to Hurricane Katrina with the exceptions of some of the barrier islands and area between Lake Pontchartrain and Lake Borgne that were included as post Katrina September 2005 configurations. The bathymetric and topographic data was interpolated to the SL15 computational mesh by moving progressively from the coarsest and deepest to finest and shallowest areas of the computational domain.

Levee and road systems that are barriers to flood propagation are features that generally fall below the defined grid scale and represent a non-hydrostatic flow scenario. It is most effective to treat these structures as sub-grid scale parameterized weirs within the domain. ADCIRC defines these as barrier boundaries by a pair of computational nodes with a specified crown height (Westerink et al. 2001). Once water level reaches a height exceeding the crown height, the flow across the structure is computed according to basic weir formulae. This is accomplished by examining each node in the defined pair for their respective water surface heights and computing flow according to the difference in water elevation. The resulting flux is specified as a normal flow from the node with the higher water level to the node with the lower water level for each node pair. Weir boundary conditions also are implemented for external barrier boundaries, which permit surge that overtops levee structures at the edge of the domain to transmit flow out of the computational area.

The entire JPM-OS synthetic storm suite was simulated for the no project condition forced with the wind and pressure fields discussed in section 2.5 and radiation stress gradients calculated by STWAVE (see section 2.7). The ADCIRC and STWAVE models were coupled in that wind and water levels computed by ADCIRC were applied as a boundary condition for STWAVE, STWAVE was run and the resulting radiation stress gradients were then applied as forcing to ADCIRC to compute the final water level.

2.8.3 Results

The primary goal of the ADCIRC simulations was to estimate overall peak water level for each storm in the JPM-OS suite for the calculation of stage-frequency curves for the no project condition and

with proposed protection measures in place. This involved an examination of the entire spatial domain every 900 seconds (15 minutes) to determine if water levels exceeded the previous time steps maximum water level at any point in the domain. The result of this analysis is a maximum envelope of water level for a given simulation. Example output generated from the ADCIRC model results are provided in Figures 2.8-2 to 2.8-6 and discussed below. The peak surge elevations were saved at stations along the Mississippi coast for the entire JPM-OS storm suite and the computed water levels used as input for the JPM analysis.

Figure 2.8-2 is the envelope of maximum water level for storm 027 for the no project condition, Figure 2.8-3 is the envelope of maximum water level for the same storm with line of defense 3 in place, and Figure 2.8-4 is the difference between the line of defense 3 and the no project condition. For this particular storm, the maximum water level envelope for the no project condition (Figure 2.8-2) shows that the highest water levels are in the vicinity of Saint Louis Bay where the water level reaches 26 ft NAVD88 (2004.65). Approximately 25 miles to the east, Biloxi Bay water levels are at 18 ft NAVD88 (2004.65) and Pascagoula is at 10 ft NAVD88 (2004.65). The bays overflow their banks and the surrounding low-lying areas are inundated. The maximum water level envelope for the line of defense 3 (Figure 2.8-3) shows that the highest water levels are *seaward* of the line of defense 3 in the vicinity of Bay Saint Louis where the water level in the Gulf reaches 27 ft NAVD88 (2004.65) along the shoreline west of the entrance to Saint Louis Bay. Water within Saint Louis Bay is locally affected by the winds with water levels of 3-5 ft, but generally remains within its banks. Approximately 25 miles to the east, Biloxi Bay water levels are at 3 ft NAVD88 (2004.65) and Pascagoula remains at 10 ft NAVD88 (2004.65) since it is unprotected by the line of defense 3. The difference between the maximum water levels with line 3 of defense and the no project condition (Figure 2.8-4) shows areas in blue (Saint Louis Bay and Biloxi Bay) where water levels are reduced, indicating that the line of defense 3 provides protection to these regions. Water levels are reduced by 18-23 ft in St Louis Bay and 14 ft in Biloxi Bay. Figure 2.8-4 also shows slightly (~1-ft) higher water levels in the Gulf as indicated by the yellow and orange areas.

Figure 2.8-5 is the envelope of maximum water level for the storm 027 with line of defense 4 in place, and Figure 2.8-6 is the difference between the line of defense 4 and the no project condition. The results are very similar to the line of defense 3 results. The maximum water level envelope for the line of defense 4 (Figure 2.8-5) also shows that the highest water levels are *seaward* of the line of defense 4 in the vicinity of Bay Saint Louis where the water level in the Gulf reaches 27 ft NAVD88 (2004.65) along the shoreline west of the entrance to Saint Louis Bay. Water within Saint Louis Bay is again locally affected by the winds with water levels of 2-5 ft, but generally remains within its banks. Approximately 25 miles to the east, Biloxi Bay water levels are at 3 ft NAVD88 (2004.65) and Pascagoula remains at 10 ft NAVD88 (2004.65) since it is unprotected by the line of defense 4. The difference between the maximum water levels with line 4 of defense and the no project condition (Figure 2.8-6) shows areas in blue (Saint Louis Bay and Biloxi Bay) where water levels are reduced, indicating that the line of defense 4 provides protection to these regions. Water levels are reduced by 18-23 ft in St Louis Bay and 14 ft in Biloxi Bay. Figure 2.8-6 also shows slightly (~1-ft) higher water levels in the Gulf as indicated by the yellow and orange areas.

The peak surge elevations were saved at stations along the Mississippi coast for the entire JPM-OS storm suite and the computed water levels used as input for the JPM analysis. The peak surge elevations for the set of storms run with the lines of defense in place were also saved at stations along the coast and stage frequency curves developed with the methodology discussed in section 2.4.3. The resulting stage frequency relationships are given in section 2.9.

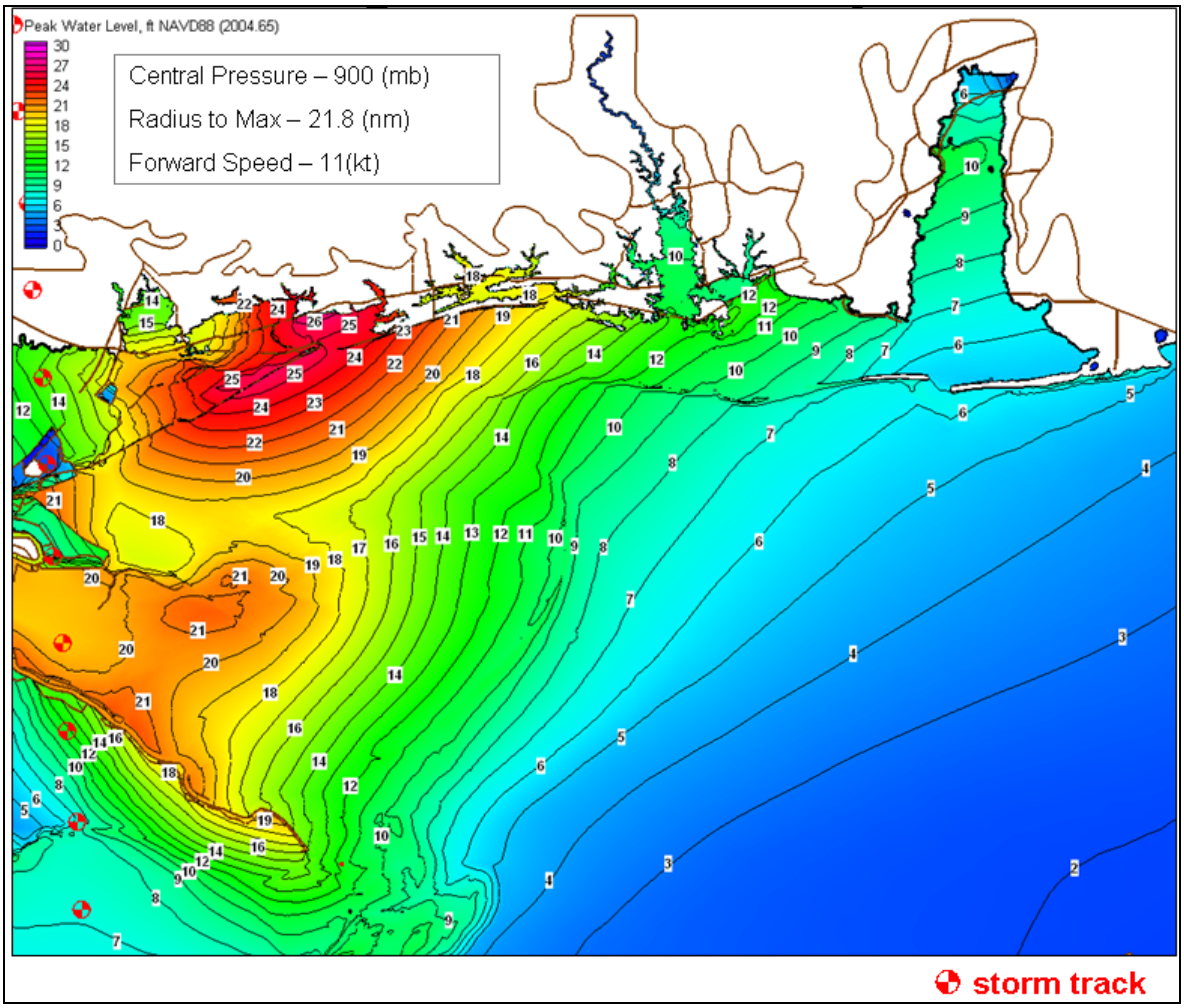


Figure 2.8-2. Envelope of maximum water level for storm 027 for the no project condition

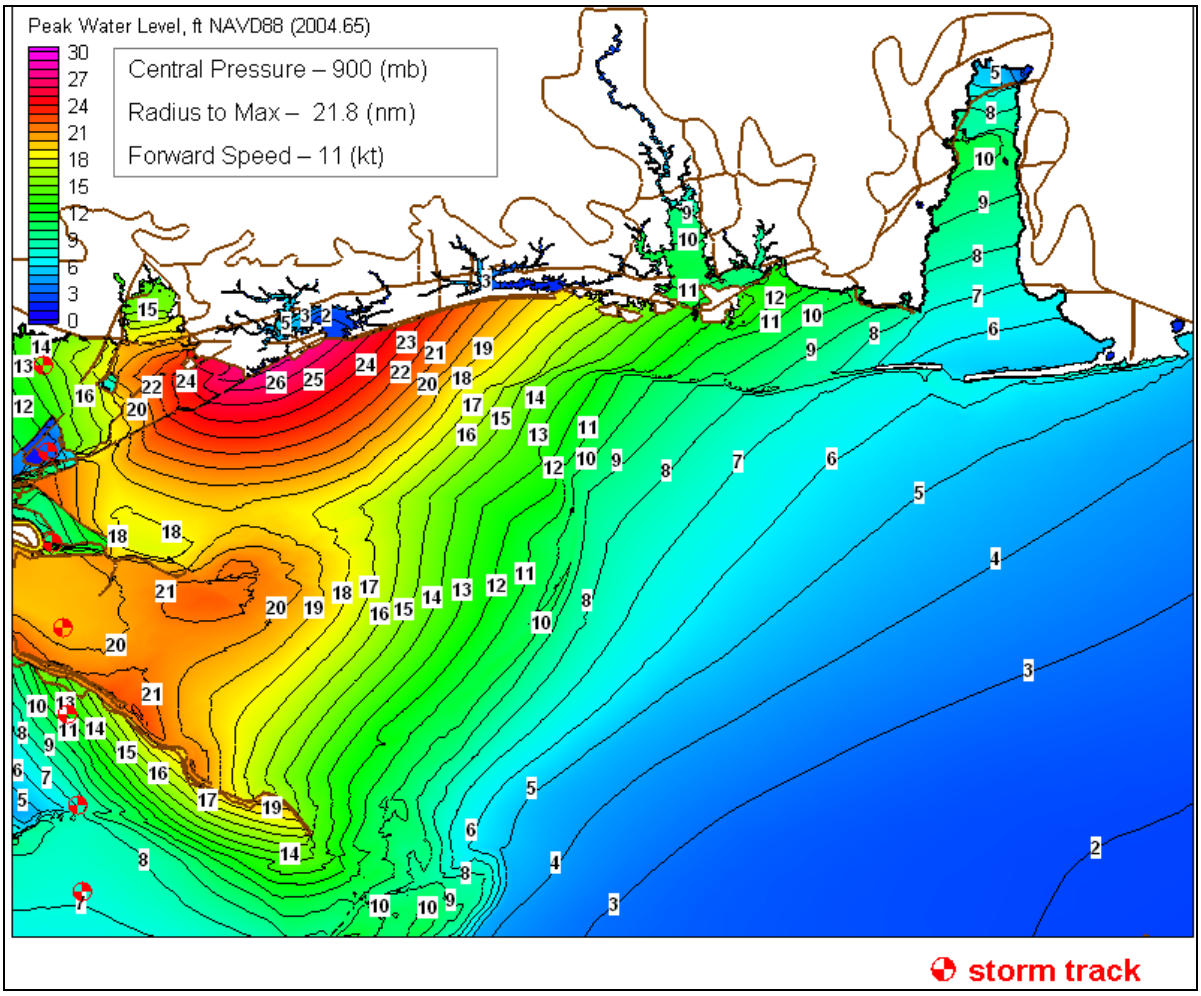


Figure 2.8-3. Envelope of maximum water level for storm 027 for the line of defense 3

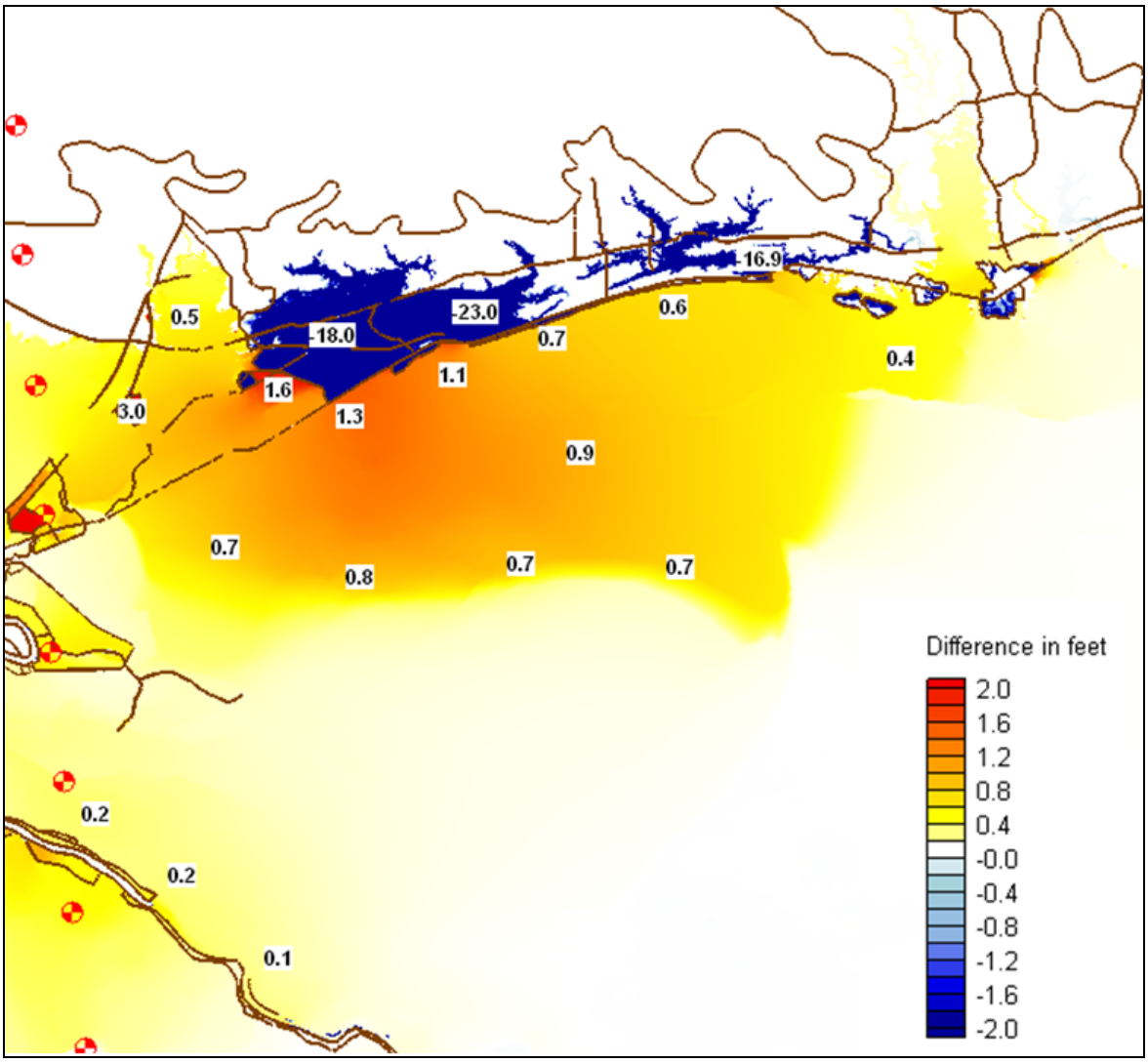


Figure 2.8-4. Difference in maximum water level between line of defense 3 and the no project condition for storm 027

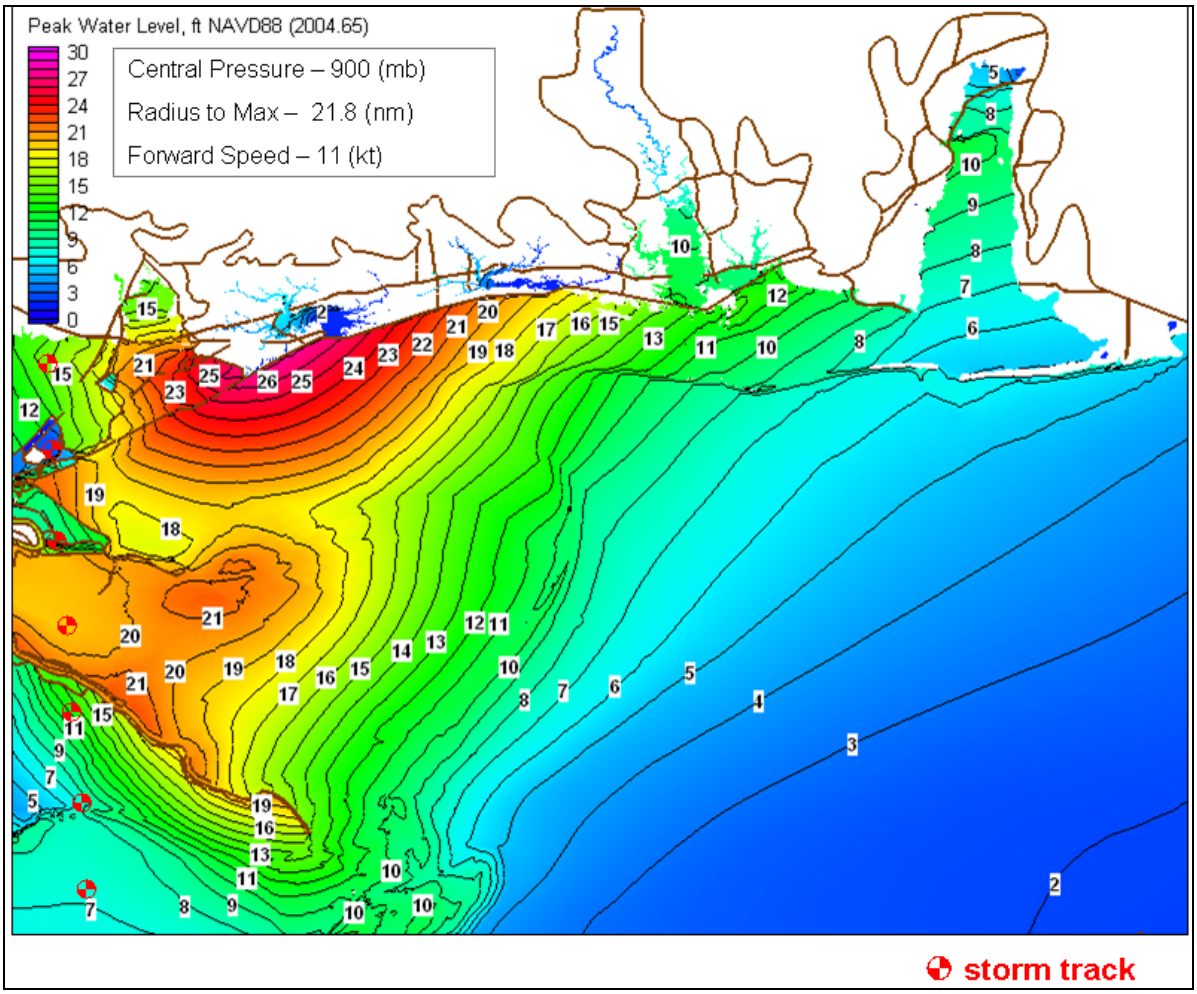


Figure 2.8-5. Envelope of maximum water level for storm 027 for the line of defense 4

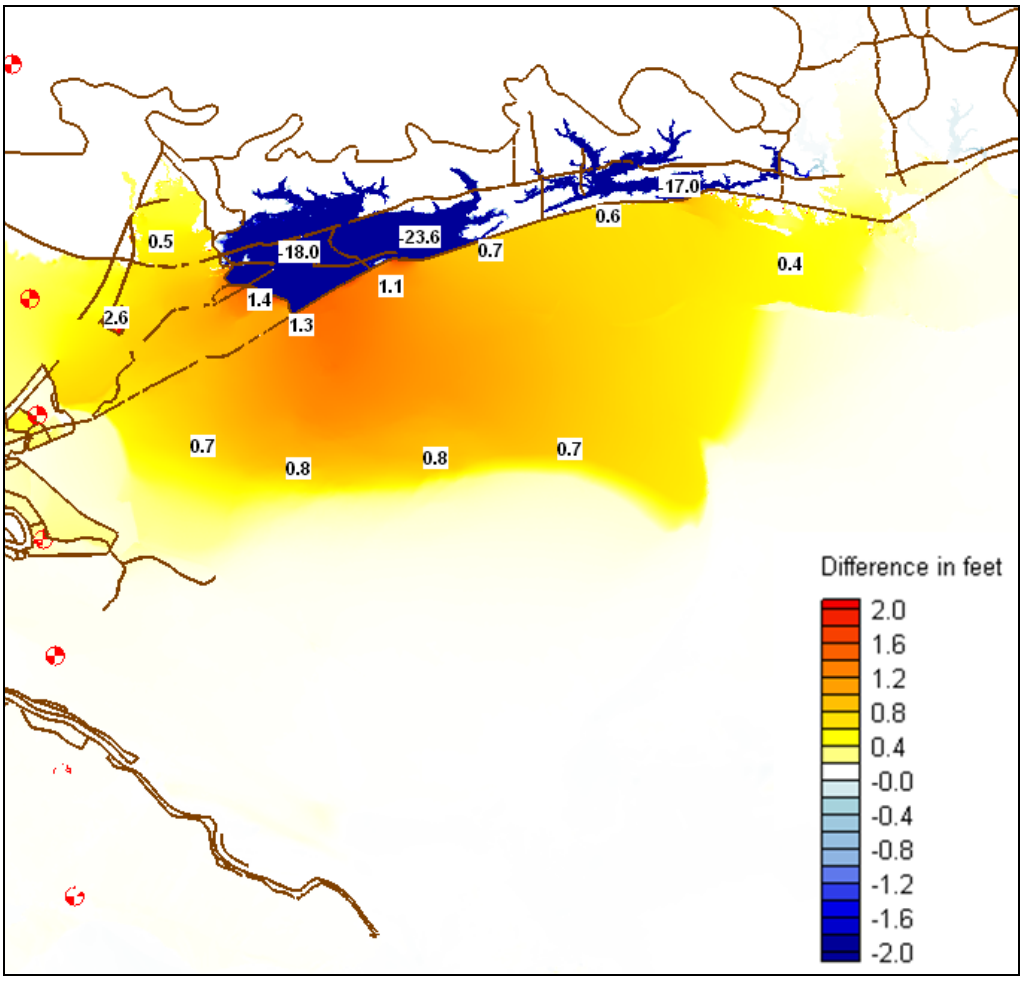


Figure 2.8-6. Difference in maximum water level between line of defense 4 and the no project condition for storm 027

2.8.4 Line of Defense 5 Results

Six maximum possible intensity (MPI) storms with landfall points along the Mississippi coast were simulated to determine inundation limits for the Mississippi coastline. These limits are used to establish line of defense 5. The six MPI storms made landfall at various points along the coast as shown in Figure 2.8-7. All MPI storms were defined at their most intense point as having a minimum central pressure of 880 mb, radius to maximum winds of 36 n mi, and a forward speed of 11 kt.

Peak water level envelopes from each of the six MPI simulations were computed. The six peak water level envelopes were then compared to compute the “peak of peaks”, which is considered the inundation limit along the entire Mississippi coastline (Figure 2.8-8). The maximum water level along the Mississippi coastline was determined to be approximately 30 ft along the entire western half of the state and east of Pascagoula. The landward extent of the inundation indicates the storm surge reaches Interstate 10 for much of the western portion of the state. Lower peaks near Biloxi and Mobile Bay (24-27 ft) may be attributed to the protection afforded by the barrier islands.

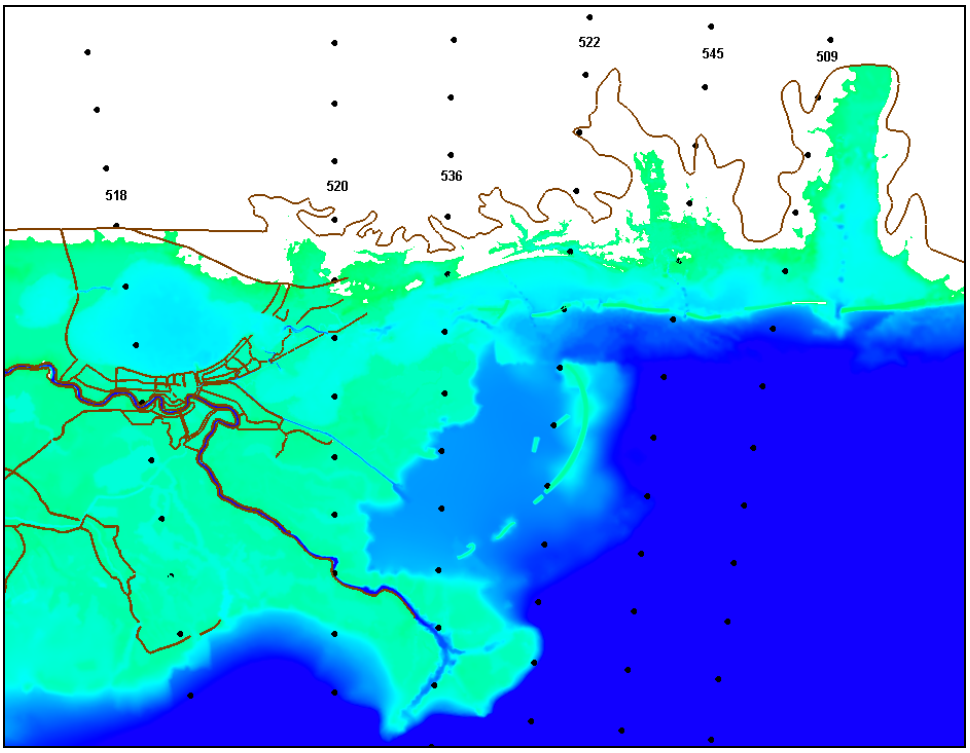


Figure 2.8-7. Storm Tracks for Maximum Possible Intensity Storms

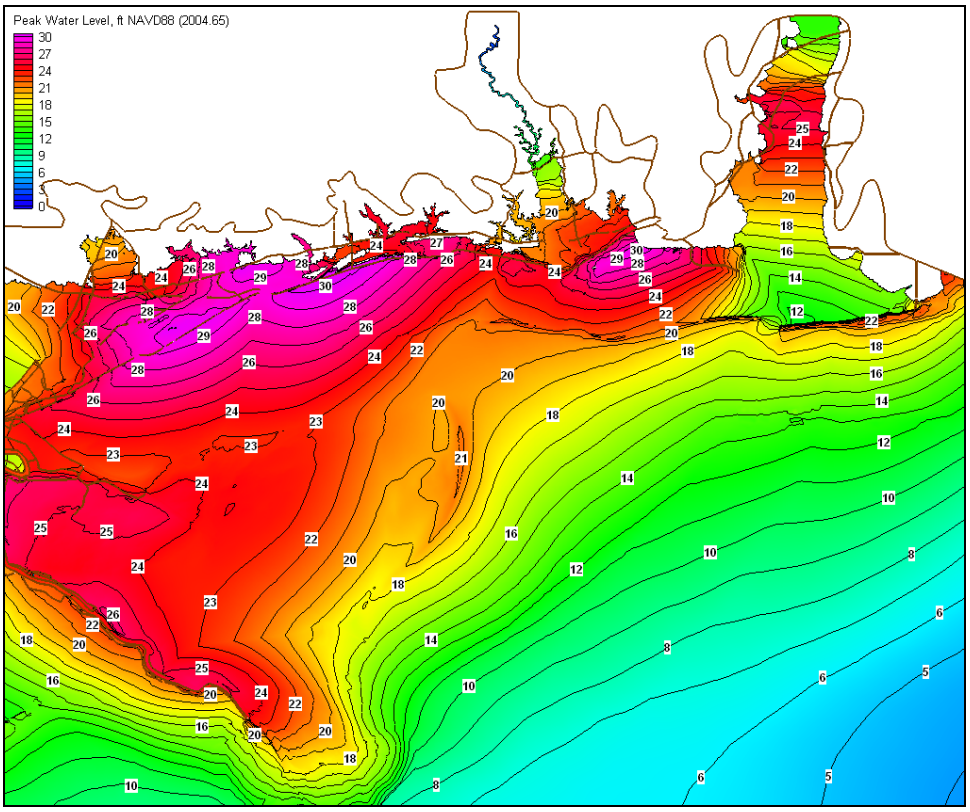


Figure 2.8-8. Envelope of Maximum Water Level for all MPI Storms

2.9 Stage Frequency Curves

The purpose of hydrodynamic modeling was to estimate the surge and wave conditions for the no project condition and with lines of defense 3 and 4 in place. The expected return periods for those surge and wave conditions is also required to quantify the risk for the existing condition and the level of protection that might be possible with the proposed protection measures. Sixty-two save locations were selected to evaluate damage reaches across Mississippi. The surge and wave conditions at these 62 locations, plus 18 additional locations in the Mississippi Sound and seaward of the barrier islands were saved and analyzed with the JPM-OS methodology described in section 2.4. The calculation of the hydrodynamic conditions has been detailed in sections 2.5 to 2.8. In this section, a description of the integrated modeling system is given and the location of the save stations identified. Finally, the frequency results for both the surge and waves are presented.

2.9.1 Integrated Modeling System

Section 2.4 described the statistical methodology and sections 2.5 to 2.8 detailed the models and methodologies applied for computing the surge and wave estimates for the Mississippi coast. Each component is part of an integrated modeling system. For completeness, the integrated system is presented. A schematic diagram of the system is shown in Figure 2.9-1.

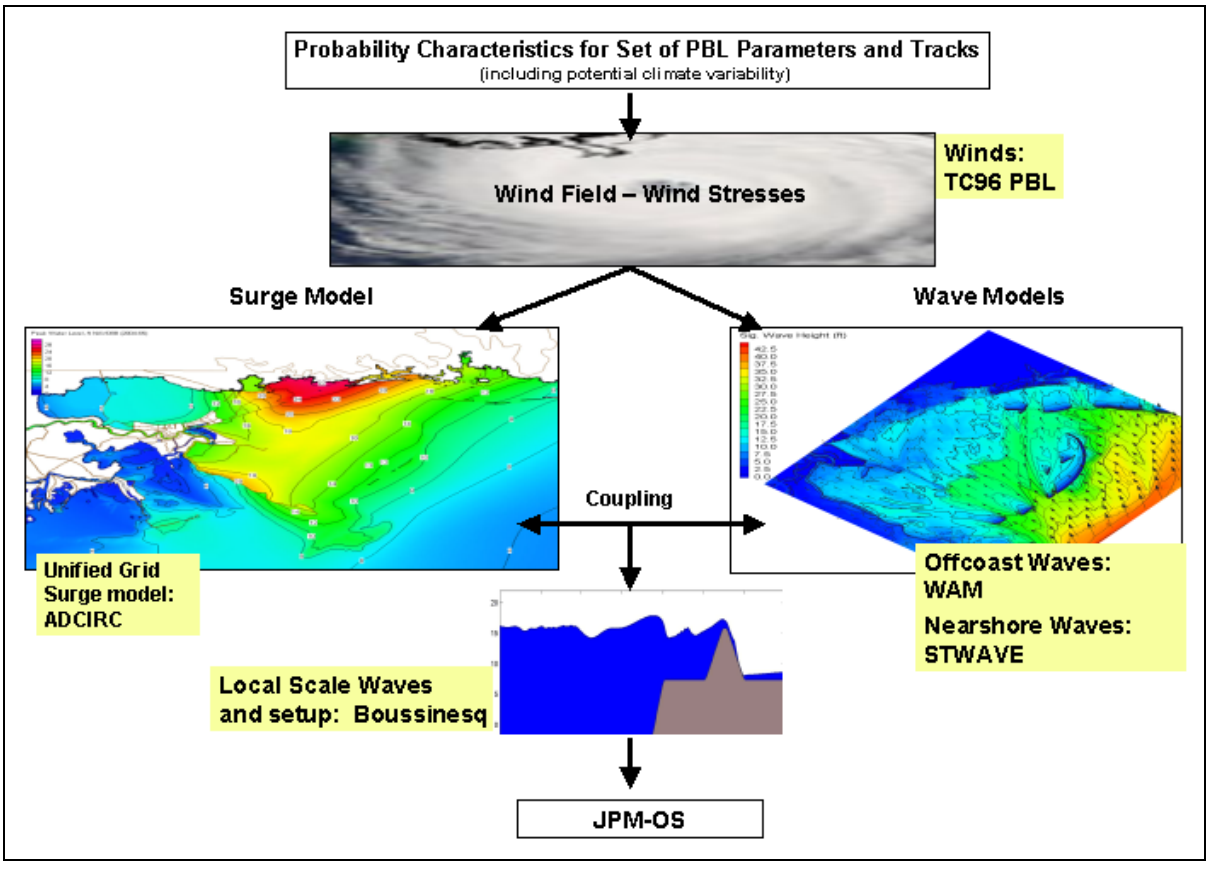


Figure 2.9-1. Diagram of Modeling System for Coastal Inundation Applications

First, for each defined storm (a track and its time-varying wind field parameters) the TC96 PBL model (Thompson and Cardone, 1996) is used to construct 15-minute snapshots of wind and pressure fields for driving surge and wave models. ADCIRC is then run to compute the wind-driven

surge component. In parallel with the initial ADCIRC runs, the large-domain, discrete, time-dependent spectral wave model WAM is run to calculate directional wave spectra that serve as boundary conditions for local-domain, near-coast wave model STWAVE. Using initial water levels from ADCIRC, winds that include the effects of sheltering due to land boundaries, and spectral boundary conditions from the large-domain wave model, STWAVE is run to produce wave fields and estimated radiation stress fields. The radiation stress fields are added to the PBL-estimated wind stresses, and the ADCIRC model is run again for the time period during which the radiation stresses potentially make a significant contribution to the water levels.

For simulations with the proposed structures, a method based on Boussinesq modeling (using a lookup table based on interpolations from generic runs) is used to provide estimates of the incremental contribution to the water level at the structure. The water levels from the second ADCIRC run and waves from STWAVE in locations adjacent to structures are provided as the boundary conditions for driving the Boussinesq-based runs.

2.9.2 Save Stations

Sixty-two save stations were identified to evaluate damage reaches across Mississippi. The surge and wave conditions at these 62 stations, plus 18 additional stations in the Mississippi Sound and seaward of the barrier islands were saved and analyzed. Figure 2.9-2 shows the location of each station.

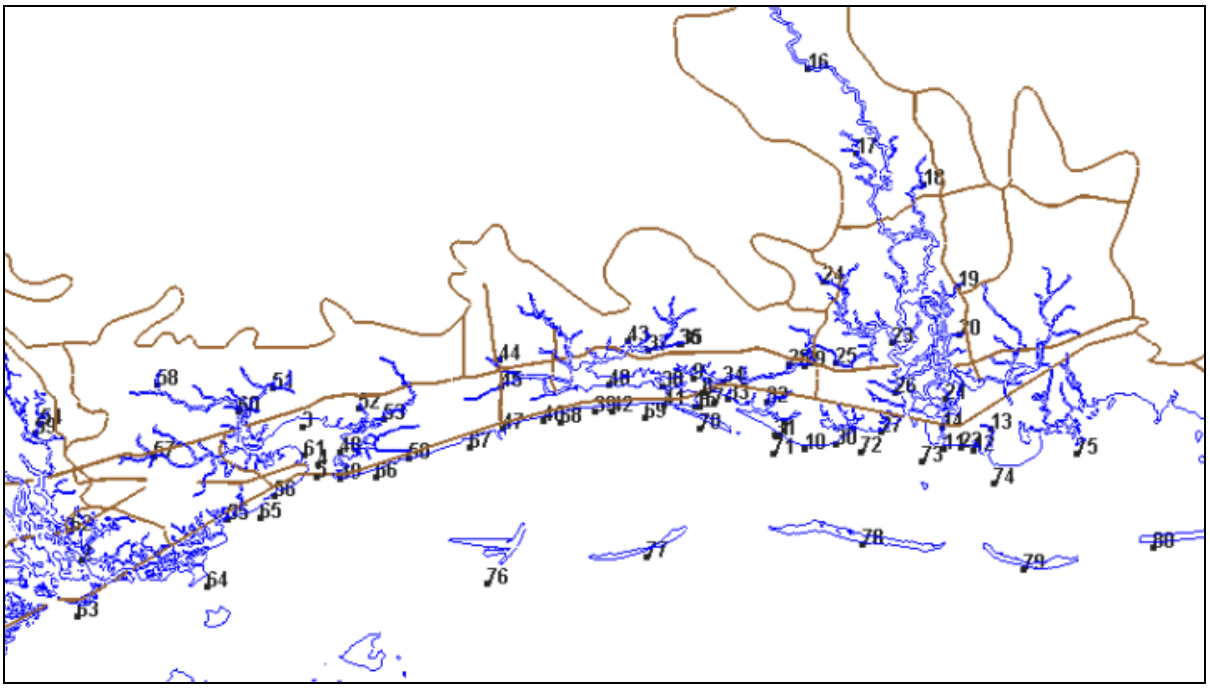


Figure 2.9-2. Save Station Locations

2.9.3 Results

2.9.3.1 Without-Project

The peak surge elevations, maximum wave heights, and peak wave periods were saved at stations along the Mississippi coast for the entire JPM-OS storm suite and used as input for the JPM analysis. The resulting frequency relationships are provided by save station in Tables 2.9-1 to 2.9-3

below for water level, wave height, and wave period, respectively. Note that there are no waves at some of the inland points.

Table 2.9-1.
Stage-Frequency Relationships – Without Project

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	8.1	11.3	14.2	19.1	20.8
2	10	13.8	16.3	20.1	21.3
3	10.8	14.9	17.9	23	24.6
4	10.4	14.4	17.3	22.3	23.9
5	10.4	14.4	17.3	22.4	24
6	8.9	12.4	15.4	20.3	22.1
7	8.8	12.3	15.4	20.3	22.1
8	9	12.6	15.6	20.6	22.4
9	9.2	12.9	16	21	22.9
10	8.1	11.2	13.9	18.7	20.4
11	7.7	11.2	13.8	18.3	19.8
12	7.4	10.9	13.6	17.9	19.4
13	7.6	11.3	14	18.3	19.7
14	7.1	9.9	12.1	16.3	17.8
15	9	12.5	15.5	20.3	22.1
16	2.6	3.3	3.8	4.5	4.8
17	3.2	4.2	4.8	6.1	6.5
18	4.2	5.5	6.6	8.5	9.3
19	5.6	7.4	8.9	11.8	13
20	5.9	7.9	9.6	12.9	14.2
21	6.3	8.6	10.6	14.5	15.9
22	7.7	11.2	13.9	18.2	19.8
23	5.8	7.7	9.3	12.4	13.6
24	5.7	7.5	9	12	13.5
25	6.1	8.1	9.8	12.6	13.7
26	6.3	8.4	10.2	13.8	15.1
27	8.1	11.4	13.9	18.7	20.3
28	7.1	9.7	11.6	15	16.3
29	6.9	9.3	11.2	14.4	15.5
30	8.2	11.6	14.2	19	20.7
31	8.1	11.3	14.2	19.1	20.8
32	8.4	11.8	14.8	19.8	21.6
33	8.8	12.3	15.4	20.4	22.3
34	8.7	12.2	15.2	20	21.8
35	8.3	11.3	13.5	17.2	18.5
36	8.3	11.3	13.5	17.2	18.5
37	8.7	11.8	14.1	17.9	19.2
38	9.1	12.6	15.5	20.1	21.8
39	9.7	13.5	16.4	21.2	23
40	9	12.1	14.4	18.3	19.7
41	9.1	12.8	15.7	20.5	22.3

Table 2.9-1.
Stage-Frequency Relationships – Without Project (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
42	9.5	13.3	16.2	21	22.8
43	8.9	12	14.3	18.3	19.6
44	9.1	12	14.1	17.7	18.8
45	8.8	11.6	13.7	17.2	18.3
46	10.2	13.9	16.7	21.6	23.4
47	10.7	14.2	17	22.1	23.9
48	10.4	14.3	17.2	22.2	23.8
49	10.5	14.3	17.3	22.6	24.3
50	10.8	14.3	17.2	22.6	24.4
51	10.5	14.4	17.1	21.6	23
52	10.4	14.3	17.3	22.4	24
53	10.3	14.1	17.1	22.2	23.8
54	6.8	9.7	11.6	14.6	15.6
55	10.9	15.1	18.1	22.9	24.3
56	10.7	14.8	17.8	22.8	24.4
57	8.9	12.1	14.3	18.2	19.4
58	10.1	13.7	16.3	20.4	21.6
59	6.9	9.9	11.8	14.9	16
60	10.6	14.5	17.2	21.6	23
61	10.6	14.5	17.5	22.4	24
62	9.6	13.5	16	20.1	21.4
63	10.1	14.1	16.5	20.3	21.5
64	10.3	14.2	16.9	21.2	22.5
65	10.6	14.7	17.6	22.5	24
66	10.6	14.2	17.1	22.4	24.2
67	10.6	14.1	16.8	22	23.8
68	10	13.7	16.5	21.4	23.1
69	9.1	12.7	15.7	20.4	22.2
70	8.5	12	14.9	19.6	21.3
71	8	11.1	13.8	18.5	20.2
72	7.9	11.2	13.7	18.4	20
73	7.5	10.8	13.3	17.7	19.2
74	7	10.3	13.2	17.4	18.8
75	6.9	10.3	14	18.7	20.2
76	9.4	12.2	14.3	17.8	19.1
77	8	11	13.2	16.8	18
78	6.7	9.6	12.1	15.9	17.3
79	5.8	8.7	11.7	15.7	17
80	5.6	8.3	11.7	16.1	17.3

Table 2.9-2.
Wave Height-Frequency Relationships – Without Project

Station Number	Significant Wave Height (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	3.5	4.9	5.9	7.3	7.7
2	1.3	2.7	3.8	6	6.8
3	2.4	3.3	4	5.5	6
4	2	3.4	4.6	7.3	8.1
5	2.8	4.2	5.6	8	8.7
6	2.9	4.6	5.9	8.1	8.8
7	3.4	5.2	6.7	9.1	9.9
8	2.6	4.4	5.7	8	8.7
9	1.8	3.1	4	5.5	6
10	4.4	5.6	6.6	8	8.3
11	2.1	3.2	4.1	6.1	6.5
12	5	6.4	7.5	9.5	10
13	0.2	0.5	0.9	1.3	1.5
14	0.4	0.8	1.3	2.2	2.5
15	2.2	4.1	5.3	7.3	8
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0.1	0.2	0.3	0.6	0.7
21	0.6	1.3	1.9	3.1	3.3
22	4.3	6	7.3	9.5	10.2
23	0.5	1	1.4	2.2	2.6
24	0	0	0	0	0
25	0	0	0	0	0
26	0.8	1.6	2.3	3.4	3.7
27	3.3	4.4	5.6	7.2	7.6
28	0	0	0	0	0
29	0	0	0	0	0
30	4.4	5.8	6.7	8.3	8.9
31	3.8	5.1	6.1	7.4	7.8
32	0.3	0.8	1.3	2.3	2.7
33	2.7	4.4	5.8	7.8	8.5
34	0	0.1	0.1	0.2	0.3
35	0	0	0	0	0
36	0	0	0	0	0
37	0	0	0	0	0
38	0.8	1.2	1.6	2.3	2.7
39	5.1	6.2	7	8.1	8.6
40	1	1.4	1.8	2.6	2.9
41	4.6	6.1	7.2	8.9	9.4
42	5.5	6.7	7.4	8.6	9.1
43	0	0	0	0	0
44	0	0	0	0	0

Table 2.9-2.
Wave Height-Frequency Relationships – Without Project (continued)

Station Number	Significant Wave Height (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
45	0	0	0	0	0
46	4.5	5.5	6.4	8	8.5
47	4.4	5.8	6.5	7.8	8.4
48	0.5	1.1	1.8	4	4.7
49	3.1	4.4	5.6	8.2	8.9
50	0.5	1.8	3.9	7.3	8.5
51	0	0	0	0	0
52	0	0.1	0.1	0.2	0.3
53	0.1	0.2	0.3	0.6	0.7
54	0	0	0	0	0
55	2.7	4	5.3	7.4	8.1
56	3	4.4	5.8	8.4	9.1
57	0	0	0	0	0
58	0	0	0	0	0
59	0	0	0	0	0
60	0.6	1.2	1.8	2.6	3
61	2	3.1	4	5.7	6.3
62	0.5	1.2	1.8	3.8	4.5
63	2.5	4.1	5.5	8.1	9.2
64	3	4.2	5.2	7.6	8.4
65	3.7	5.1	6.3	9	9.8
66	4.2	5.1	6.1	8.4	9.2
67	5.1	6.1	6.7	8.1	8.7
68	4.4	5.5	6.4	8	8.4
69	6.3	7.6	8.4	9.8	10.2
70	5.5	6.9	8	9.6	10.2
71	5	6.1	7	8.3	8.7
72	5.2	6.6	7.7	9.8	10.5
73	4.8	6	6.8	8.3	8.8
74	4.7	6	6.8	8.1	8.4
75	6.4	7.7	9.6	11.3	11.7
76	8.3	9.9	11	13	13.6
77	10.6	12.4	13.6	15.5	16.1
78	10.4	12.2	13.6	16	17
79	11.9	13.6	15.1	17	17.5
80	10	11.5	13.3	15.4	15.9

Table 2.9-3.
Wave Period-Frequency Relationships

Station Number	Peak Wave Period (sec)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	8.4	11.6	13.9	16.3	16.3
2	3.4	6.3	7.9	12.6	14.4
3	3.8	5.1	6.7	9.9	11.1
4	5.5	7.0	8.0	10.2	11.0
5	7.0	9.2	11.1	14.6	14.9
6	6.2	10.1	13.0	15.9	16.3
7	9.5	12.7	14.2	16.3	16.3
8	5.9	8.9	12.1	14.7	15.6
9	6.0	8.3	11.7	14.8	15.6
10	9.5	12.6	14.3	16.3	16.3
11	10.7	13.1	14.9	16.3	16.3
12	11.7	13.0	14.0	14.9	14.9
13	2.3	2.6	3.0	3.5	3.8
14	4.4	5.2	5.8	7.0	7.4
15	5.3	7.5	9.8	13.6	14.6
16	2.2	2.4	2.4	2.4	2.4
17	2.2	2.4	2.4	2.4	2.4
18	2.2	2.4	2.4	2.4	2.4
19	2.2	2.4	2.4	2.4	2.4
20	2.2	2.4	2.6	2.9	2.9
21	2.4	2.8	3.2	4.1	4.5
22	12.1	13.2	14.1	14.9	14.9
23	3.0	3.5	3.9	4.3	4.3
24	2.2	2.4	2.4	2.4	2.4
25	2.2	2.4	2.4	2.4	2.4
26	2.4	2.9	3.3	3.9	4.2
27	8.5	11.6	14.0	16.3	16.3
28	2.2	2.4	2.4	2.4	2.4
29	2.2	2.4	2.4	2.4	2.4
30	5.2	7.1	10.7	14.9	14.9
31	10.4	12.3	13.6	16.1	16.3
32	2.6	3.4	4.3	8.5	11.2
33	10.2	12.7	13.9	16.3	16.3
34	2.2	2.4	2.6	2.9	2.9
35	2.2	2.4	2.4	2.4	2.4
36	2.2	2.4	2.4	2.4	2.4
37	2.2	2.4	2.4	2.4	2.4
38	2.7	3.2	3.7	4.4	4.7
39	11.4	12.8	13.6	15.1	15.6
40	2.5	3.0	3.3	4.0	4.1
41	11.3	12.6	13.5	14.9	15.2
42	11.4	12.8	13.7	15.5	16.0
43	2.2	2.4	2.4	2.4	2.4
44	2.2	2.4	2.4	2.4	2.4

Table 2.9-3.
Wave Period-Frequency Relationships (continued)

Station Number	Peak Wave Period (sec)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
45	2.2	2.4	2.4	2.4	2.4
46	11.4	13.0	14.1	16.3	16.3
47	10.2	12.7	13.9	15.8	16.3
48	2.6	3.4	4.4	6.2	6.8
49	7.1	9.6	11.3	15.5	16.3
50	2.8	6.5	10.3	13.5	13.5
51	2.2	2.4	2.4	2.4	2.4
52	2.4	2.8	3.2	3.8	3.9
53	2.2	2.4	2.6	2.7	2.7
54	0.0	0.0	0.0	0.0	0.0
55	8.0	10.8	12.4	15.3	16.3
56	7.0	8.9	10.3	12.7	13.8
57	2.2	2.4	2.6	2.7	2.7
58	2.2	2.4	2.4	2.4	2.4
59	0.0	0.0	0.0	0.0	0.0
60	2.3	2.8	3.2	3.9	4.2
61	3.7	6.0	7.7	10.8	12.2
62	2.6	3.6	4.9	7.5	8.3
63	5.4	6.7	7.7	9.3	9.9
64	7.0	8.6	10.0	12.0	12.7
65	6.1	7.7	9.0	10.8	11.4
66	6.1	9.7	12.4	14.9	14.9
67	10.7	13.7	14.9	14.9	14.9
68	11.3	12.9	13.9	14.9	14.9
69	11.5	13.2	14.5	16.3	16.3
70	11.3	12.9	14.0	14.9	14.9
71	5.3	8.8	13.1	16.2	16.3
72	5.7	8.9	12.6	14.9	14.9
73	11.6	13.3	14.3	14.9	14.9
74	7.2	10.6	12.9	16.3	16.3
75	12.1	13.9	14.9	14.9	14.9
76	12.4	14.1	15.1	16.3	16.3
77	12.0	13.3	14.3	14.9	14.9
78	12.4	13.8	14.6	14.9	14.9
79	12.7	14.0	14.7	14.9	14.9
80	12.4	13.8	14.6	14.9	14.9

2.9.3.2 Line of Defense 3

The peak water level, maximum wave height, and wave period for the set of storms run with the lines of defense in place were also saved at stations along the coast. The water level at save stations adjacent to the proposed structures was increased by the amount predicted from the Boussinesq modeling. The waves were not calculated for stations behind the proposed line of defense. The

frequency relationships were estimated from the 27 storm subset and methodology discussed in section 2.4.3. The wave periods were not altered by the presence of the line of defense and thus are the same as for the no project condition. The frequency relationships for water level and wave height are provided by save station in Tables 2.9-4 and 2.9-5, respectively.

Table 2.9-4.
Stage-Frequency Relationships – LOD 3

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	8.5	12	15	19.8	21.6
2	10.2	14.3	16.8	21	22.3
3	1.3	1.3	1.5	2.5	2.6
4	1.2	1.2	1.4	1.8	2
5	11.9	15.5	18.3	23.9	25.5
6	9.2	13.2	16.4	21.5	23.4
7	9	12.8	16	21	22.9
8	9.3	13.2	16.3	21.5	23.4
9	1.3	1.3	1.4	1.4	1.5
10	8.1	11.4	14.3	18.9	20.7
11	8.1	11.5	14.3	18.9	20.4
12	8	11.1	14.3	18.5	20
13	8.2	12	14.9	19	20.4
14	7.1	9.9	12.1	16.5	18
15	9.3	13.3	16.4	21.4	23.3
16	2.6	3.2	3.8	4.5	4.8
17	3	4.3	4.9	6.2	6.6
18	4.2	5.6	6.7	8.5	9.3
19	5.6	7.6	9.1	12	13.1
20	6	7.9	9.8	13.1	14.3
21	6.6	9	11.1	14.9	16.3
22	8.2	11.8	14.6	18.8	20.4
23	6	7.9	9.5	12.6	13.7
24	5.8	7.6	9.1	12.1	13.6
25	4.2	5.4	6.5	8	8.1
26	6.5	8.7	10.6	14.1	15.4
27	8.4	11.9	14.6	19.2	20.8
28	1.6	1.7	2	2.3	2.4
29	1.6	1.8	2.2	2.9	2.9
30	8.6	12.2	15	19.6	21.4
31	8.5	12	15	19.8	21.6
32	8.7	12.1	15.3	20.1	22
33	9.1	12.9	16.1	21.2	23.2
34	1.3	1.3	1.4	1.4	1.5
35	1.2	1.9	2	2.2	2.4
36	1.2	1.9	2	2.2	2.4
37	1.3	2	2.1	2.5	2.7
38	1.1	1.3	1.3	1.4	1.4
39	10	14	16.8	21.8	23.7

Table 2.9-4.
Stage-Frequency Relationships – LOD 3 (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
40	1.3	1.6	1.6	1.9	2
41	9.5	13.4	16.3	21.2	23.1
42	9.8	13.8	16.6	21.6	23.5
43	1.5	2.2	2.3	2.9	3.1
44	3	4.5	4.8	6.3	6.4
45	2.3	3.1	3.5	4.7	4.7
46	10.5	14.3	16.9	22.4	24.1
47	11	14.6	17.4	22.9	24.6
48	1.4	1.5	1.6	1.8	2
49	10.9	15.2	18.2	23.8	25.5
50	11	14.5	17.7	23.6	25.6
51	2.2	2.6	3.1	4.6	4.8
52	1.9	2	2.1	2.2	2.3
53	0	0	0.1	0.1	0.1
54	6.9	9.9	11.8	14.9	15.9
55	11.3	15.9	19.2	24.2	25.8
56	11.1	15.7	18.7	24.1	25.7
57	2.1	2.5	2.6	3.5	3.7
58	2.2	2.4	3.4	4.7	4.8
59	7	10.1	12.1	15.3	16.4
60	2.4	3.2	4	5.6	5.8
61	1.1	1.2	1.5	1.8	2
62	0	0	0	0	0
63	10.4	14.5	17.1	21.1	22.3
64	10.6	14.8	17.7	22.4	23.7
65	11	15.4	18.6	23.6	25.1
66	10.9	14.6	17.7	23.2	25
67	10.7	14.3	17.1	22.7	24.3
68	10.1	14	16.6	22	23.6
69	9.2	13	16.1	20.8	22.7
70	8.6	12.3	15.3	20	21.8
71	8	11.4	14.2	18.8	20.6
72	8	11.5	14	18.7	20.3
73	7.5	10.9	13.4	17.9	19.4
74	7	10.4	13.2	17.5	18.9
75	6.9	10.3	14	18.7	20.2
76	9.5	12.2	14.7	18.7	19.8
77	8	11.2	13.3	16.9	18.2
78	6.7	9.6	12.1	16	17.6
79	5.8	8.7	11.7	15.7	17
80	5.6	8.3	11.7	16.1	17.3

Table 2.9-5.
Wave Height-Frequency Relationships – LOD 3

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	3.6	4.9	6.1	7.8	8.3
2	1.4	2.9	4.0	6.2	7.0
5	2.8	4.4	5.9	8.4	9.1
6	3.0	4.8	6.2	8.4	9.1
7	3.5	5.2	6.9	9.7	10.7
8	2.8	4.5	5.9	8.4	9.2
10	4.6	5.7	6.7	8.2	8.6
11	2.1	3.2	4.2	6.4	6.9
12	5.0	6.4	7.5	9.4	9.9
13	0.2	0.5	0.8	1.0	1.1
14	0.4	0.7	1.1	1.8	2.0
15	2.5	4.0	5.6	7.6	8.3
16	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0
20	0.1	0.2	0.3	0.6	0.7
21	0.1	0.8	0.9	0.9	0.5
22	4.3	6.1	7.4	9.6	10.3
23	0.4	0.8	1.1	1.9	2.2
24	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0
26	0.8	1.6	2.4	3.5	3.8
27	4.0	5.1	6.1	7.2	7.4
28	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0
30	4.4	6.0	6.9	8.4	9.0
31	3.9	5.1	6.2	7.6	7.9
32	0.2	0.5	1.0	1.8	2.2
33	2.8	4.5	5.9	7.9	8.6
39	5.1	6.3	7.1	8.2	8.7
41	4.5	5.9	6.2	6.0	5.7
42	5.5	6.8	7.5	8.7	9.2
46	4.6	5.7	6.6	8.2	8.7
47	4.5	6.0	6.6	8.0	8.6
49	3.0	4.6	5.2	8.4	9.3
50	3.0	3.4	4.9	7.7	8.6
54	0.0	0.0	0.0	0.0	0.0
55	2.7	4.2	5.5	7.6	8.3
56	3.1	4.6	6.0	8.7	9.4
59	0.0	0.0	0.0	0.0	0.0
63	2.6	4.1	5.5	7.9	9.0
64	3.0	4.2	5.3	7.8	8.6
65	3.7	5.2	6.5	9.2	10.1

Table 2.9-5.
Wave Height-Frequency Relationships – LOD 3 (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
66	4.3	5.2	6.2	8.6	9.4
67	5.1	6.3	6.8	8.2	8.8
68	4.4	5.6	6.5	8.1	8.5
69	6.3	7.7	8.3	9.4	9.6
70	5.5	7.0	8.1	9.8	10.4
71	5.1	6.0	7.2	8.4	8.7
72	5.2	6.6	7.8	10.0	10.8
73	4.8	5.9	7.0	9.1	9.9
74	4.8	6.0	6.7	7.7	7.9
75	6.5	7.8	9.7	11.4	11.8
76	8.3	9.9	10.9	12.7	13.2
77	10.7	12.4	13.6	15.5	16.1
78	10.2	12.2	13.3	15.0	15.7
79	11.9	13.6	15.1	16.8	17.2
80	10.0	11.4	13.3	15.7	16.4

2.9.3.3 Line of Defense 4

The frequency relationships for line of defense 4 were also estimated from the 27 storm subset and methodology discussed in section 2.4.3. The waves were not calculated for stations behind the proposed line of defense. The wave periods were not altered by the presence of the line of defense and thus are the same as for the no project condition. The frequency relationships for water level and wave height are provided by save station in Tables 2.9-6 and 2.9-7, respectively.

Table 2.9-6.
Stage-Frequency Relationships – LOD 4

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	8.2	11.6	14.6	19.4	21.1
2	10.2	14.2	16.8	20.7	22
3	1.2	1.2	1.4	2.3	2.4
4	1.2	1.2	1.3	1.3	1.4
5	11.9	15.5	18.2	23.8	25.4
6	9.1	13.1	16.4	21.5	23.4
7	9	12.8	16	21	22.9
8	9.3	13.2	16.3	21.5	23.4
9	1.2	1.2	1.3	1.3	1.4
10	8.1	11.4	14.3	18.9	20.7
11	7.7	11.2	13.9	18.5	19.7
12	7.5	10.9	13.7	18	19.3
13	7.6	11.4	14	18.4	19.8
14	7.1	9.9	12.1	16.5	18
15	9.2	13.2	16.4	21.4	23.3

Table 2.9-6.
Stage-Frequency Relationships – LOD 4 (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
16	2.6	3.2	3.8	4.5	4.8
17	3.2	4.2	4.8	6.1	6.5
18	4.2	5.5	6.6	8.5	9.3
19	5.6	7.4	9	11.8	13.1
20	5.9	7.9	9.7	13	14.3
21	6.4	8.7	10.8	14.6	16
22	7.7	11.2	14	18.3	19.9
23	5.8	7.7	9.4	12.5	13.7
24	5.7	7.5	9	12	13.5
25	5.2	6.6	8	9.7	9.8
26	6.3	8.5	10.4	13.9	15.2
27	8.1	11.4	14.2	18.9	20.5
28	1	1	1.1	1.1	1.1
29	0.8	0.8	0.8	0.9	0.9
30	8.2	11.7	14.6	19.2	20.9
31	8.2	11.6	14.6	19.4	21.1
32	8.7	12.2	15.3	20.2	22.1
33	9.1	13	16.3	21.3	23.3
34	1.2	1.2	1.2	1.3	1.3
35	1.2	1.9	2	2.2	2.4
36	1.2	1.9	2	2.2	2.4
37	1.3	2	2.1	2.5	2.7
38	1	1.2	1.2	1.2	1.2
39	10	14	16.9	22	23.9
40	1.3	1.6	1.6	1.8	1.9
41	9.5	13.6	16.6	21.3	23.3
42	9.8	13.9	16.9	21.9	23.8
43	1.5	2.4	2.5	2.9	3.1
44	3	4.4	4.8	6.4	6.4
45	2.3	3.1	3.5	4.6	4.7
46	10.5	14.4	17	22.7	24.4
47	11	14.7	17.6	23.2	24.9
48	1	1.4	1.4	1.4	1.4
49	10.9	15.3	18.2	23.9	25.7
50	11.3	14.7	18.1	24.4	26.2
51	2.2	2.6	3.1	4.6	4.8
52	1.5	1.5	1.5	1.6	1.7
53	0	0	0.1	0.1	0.1
54	6.9	9.9	11.8	14.9	15.9
55	11.3	16	19.2	24.4	25.9
56	11.1	15.8	18.8	24.3	25.9
57	2.1	3	3.2	3.5	3.7
58	2.2	2.4	3.4	4.7	4.8
59	7	10.1	12.1	15.3	16.4

Table 2.9-6.
Stage-Frequency Relationships – LOD 4 (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
60	2.4	3.3	4	5.6	5.8
61	1.3	1.3	1.4	1.4	1.4
62	9.7	13.8	16.4	20.7	22.1
63	10.4	14.5	17	21	22.3
64	10.6	14.7	17.6	22.3	23.6
65	10.9	15.4	18.5	23.6	25.1
66	10.8	14.6	17.6	23.2	25
67	10.8	14.3	17.1	22.7	24.3
68	10.1	14	16.6	22	23.6
69	9.2	13	16.1	20.8	22.7
70	8.6	12.3	15.3	20	21.8
71	8	11.4	14.2	18.8	20.5
72	8	11.5	14	18.6	20.2
73	7.5	10.9	13.4	17.9	19.4
74	7	10.4	13.2	17.5	18.9
75	6.9	10.3	14	18.7	20.2
76	9.5	12.2	14.7	18.6	19.8
77	8	11.2	13.3	16.9	18.2
78	6.7	9.6	12.1	15.9	17.1
79	5.8	8.7	11.7	15.7	17
80	5.6	8.3	11.7	16.1	17.3

Table 2.9-7.
Wave Height-Frequency Relationships – LOD 4

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	3.6	4.9	6.1	8	8.6
2	1.3	2.9	4	6.3	7.1
5	2.8	4.3	5.7	8.1	9
6	3	4.8	6.2	8.7	9.5
7	3.4	5.2	6.9	9.7	10.7
8	2.8	4.5	6.2	9.4	10.5
10	4.6	5.7	6.8	8.5	9
11	2.1	3.2	4.2	6.4	6.9
12	4.8	6.2	7.2	9.1	9.6
13	0.1	0.3	0.5	0.8	1
14	0.2	0.7	1.1	1.8	2
15	2.4	4	5.5	7.8	8.6
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0.1	0.2	0.3	0.6	0.7

Table 2.9-7.
Wave Height-Frequency Relationships – LOD 4 (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
21	0.3	1	1.6	2.8	3
22	4.3	6.1	7.4	9.6	10.3
23	0.3	1	1.3	1.7	2
24	0	0	0	0	0
25	0	0	0	0	0
26	0.8	1.6	2.4	3.5	3.8
27	3.8	5	6	7.1	7.2
28	0	0	0	0	0
29	0	0	0	0	0
30	4.4	6	6.8	8.2	8.7
31	3.9	5.1	6.3	7.7	8.1
32	0.2	0.4	0.7	1	1.9
33	2.9	4.5	6	8.2	9
39	5.1	6.3	7.1	8.3	8.8
41	5.1	7.1	7.5	7.5	7.3
42	5.5	6.8	7.5	8.7	9.2
46	4.5	5.5	6.6	8.2	8.7
47	4.5	6	6.3	8	8.6
49	3.1	4.6	5.7	8.4	9.2
50	0.5	1.9	4.1	7.6	8.9
54	0	0	0	0	0
55	2.7	4.2	5.5	7.5	8.1
56	3	4.5	6	8.6	9.4
59	0	0	0	0	0
62	0.5	1.3	1.9	4	4.7
63	2.6	4.2	5.6	8.1	9.2
64	3	4.2	5.3	7.8	8.6
65	3.7	5.1	6.4	9.2	10.1
66	4.4	5.1	6.1	8.5	9.3
67	5.1	6.3	6.8	8.2	8.8
68	4.4	5.6	6.6	8.3	8.8
69	6.4	7.7	8.4	9.7	10.1
70	5.5	7	8.1	9.6	10.2
71	5.1	6	7.3	8.7	9.2
72	5.2	6.6	7.8	10.1	10.9
73	4.8	5.9	6.7	8.2	8.7
74	4.8	6.1	6.8	7.9	8.2
75	6.5	7.8	9.7	11.4	11.8
76	8.3	9.9	10.9	12.7	13.2
77	10.7	12.3	13.7	16.1	16.9
78	10.3	12.2	13.3	15	15.7
79	11.9	13.6	15.1	17	17.5
80	10	11.3	13.2	15.5	16.1

2.10 Barrier Island Sensitivity

Topography, landscape features, and vegetation have the potential to reduce storm surge elevations. Land elevations greater than the storm surge elevation provide a physical barrier to the surge. Landscape features (e.g., ridges and barrier islands) even when below the surge elevation have the potential to create friction and slow the forward speed of the storm surge. The barrier islands serve as the first line of defense for the Mississippi coast. The purpose of this section is to document a sensitivity study of various barrier island configurations to qualitatively assess the impact of barrier island restoration on storm surge at the mainland coast for storms of varying intensities.

The barrier island sensitivity study was conducted on a grid consistent with that applied for the Interagency Performance Evaluation Team (IPET) study. The analysis provides valuable information on trends and relative performance but one should be cautious about making quantitative assessments of surge reduction. It should be noted that the analysis does not consider the morphologic changes to the barrier islands caused by erosion that occur during a storms passage. The analysis also does not consider changes in the structure of the hurricane itself due to landfall infilling phenomenon that may be influenced by landscape features such as barrier islands.

2.10.1 Storm Suite

Eleven storms were identified for evaluating storm surge response to changes in barrier island configuration: two historical storms and nine hypothetical storms (Table 2.10-1). The two historical storms, Camille and Katrina, were selected because those hurricanes did in fact make landfall on the Mississippi coast in 1969 and 2005, respectively. A suite of storms making landfall on the Mississippi coast were also designed and selected for simulation. The first hypothetical storm (HST001) was designed to produce a 22 ft surge potential seaward of the barrier islands on the Mississippi coast. The storm had a central pressure of 890 mb and a radius to maximum winds of approximately 11 nm, that of Hurricane Camille. Two additional storms were defined by scaling HST001 to produce storms with a surge potential of 13 ft seaward of the barrier islands (HST002) and a surge potential of 8 ft (HST003). The hypothetical storms followed the Katrina track (both geographically and temporally), but were shifted eastward to make landfall at the three locations shown in Figure 2.10-1.

Table 2.10-1.
Barrier Island Sensitivity Storm Suite

Storm Number	Storm Name	Track	Barrier Island Configuration
1	Katrina	Historical	Post-Katrina
			Restored-High
2	Camille	Historical	Post-Katrina
			Restored-High
3	HST001-04	04	Post-Katrina
			Restored-High
			Restored-Low
4	HST003-04	04	Post-Katrina
			Restored-High
5	HST001-06	06	Post-Katrina
			Restored-High
			Restored-Low
6	HST003-06	06	Post-Katrina
			Restored-High
7	HST002-04	04	Post-Katrina
			Restored-High

Table 2.10-1.
Barrier Island Sensitivity Storm Suite (continued)

Storm Number	Storm Name	Track	Barrier Island Configuration
8	HST002-06	06	Post-Katrina
			Restored-High
9	HST001-05	05	Post-Katrina
			Restored-High
			Restored-Low
10	HST002-05	05	Post-Katrina
			Restored-High
11	HST003-05	05	Post-Katrina
			Restored-High

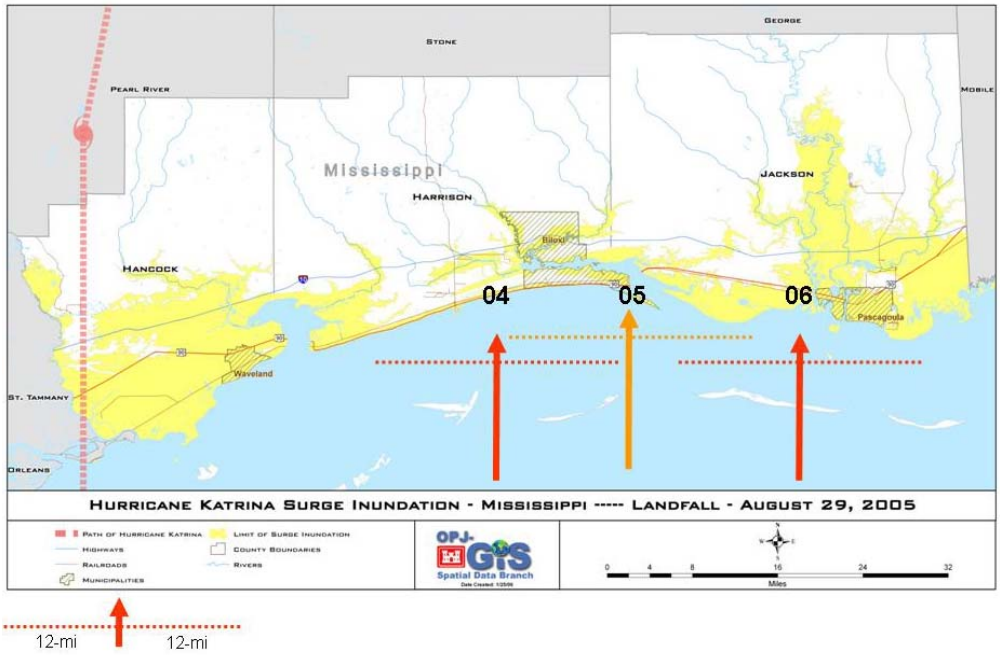


Figure 2.10-1. Hypothetical Storm Tracks

2.10.2 Barrier Island Configuration

The sensitivity storm suite consisting of the eleven storms described in Section 2.10.1 was used to simulate storm surge on three barrier island configurations. The barrier island configurations modeled were: 1) the existing Post-Katrina degraded condition (elevations ranging from approximately 2 to 6 ft (NAVD88 2004.65)); 2) a Restored-Hight barrier island configuration with an extended (pre-Camille) footprint and an elevation of 20 ft NAVD88 2004.65; and 3) a Restored-Low configuration with a footprint representative of the islands pre-Katrina and elevations ranging from approximately 5 to 10 ft (NAVD88 2004.65). The Restored-High configuration represents a massive barrier island configuration that would be difficult to achieve and was modeled for sensitivity purposes. The Restored-Low is a more likely restoration scenario with pre-Katrina footprints and heights of 10 ft or less. Figures 2.10-2 shows the topography of each of the five Mississippi barrier islands for the Post-Katrina and the Restored condition. Note that for the Restored-High condition, the gaps in Ship Island and Dauphin Island have been repaired to the pre-Camille configuration. Bathymetry for the Post-Katrina degraded condition was derived from a SHOALS air-borne LIDAR

survey taken in September/October 2005. Figure 2.10-3 shows the difference between the Restored-Low and Post-Katrina conditions.

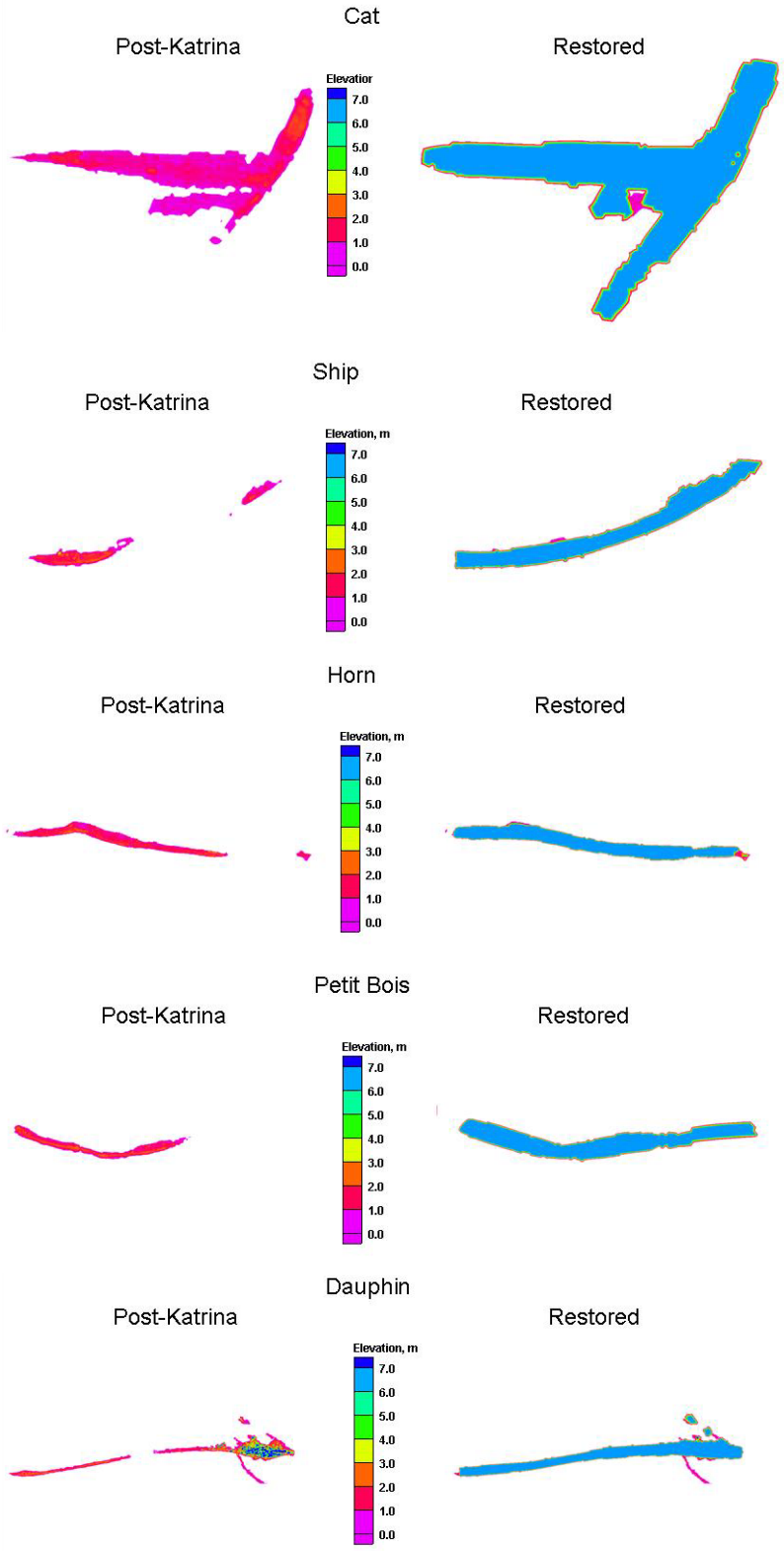


Figure 2.10-2. Mississippi barrier island Post-Katrina and Restored-High configurations

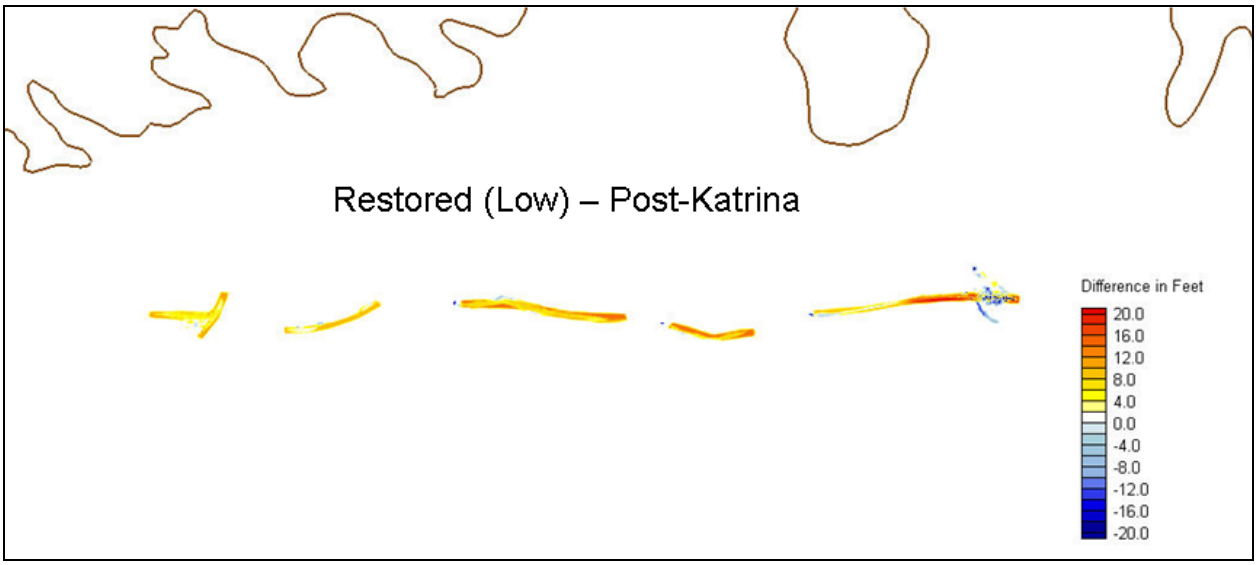


Figure 2.10-3. Difference between Restored-Low and Post-Katrina Mississippi barrier island configurations

The entire eleven storm suite was simulated on the Post-Katrina and Restored-High grids. Storms HST001-04, HST001-05, and HST001-06 were also simulated on the Restored-Low grid (see Table 2.10-1).

2.10.3 Results

Peak water level maps for each of the 11 storms simulated on the existing Post-Katrina configuration were compared to the same storms simulated on the Restored-High barrier island configuration; and the three storms simulated on the Restored-Low configuration were also compared to Post-Katrina. In general, raising the barrier islands caused a decrease in peak water level landward of the barrier islands when compared to the peak water level for the baseline Post-Katrina configuration and an increase in peak water level seaward of the barrier islands. Table 2.10-2 shows the peak water levels for each simulation with Post-Katrina and the Restored-High barrier island configurations. Reduction in the peak water level landward of the barrier islands is as much as 10 ft.

Table 2.10-2.
Peak Water Level for Barrier Island Sensitivity Storms

		Peak Water Level, ft					
		Waveland		Biloxi		Pascagoula	
Storm Name	Track	Post-Katrina	Restored	Post-Katrina	Restored	Post-Katrina	Restored
Katrina	Historical	26-28	26-28	20	18	16	12
Camille	Historical	28	26	22	20	12	10
HST001-04	04	8-12	8-10	40	35	28	18
HST003-04	04	6	6	14	13	6	6
HST001-06	06	3	3	8	8	40	31
HST003-06	06	2	2	6	6	12	6
HST002-04	04	8	6	24	20	14	9
HST002-06	06	2	2	8	6	16	14
HST001-05	05	3	3	24	22	32-33	26-27
HST002-05	05	3	3	18	14	16	11
HST003-05	05	2	2	12	10	7	6

For the purposes of discussion and comparison, Figures 2.10-4 through 2.10-12 show peak water levels for simulations of Hurricane Katrina, HST001-05, HST002-05, HST003-05 storms for both the Post-Katrina and Restored-High barrier island configurations and HST001-05 for the Restored-Low configuration. Peak water levels for Hurricane Katrina show maximum water levels of approximately 26-28 ft for the Waveland area for both the Post-Katrina and Restored-High barrier island configurations (Figures 2.10-4 and 2.10-5). This area of maximum water level is west of all barrier islands that protect the Mississippi coast, therefore little change is observed in this region when the barrier islands are raised. Peak water levels near Biloxi are approximately 20 ft for Post-Katrina and 18 ft for the Restored condition. This area is afforded 1-2 ft of surge protection from the raised Ship and Horn Islands. Further to the east, water levels in Pascagoula are reduced from 12-16 ft to 10-12 ft with the presence of the raised Horn, Petit Bois, and Dauphin Islands. Note that the barrier islands are completely inundated for the Post-Katrina configuration and remain dry for the Restored-High barrier island configuration.

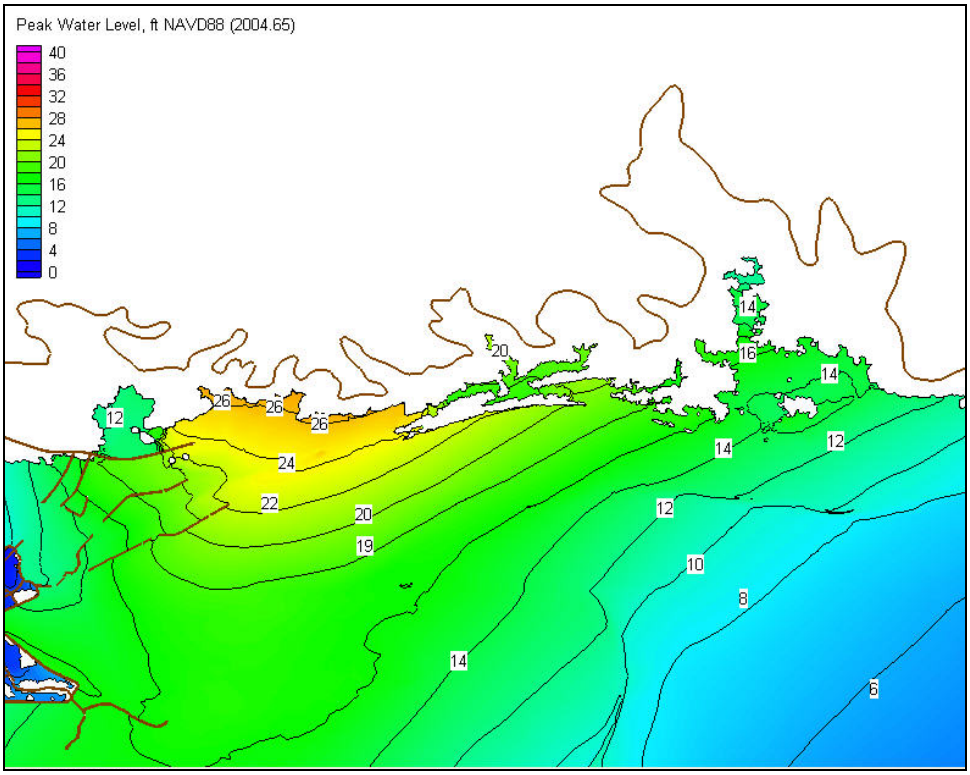


Figure 2.10-4. Katrina peak storm surge with waves; Post-Katrina configuration

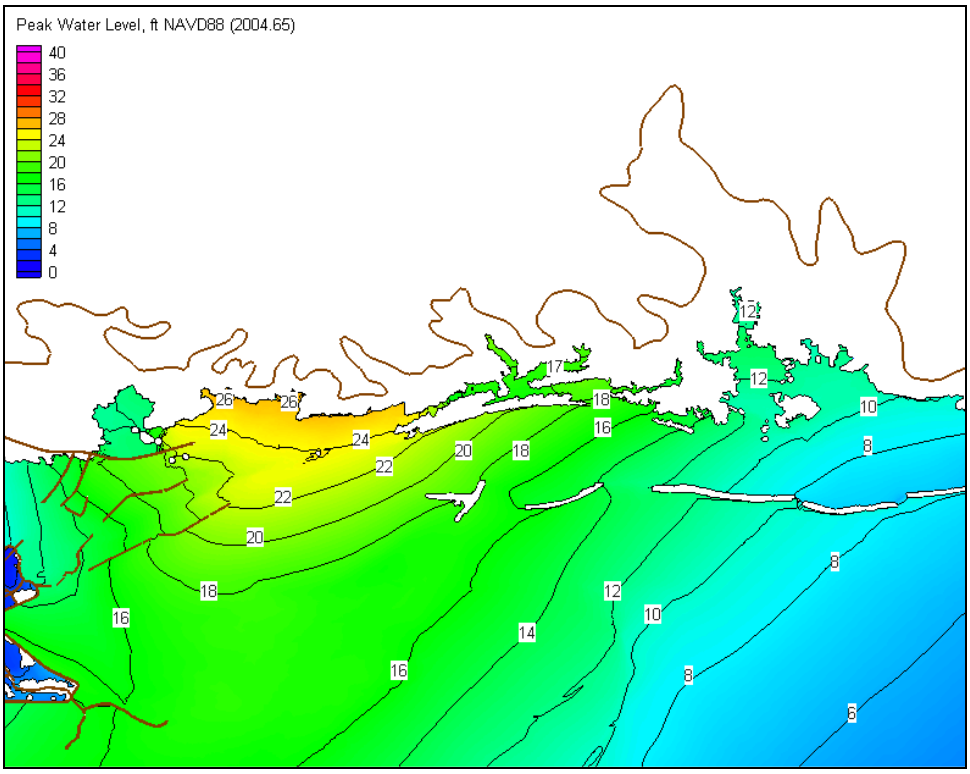


Figure 2.10-5. Katrina peak storm surge with waves; Restored-High configuration

Peak water levels for the HST001-05 storm are higher than the Hurricane Katrina water levels, with the greatest inundation levels in Biloxi and Pascagoula (Figures 2.10-6 to 2.10-8). Post-Katrina peak water levels are 32-33 ft and extend well into the Pascagoula basin with water levels of 24-26 ft. Peak water levels are a maximum of 26-27 ft for the Restored-High barrier island configuration and are 28-30 ft for the Restored-Low. The water levels up the Pascagoula basin reach 18 ft for the Restored-High barrier island configuration and reach 22 ft for the Restored-Low. Water levels at the entrance to Biloxi Bay are 22-24 ft for Post-Katrina, 20-22 ft with the Restored-High barrier islands, and 22-24 ft for the Restored-Low. Water levels seaward of the raised barrier islands are elevated compared to the Post-Katrina barrier islands. That is, the raised barrier islands effectively block some of the surge and it piles up seaward of the islands. Water levels near St. Louis Bay are nearly identical with and without raised barrier islands.

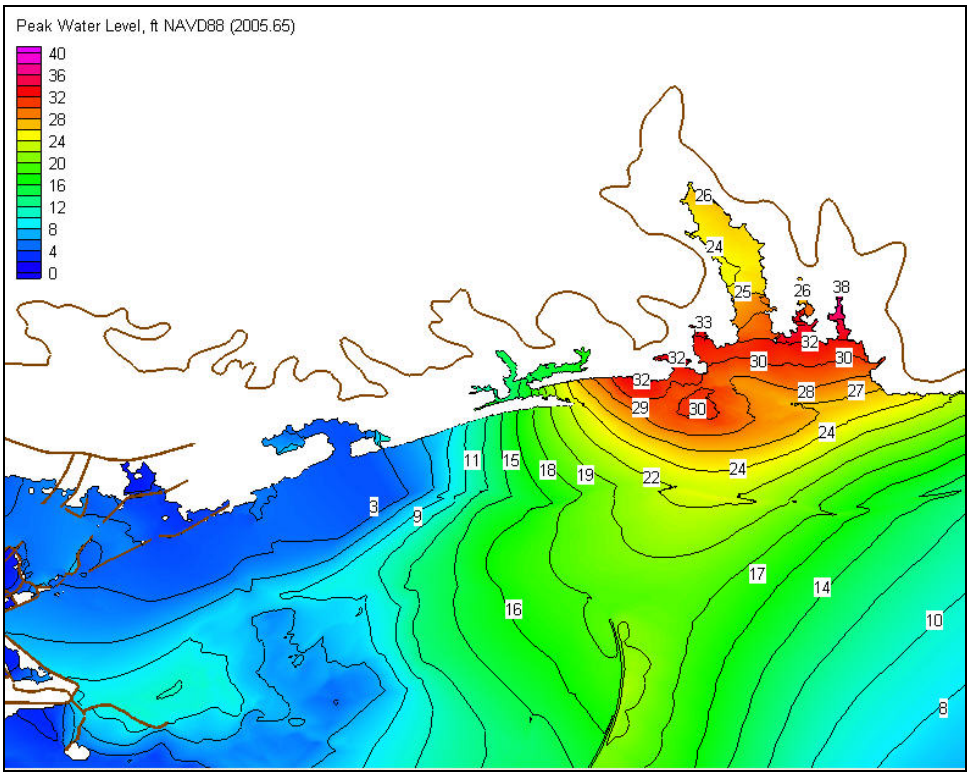


Figure 2.10-6. HST001-05 peak storm surge; Post-Katrina configuration

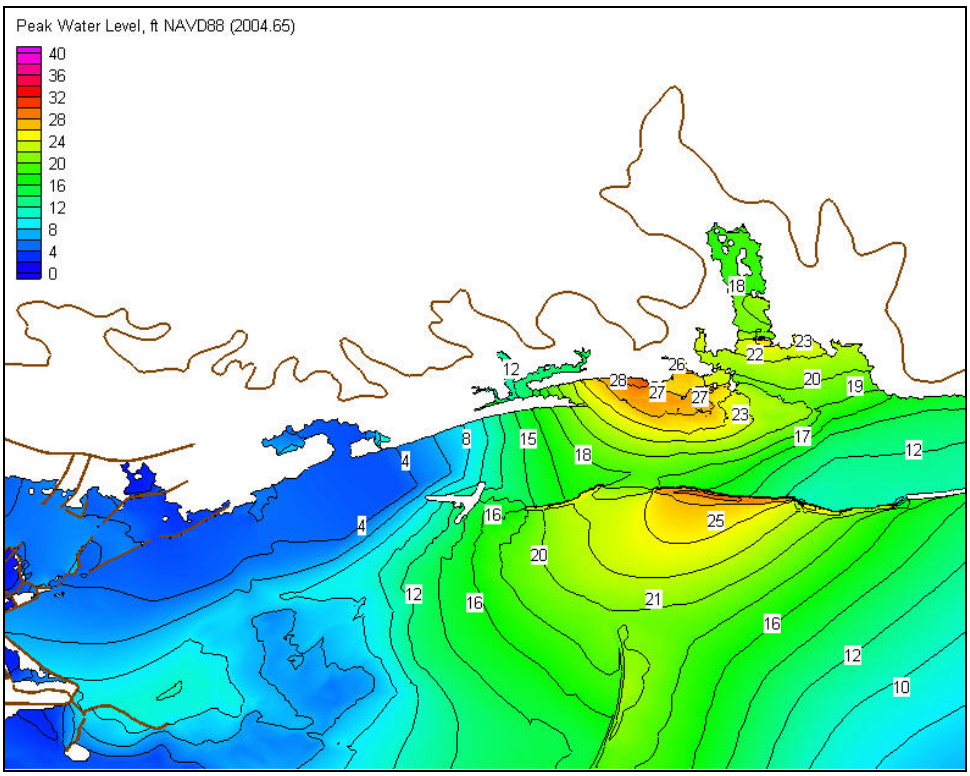


Figure 2.10-7. HST001-05 peak storm surge; Restored-High configuration

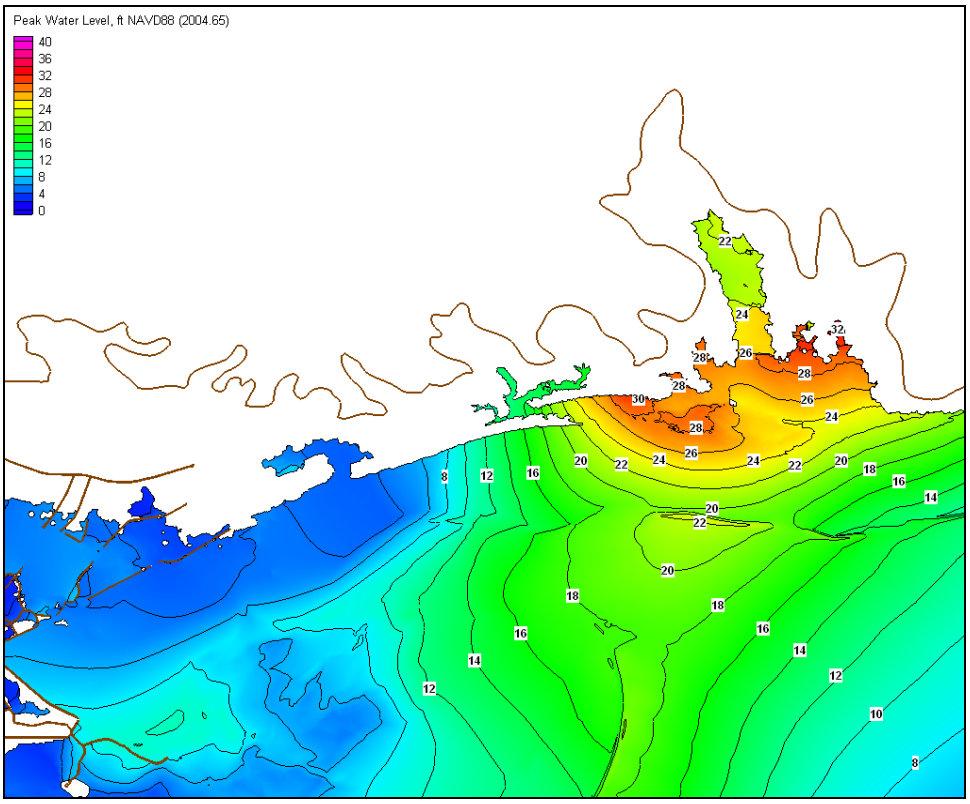


Figure 2.10-8. HST001-05 peak storm surge; Restored-Low configuration

Peak water levels for the HST002-05 storm (Figures 2.10-9 and 2.10-10) are less than the HST001-05 water levels, as expected. The general geographical area of maximum surge however is in the same location (Biloxi and Pascagoula). Peak water levels for the Post-Katrina barrier islands are 14-16 ft in Pascagoula and 16-18 ft near Biloxi. Penetration distance into the Pascagoula basin for the less intense storm is less, as expected. Peak water levels for the Restored-High barrier islands are 10-11 ft in Pascagoula and 14 ft at Biloxi. Water levels seaward of the raised barrier islands are elevated compared to the Post-Katrina barrier islands. Note that even for the 13 ft surge potential storm, the barrier islands are I inundated for the Post-Katrina configuration and remain dry for the Restored barrier island configuration.

Peak water levels for the HST003-05 storm (Figures 2.10-11 and 2.10-12) are less than the HST001-05 and HST002-05 water levels, as expected. The penetration distance into the Pascagoula basin is shorter and peak water levels are only 5-7 ft. Water levels at the entrance to Biloxi Bay are 10-12 ft for the Post-Katrina configuration and 10 ft for the Restored-High barrier islands. The difference between the Post-Katrina and Raised-High barrier island peak surges level is approximately 1-2 ft. Surge build-up seaward of the raised barrier islands is observed near Ship and Horn Islands and the barrier islands are still inundated for the Post-Katrina configuration for the 8 ft surge potential storm.

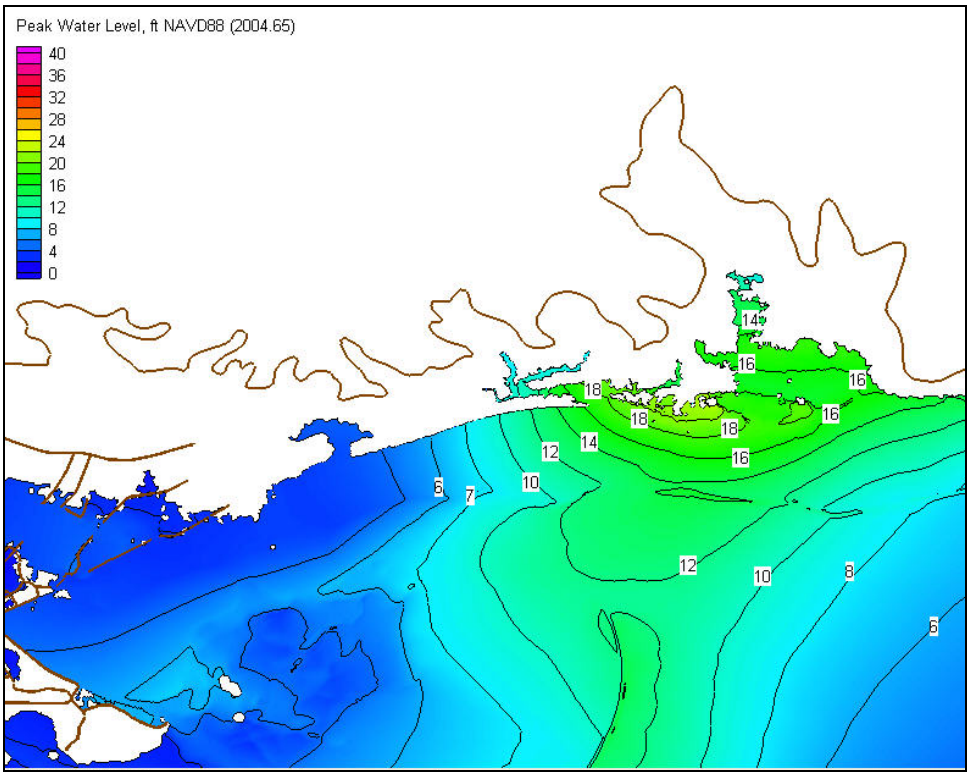


Figure 2.10-9. HST002-05 peak storm surge; Post Katrina configuration

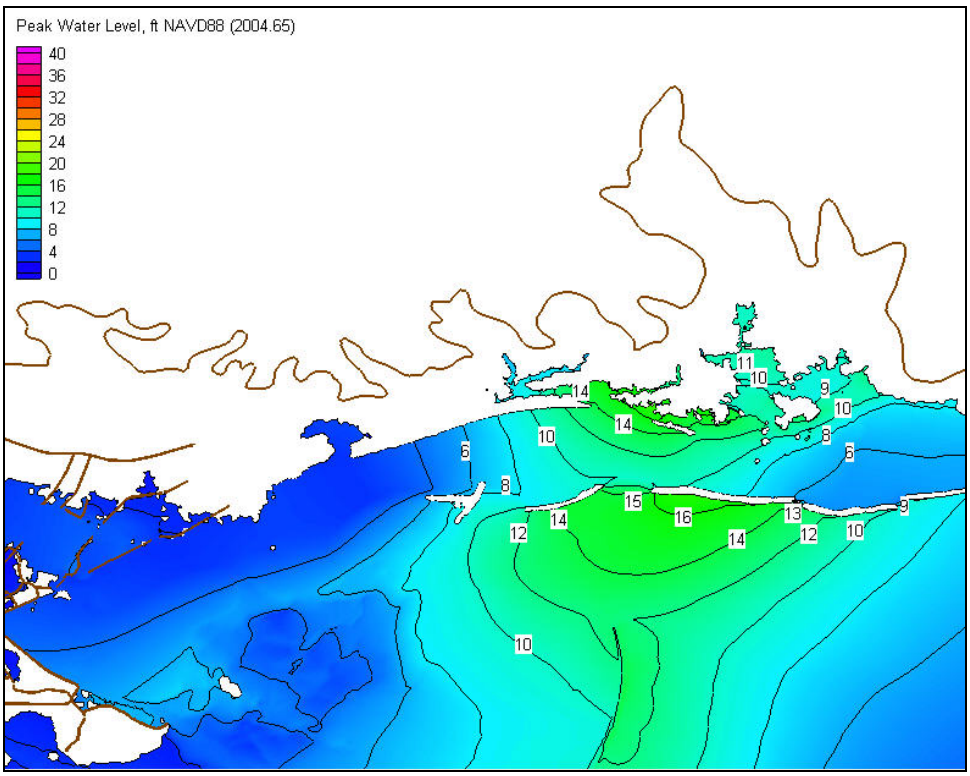


Figure 2.10-10. HST002-05 peak storm surge; Restored-High configuration

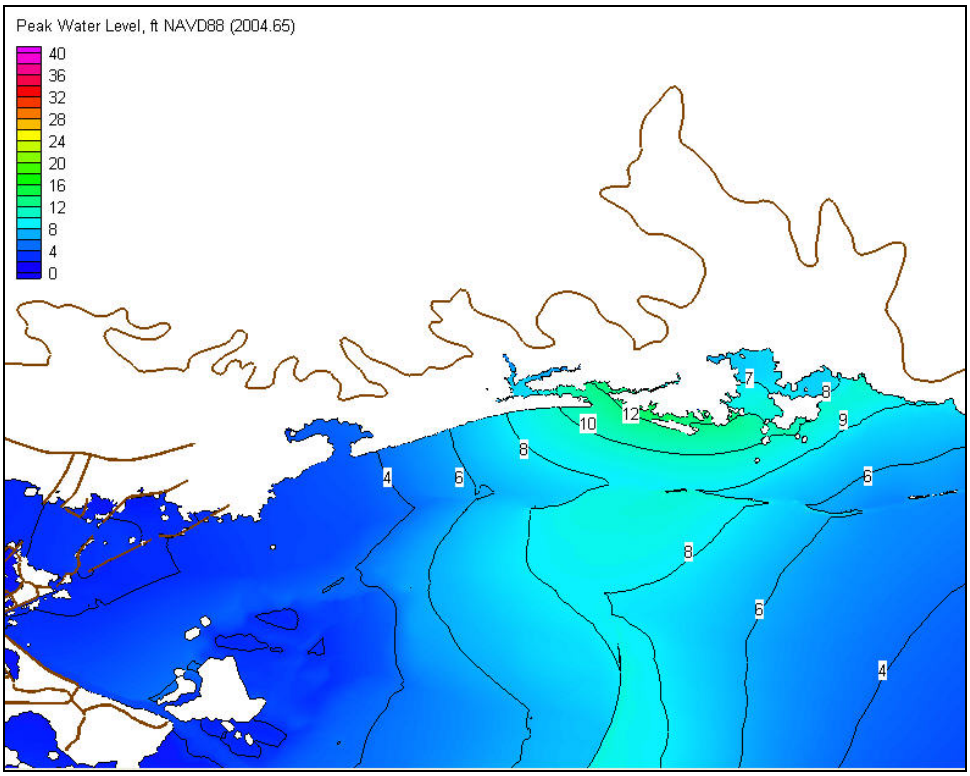


Figure 2.10-11. HST003-05 peak storm surge; Post-Katrina configuration

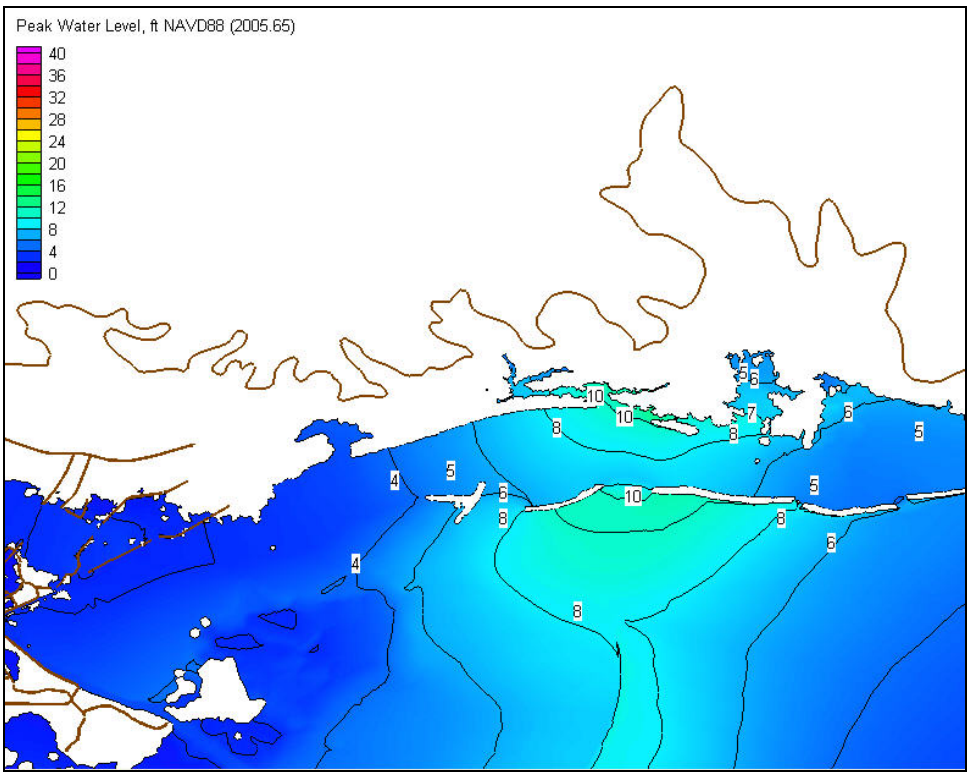


Figure 2.10-12. HST003-05 peak storm surge; Restored-High configuration

The difference in Hurricane Katrina peak water levels for the Restored-High barrier islands versus the Post-Katrina barrier islands (Figure 2.10-13) shows a reduction in water level of 1.0 to 3.5 ft landward of the barrier islands and an increase in water level of less than 1 ft seaward of the barrier islands. The most significant change in water level is in the Pascagoula basin where water levels are reduced 1-3 ft. Note that the area of maximum water level for Hurricane Katrina is in Waveland, which is west of all barrier islands that protect the Mississippi coast. Therefore, little change in peak water level (less than 0.5 ft) is observed in this region when the barrier islands are raised. Peak water levels near Biloxi are approximately 20 ft for Post-Katrina and 18 ft for the Restored-High condition. This area is afforded 1-2 ft of surge protection from the raised Ship and Horn Islands. Further to the east, water levels in Pascagoula are reduced from 12-16 ft to 10-12 ft with the presence of the raised Horn, Petit Bois, and Dauphin Islands. The percent reduction in peak water level landward of the barrier islands is greatest in the eastern part of the state (behind Horn and Petit Bois islands) and decreases to the west. Surge reductions were approximately 20% in the Pascagoula area, 5 to 10% in the central part of the state, and less than 5% in Waveland. Similar percent reductions in surge were calculated for Hurricane Camille.

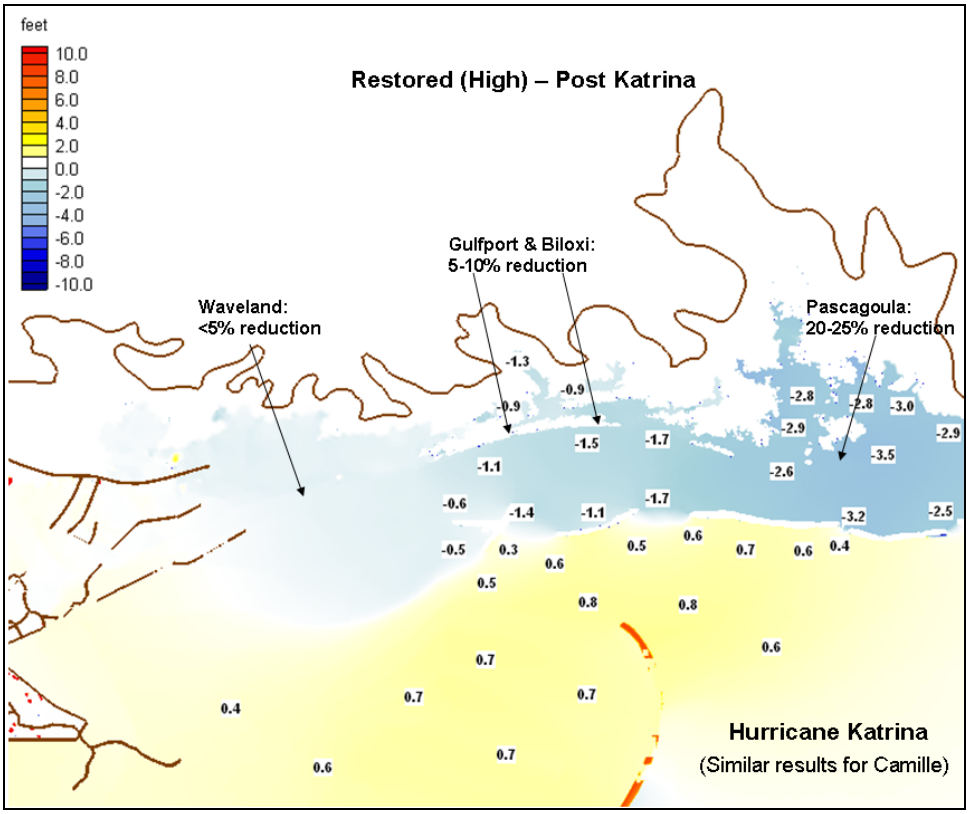


Figure 2.10-13. Difference in peak surge (Restored-High – Post Katrina) for Hurricane Katrina

A greater change in water level from the Post-Katrina to the Restored-High barrier island configuration was observed for the HST001-05 (Figure 2.10-14). HST001-05 made landfall at Biloxi and maximum water levels are observed east of the landfall point, where hurricane winds are strongest. This track passes between Ship and Horn Islands, therefore restoring Horn Island causes a major buildup of surge seaward of this island. Water levels landward of the barrier islands are greatly reduced for the Restored-High barrier island configuration. Post-Katrina flooding extends well into the Pascagoula basin. Water levels are 6-8 ft less in Pascagoula and 2-3 ft less near Biloxi for the Restored-High barrier island configuration. Seaward of the barrier islands surge levels increase 2-4 ft for the Restored-High barrier island configuration. The percent reduction in peak water level

landward of the barrier islands is greatest in the eastern part of the state (behind Horn and Petit Bois islands) and decreases to the west. Surge reductions were approximately 20-40% in the Pascagoula area, 5 to 15% in the central part of the state, and less than 5% in Waveland. Similar percent reductions in surge were calculated for other tracks.

A much smaller change in water level is observed between the Post-Katrina and Restored-Low barrier island configurations (Figure 2.10-15). Water level reductions are cut in half relative to the high restoration with 3-4 ft less surge compared to Post-Katrina in Pascagoula and 0-2 ft less in the central part of the state. The percent reduction in peak water level landward of the barrier islands is again greatest in the eastern part of the state (behind Horn and Petit Bois islands) and decreases to the west. However, surge reductions are approximately 10% or less coast –wide. Similar percent reductions in surge were calculated for other tracks.

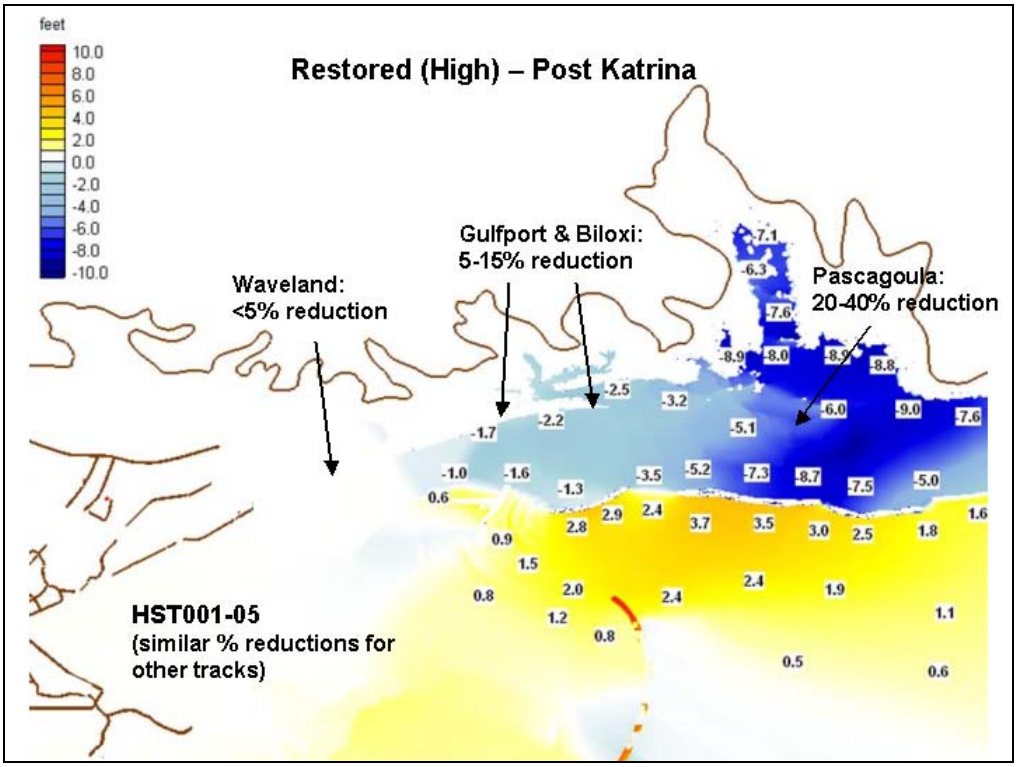


Figure 2.10-14. Difference in peak surge water level (Restored-High – Post Katrina) for HST001-05

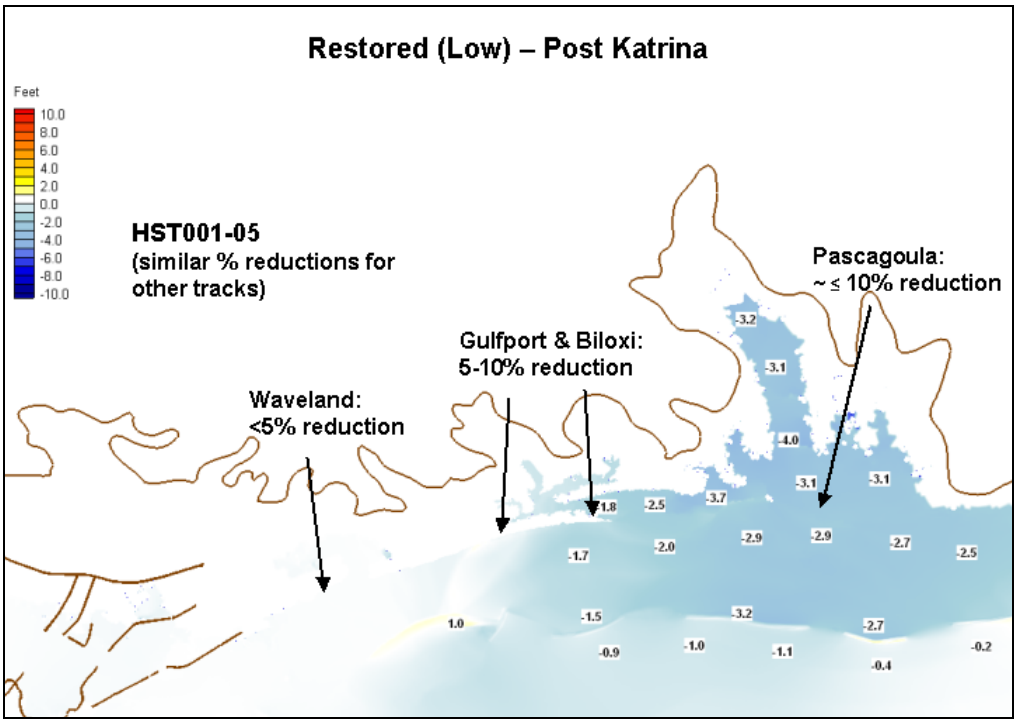


Figure 2.10-15. Difference in peak surge water level (Restored-Low – Post Katrina) for HST001-05

For HST002-05, the difference in the peak water level for the Restored-High barrier island configuration versus the Post-Katrina shows that water levels landward of the barrier islands are reduced 5-6 ft (Figure 2.10-16). Note that the inundation was less for the 13 ft surge potential storm compared to the 22 ft surge potential storm and the reduction in water level is also less for the weaker storm. Reduction in water level with the Restored-High barrier islands is most significant in Pascagoula (5-6 ft) and Biloxi (3 ft). Increased water level seaward of the barrier islands is most significant near Horn Island, but the build up is not as intense as for HST001-05. The percent reduction in surge was greatest for this storm.

With HST003-05, peak water levels were only 10-12 ft at the entrance to Biloxi Bay for the Post-Katrina barrier islands and 10 ft with the Restored-High barrier islands. The difference in peak water level for the Restored-High versus Post-Katrina barrier island configurations shows the protection afforded by the raised barrier islands is 1 to about 2.5 ft at the coast (Figure 2.10-17). The general pattern/area that is protected by the raised barrier islands is still the Pascagoula (~2 ft) and Biloxi (~1.5 ft) areas and surge build-up is observed seaward of Horn Island (~1 ft).

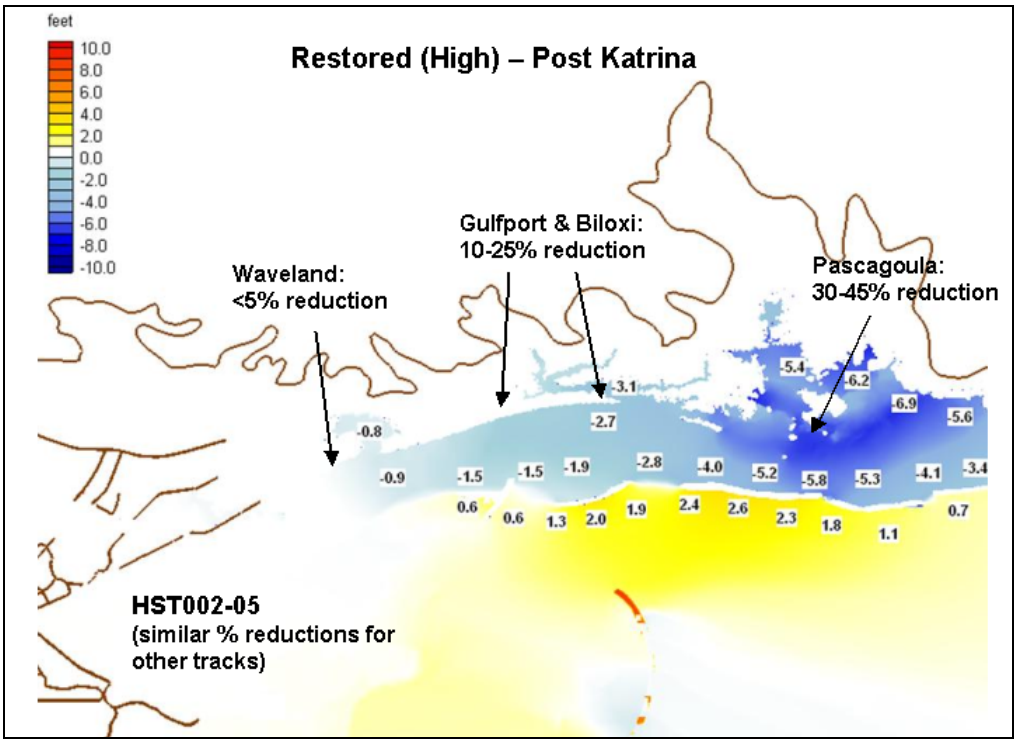


Figure 2.10-16. Difference in peak surge water level (Restored-High – Post Katrina) for HST002-05

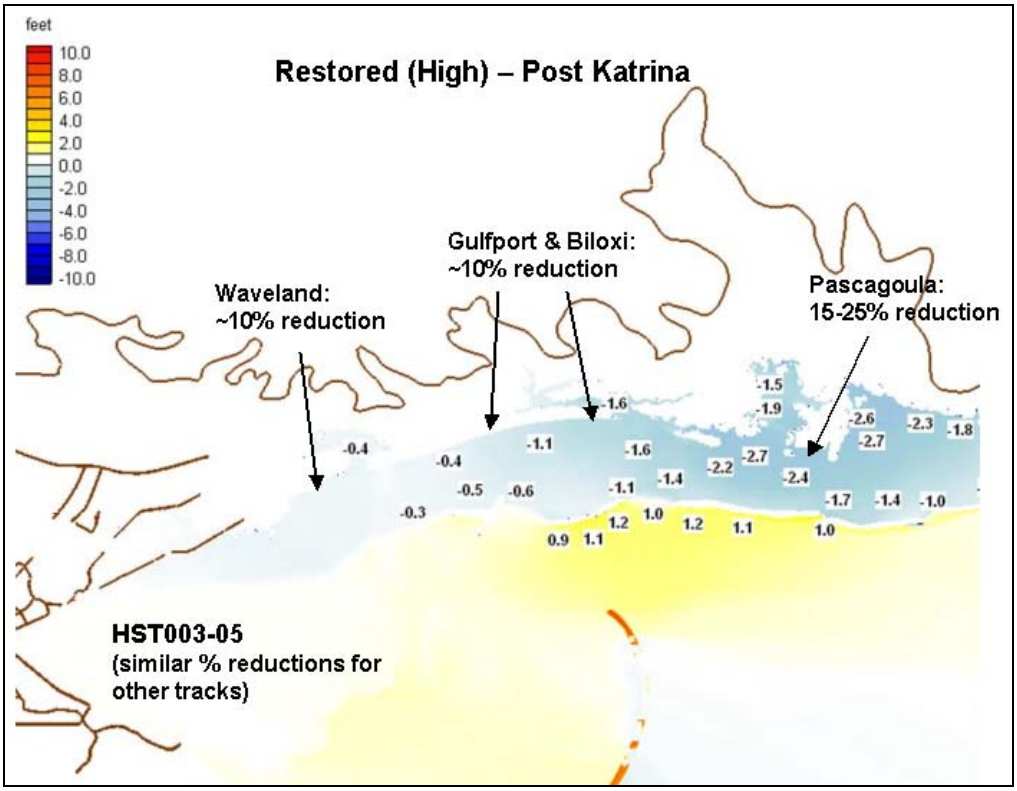


Figure 2.10-17. Difference in peak surge water level (Restored-High – Post Katrina) for HST003-05

2.10.4 Summary

The model results indicate that the barrier islands do provide some level of protection for most of the Mississippi coast, and that restoration of the islands will reduce surges at the mainland coast. The higher and greater in planform extent the islands are, the greater amount of protection the islands provide. The barrier islands do not significantly reduce surges in Hancock County and the surge reductions increase moving from west to east, with the greatest reductions in Jackson County. While model results showed that surge in Jackson County was reduced by as much as 40% for the Restored-High configuration, this represents a massive barrier island configuration that would be difficult to achieve. The Restored-Low is a more likely restoration scenario with pre-Katrina footprints and heights of 10 ft or less, the percent reduction in Jackson County for this configuration was much less at approximately 10%.

2.11 Wetlands, Landscape Features, and Storm Surge

Topography, landscape features, and vegetation have the potential to reduce storm surge elevations. Land elevations greater than the storm surge elevation provide a physical barrier to the surge. Landscape features (e.g., ridges and barrier islands) and vegetation (e.g., maritime forests and wetlands) are typically below the surge elevation, but they have the potential to create friction and slow the forward speed of the storm surge. The surge then has time to dissipate offshore and alongshore, reducing inland surge elevations. The purpose of this section is to present a literature review that documents studies that have measured and modeled storm surge elevations with the goal of understanding how landscape features and vegetation modify the surge elevation. A sensitivity study of a degraded and restored Biloxi marsh utilizing the modeling tools applied for this study is also presented. Sensitivity to barrier islands is discussed in Section 2.10.

2.11.1 Literature Review

The purpose of this literature review is to document studies that have measured storm surge elevations with the goal of understanding how landscape features and vegetation modify the surge elevation. Numerical modeling studies of this phenomenon are also reviewed.

2.11.1.1 Existing Relationships

Relationships documenting the reduction in storm surge elevation due to landscape features and vegetation have been determined based on limited measurements in Louisiana. Obtaining reliable data from field observations is difficult as many factors control the elevation of the surge. To properly characterize the influence of landscape features and vegetation on storm surge, measurements should be (1) in line with the path of the storm, (2) on the same side of the storm, (3) not so far apart that processes (e.g., barometric pressure, winds, rainfall) are significantly different, (4) inside an enclosed space, to remove the influence of wave height on the measurements, and (5) representative of a homogeneous landscape feature (Figure 2.11-1). The relationships developed from the limited data available and discussed below do not, in general, adhere to these requirements and therefore should not be relied upon for engineering design.

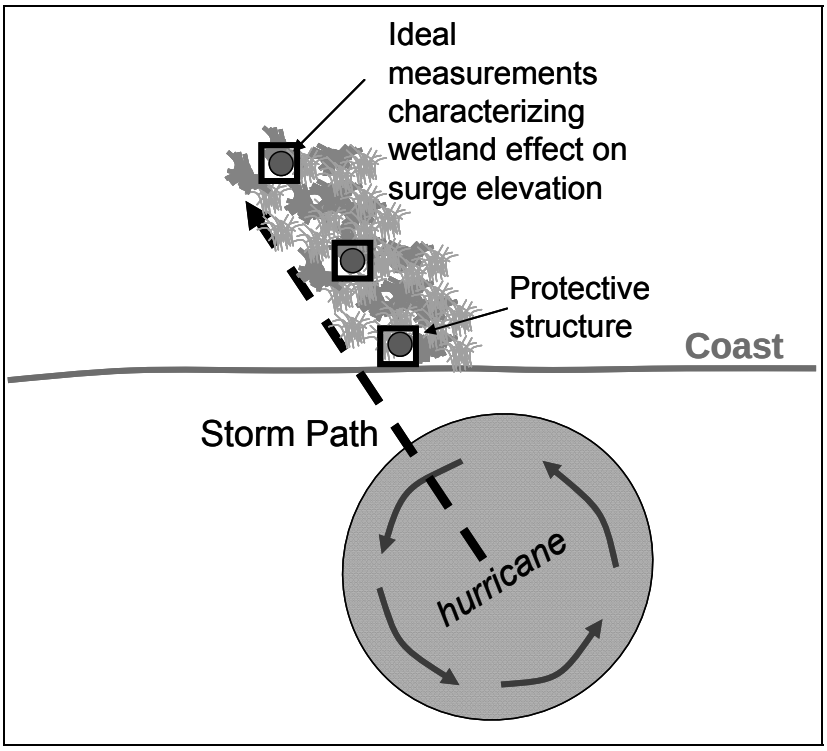


Figure 2.11-1. Ideal measurements for isolating the influence of landscape features on storm surge elevations

In a Letter from the Chief of Engineers (1965) documenting an interim hurricane survey of Morgan City and vicinity, Louisiana, measurements of high water marks due to hurricane surge were correlated with distance inland from the coast. Surge elevations at 16 locations near Morgan City due to seven hurricanes (Sep 1909, Aug 1915, Sep 1915, Aug 1926, Sep 1947, Sep 1956, and Jun 1957) were documented giving 42 data points (Figure 2.11-2). The report states that this area has numerous bays and marshes, but the data evaluated include the western part of Louisiana with cheniers (relatively high wooded ridges). Inconsistent results were obtained when attempting to correlate hurricane translation speed, surge hydrograph at the coast, and surge elevations inland. However, a trend was observed for the decrease in storm surge as a function of distance inland, and is independent of hurricane translation speed, wind speed, and direction. The relationship indicates that storm surge was reduced by 1 foot for every 2.75 miles inland (1 cm decrease in storm surge per 145 m inland).

Lovelace (1994) documented storm surge elevations after Hurricane Andrew in Louisiana. Citing this study, the Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority (2004) suggest that storm surge reduces about 3-inch (0.25 ft) per mile (1 cm per 211 m) of marsh along the central Louisiana coast. Stone et al. (2003) modeled a Category 3 hurricane that made landfall in 1915 and compared wave and storm surge for the south-central Louisiana coast in 1950 (1.09 million acres of land) to that in 1990 (0.85 million acres of land). Models used were a hurricane planetary boundary model, ADCIRC circulation model, and SWAN wave model. Acreage impacted by a 2.1 m (7 ft) surge and 3.7 m (12 ft) increased by 69,000 and 49,000 acres, respectively, between 1950 and 1990. Surge levels greater than 4.6 m (15 ft) were not significantly different between the two time periods.

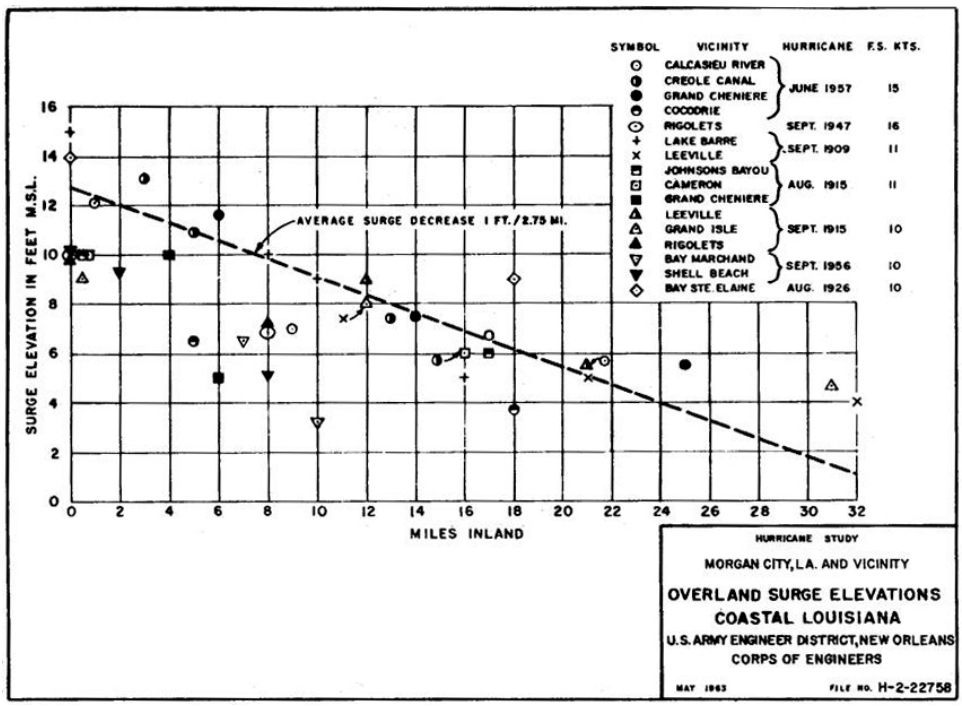


Figure 2.11-2. Observed maximum surge high water marks versus distance inland (USACE 1965)

The Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority (2004; Chapter 6, p. 55) discuss that it is "commonly acknowledged that barrier islands and wetlands reduce the magnitude of hurricane storm surges and related flooding; however, there are scant data as to the degree of reduction." At the time the report was written, the best information documenting this phenomenon came from gages measuring water elevations during the second landfall of Hurricane Andrew (data documented by Lovelace 1994), which occurred in the vicinity of Point Chevreuil, Louisiana on August 26, 1992. Gage data from Cocodrie, Louisiana indicated a maximum water level elevation equal to 9.3 ft (2.8 m) during this Category 3 Hurricane. Over a 23-mile (37 km) stretch of marsh and open water from Cocodrie to the Houma Navigation Canal, the water elevation decreased from 9.3 ft (2.8 m) to 3.3 ft (1 m), equating to a reduction in surge amplitude equal to 3.1 inch (0.26 ft) per mile of marsh and open water (1 cm per 203 m). A similar set of measurements showed reduction of the storm surge from 4.9 ft (1.5 m) at Oyster Bayou to 0.5 ft (0.15 m) at Kent Bayou, located 19 miles (30.6 km) north. This second set of measurements indicated a 2.8-inch (0.23 ft) decrease in surge per mile (1 cm per 230 m) over "fairly solid marsh." The report cautions that these represent measurements from one storm; other factors, such as storm characteristics, coastal geomorphology, and track of the storm influence the degree to which wetlands decrease storm surge.

The Working Group for Post-Hurricane Planning for Louisiana Coast (2006) wrote "barrier islands, shoals, marshes, forested wetlands and other features of the coastal landscape can provide a significant and potentially sustainable buffer from wind wave action and storm surge generated by tropical storms and hurricanes." ADCIRC results from Rick Luettich (Dec 30, 2005) indicated if wetlands east of the Mississippi River Gulf Outlet (MRGO) were removed and the lake was deepened to 2.5-m (8-ft), the storm surge from Hurricane Katrina would increase by 1-2 m (3-6 ft) for St. Bernard Parish and Eastern New Orleans.

2.11.1.2 Engineering Relationships

This section presents a preliminary review of the engineering literature about the quantitative relationships between coastal landscape features and the characteristics of hurricane storms. The effects of each landscape feature on each of the hurricane storm characteristics are reviewed.

Wetlands contain a variety of vegetation types. The physical properties of wetlands that modify storm characteristics include the vegetation type, location, height and density. Vegetation has an effect on storm waves. Waves become depth limited, not fetch limited, over relatively short distance if the friction factor is high enough. Wind stress is also affected by land cover. The sediment geotechnical properties and morphology of each wetland can modify wave height and direction.

Barrier islands and interior landscape ridges modify storm surge as a function of location, elevation, width, vegetation cover, and foreshore slope. The degree to which a barrier island decreases storm surge elevation depends on whether the island is overtopped and if the adjacent tidal inlet cross sectional area is in equilibrium with the bay tidal prism. Inlet parameters include location, cross sectional area, depth, width, and frictional roughness.

2.11.1.2.1 Winds

The strength and impact of hurricane winds in coastal areas is affected by landscape features in two distinct manners. First, the intensity of hurricane storms undergoes a significant decrease in intensity after landfall. Data suggest that this process, referred to as “filling,” is initiated before the eye of the storm crosses over land. The filling gradually reduces the wind velocity within the storm. The rate of wind speed reduction has been related to the number of hours after landfall and to the geographic region (NWS 23 1979). This rate of reduction is of highest category for the Mississippi coast, showing a reduction of the wind speed of about 15% at 5 hours after landfall and a reduction of about 30% at 10 hours after landfall.

Landscape features also affect hurricane winds because vegetation which extends above the water surface, both before and during flooding, reduces the speed of the wind at the water surface. This reduction in wind speed translates to a reduction in the wind stress which generates both storm waves and surges. The reduction in wind stress due to the presence of vegetation has been described with a “stress reduction factor” or SRF (Federal Emergency Management Agency (FEMA) 1985). The SRF is affected differently by various land covers and the most important contribution is the areal distribution of the various land covers. Wooded areas have the greatest effect, with the type, height and density of the trees being of primary importance. The SRF may be as low as 0.10, indicating a 90% reduction of the open water wind stress. The SRF for wooded areas is related to the fractional projected area of the trees. This fractional area is the area of the trees divided by the total flow area, with both areas being projected on a vertical plane perpendicular to the wind velocity. The effect of trees on the SRF is not linear. For a fractional projected area of 10% the SRF is 0.85, while for 40%, the SRF is 0.30. The effect decreases with higher fractional areas. At fractional areas equal to 60% and 80%, the SRF is 0.20 and 0.10, respectively.

Marsh grasses also affect the SRF, although this effect is very complex. Overall marsh grass has a smaller roughness than wooded areas, and has a smaller effect on wind velocity. Marsh grass is quite flexible and can be blown over during the hurricane. Also the marsh grasses can become inundated exposing the water surface to the full effect of the wind. The expected range in SRF for marsh is 0.70 to 0.90 with the higher value being used when the surge height is higher than the average height of the marsh grass.

A value for 0.30 for the SRF has been used successfully by the USGS in the SWIFT2D hydrologic modeling of coastal wetlands (Swain 2005). The value of SRF equal to 0.30 was used for all

computational grids having a Manning's coefficient greater than 0.10, implying that the vegetation is emergent.

Open water near land can experience a reduction in the wind stress when the wind is blowing offshore. This "downwind sheltering effect" results from the modification of the winds surface boundary layer as it passes a land surface having high roughness. This effect may extend to a distance of 2 to 10 nautical miles from the upwind land, and would be particularly important behind barrier islands. The approach used by FEMA is to linearly increase the wind stress from the reduced overland value to the open water value over a distance of from 2 to 10 nautical miles.

2.11.1.2.2 Waves

Storm waves are affected by several coastal landscape properties. These properties include the water depth (before and during flooding), bottom roughness or friction, water column friction, and bottom sediment characteristics.

The effect of water depth on waves becomes fundamental as waves propagate into shallow water and controls wave kinematics and dynamics (U.S. Army Corps of Engineers 2003). Shallow water wave processes includes generation, shoaling, refraction, diffraction, reflection, breaking, setup, run-up, bottom friction, water column friction, and dissipation of wave energy through wave/bottom interaction. The water depth and variations in water depth associated with coastal landscape features become particularly important when they cause wave breaking. Wave breaking occurs when the still water depth equals about 78% of the wave height and involves intense energy loss and can, for example, reduce wave heights by 90% over a distance of 10 meters. Wave run-up and overtopping occur if the height of a barrier island or an interior ridge equals or is less than the still water elevation.

Bottom friction and wave/bottom interaction in shallow bays dissipates wave energy and can limit the height of waves to values considerably below the breaking criteria. This effect depends upon the type of bottom sediment in the bay. Muddy bottom sediments have a response that can involve actual motion of the bottom due to the elastic properties of clay and mud.

The wave energy loss through vegetation results from the drag force of the wave current on the plants (FIA 1984, FEMA 1988). The rate of energy loss depends upon the geometry of the individual plants and the density of the plants in a given area. For areas containing a variety of plant types, the number of plants of each type can be specified as the fraction of the total area covered by a plant type and the average number of plants per square foot in the fractional area. The total energy loss for all plants along a transect is the sum of the energy loss associated with all of the individual plant types. The time average energy loss, $E_{i,j}$ for all plants of all plant types is given by:

$$E_{i,j} = \frac{\int_0^T \int_0^{h_i} \left| F_{i,j} u \right| dz\, dt}{T} \qquad \text{E 2.11-1}$$

where z is the elevation, $F_{i,j}$ is the drag force for the jth member of the ith plant type, h_i is the height of the submerged plant or the wave crest height if the plant is exposed, u is the horizontal wave current, and T is the total time being evaluated. The drag force on each individual plant is given as:

$$F_{i,j} = \frac{\rho C_D D_{i,j} |u| u}{2} \qquad \text{E 2.11-2}$$

where ρ is the water mass density, C_D is the plant drag coefficient, and $D_{i,j}$ is the effective diameter of the jth member of the ith plant type. The drag coefficient generally varies with plant roughness and the Reynolds number, but is taken as 1.0 for most plants. The contribution from the flat parts of the plant leaves is generally ignored.

The growth or decay of wind waves propagating over vegetated areas can estimate the effects of high friction by adjusting the fetch length (Camfield 1977). In this analysis the friction factors associated with vegetation can be up to 100 times the friction factor associated with unvegetated shallow water. The friction factor for various vegetation types are given as a function of water depth for thick stands of marsh grass; dense grass, brush or bushy willows and scattered tress; and dense stands of trees. Based upon a water depth of 3 m (10 ft), the friction factor for marsh grass is 0.20, for dense grass and brush it is 0.48 and for dense stands of trees, 0.90. These values represent an increase over the unvegetated bottom friction by factors of 20, 48, and 90, respectively. An example can be cited of the effectiveness of vegetated wetlands to dissipate wave energy (U.S. Army Corps of Engineers 2003). Storm waves having an initial height of 3 m (10 ft) are predicted to be reduced to a height of 1.5 m (4.8 ft) after passing over 1000 m (3300 ft) of tall grass and brush.

2.11.1.2.3 Currents and Storm Surge Elevation

Currents and surge are affected by coastal landscape features through two mechanisms. Bottom friction is generated by fluid shear stresses on the water bottom, while flow-drag resistance is generated by fluid stresses on objects extending through the water column (FEMA 1985). Bottom friction only occurs in bays whereas bottom friction and flow-drag resistance can occur in vegetated areas.

The most widely used formulation of bottom friction for flow in shallow water is the Manning-Chezy formula,

$$\tau = \frac{g|U|u}{C^2}, \ and \ \ C = \frac{1.486 h^{1/6}}{N} \qquad \text{E 2.11-3}$$

where τ is the bottom stress, $|U|$ is the flow speed, u is the vector velocity, C is the Chezy coefficient, h is the flow depth, and N is the Manning's coefficient. The Manning's coefficient is not a constant and varies with water depth and bottom roughness. For bays the Manning's coefficient has been represented as an exponential function of the water depth, by the following formula (FEMA 1985),

$$N = Ah^{-B} \qquad \text{E 2.11-4}$$

where A and B are curve fitting parameters. Calibration data for various studies indicate B is about 0.5 and A varies between 0.08 and 0.12, with a mean value of 0.10. This formula indicates the Manning's coefficient decreases as the water depth increases, with values of N of about 0.044 for a depth of 1.5 m (5 ft), 0.032 for a depth of 3 m (10 ft) and 0.022 for a water depth of 6 m (20 ft). Since the Manning's N is typically used as a tuning factor in calibrating hydrodynamic models, in this formulation A can be used for the same purpose. For flooded wetlands, the Manning's N is assumed to be a constant that varies with vegetation type.

Flow-drag resistance also occurs in vegetated areas and represents flow resistance within the water column. Taking the approach that the flow-drag force on natural vegetation can be expressed as some the force on an equivalent cylinder, the total drag force for a given area of wetland can be given by

$$F_d = \frac{\rho C_d n D h_p V^2}{2} \qquad \text{E 2.11-5}$$

where F_d is the drag force, C_d is the drag coefficient for the cylinder, n is the total number of plants, D is the diameter of each cylinder, h_p is the height of the submerged part of the cylinder, and V is the flow velocity. The drag coefficient C_d is not a constant and depends upon the size and proximity of each plant. An equivalent stress can be defined as the total drag force over an area, divided by the size of the area.

An alternative representation of the drag force on a number of plants is based upon the Darcy-Weisbach formulation,

$$F_d = \frac{\rho f V^2}{8} \qquad \text{E 2.11-6}$$

where f is the Darcy-Weisbach resistance coefficient. This coefficient has been related to the "roughness concentration" given as

$$f = a\sigma^b, \; and \; \sigma = nDh_p \qquad \text{E 2.11-7}$$

where σ is the roughness concentration, and a and b are calibration parameters.

The effect of wetland vegetation density on the Manning's coefficient for overland flow was studied in a series of laboratory experiments (Hall 1994). The experiments involved placing bulrushes in various spatial densities in a 1.2 m (4 ft) wide channel and then subjecting them to discharges of 0.009, 0.026, 0.044 and 0.057 m^3/sec. The results of the tests indicated that for flow velocities in the range of 0.01 to 0.05 m/sec (0.03 to 0.16 ft/s), the Manning's N decreased as the average flow velocity increased, ranging about 0.3-0.9 at the lowest velocity to 0.2-0.3 at the highest velocity. A linear relationship was found between the density of plants and the Manning's N, with the value of N being about 0.6 for a density of 800 stems per square meter.

2.11.2 Sensitivity Analysis

A sensitivity analysis was performed to assess the impact of bathymetric and frictional resistance changes on ADCIRC-simulated peak surge elevations and STWAVE-simulated waves. The impact of coastal landscape features on surge propagation and waves is a relatively new application for surge and wave models and an area of active research that suffers from a lack of quality data. The purpose of the analysis is to qualitatively assess the potential of coastal features for reducing storm surge and waves for hurricanes with varying intensity. The analysis provides valuable information on trends and relative performance but should not be taken as a quantitative assessment of surge and wave reduction. It should be noted that the analysis does not consider the changes to the landscape that occur during a storms passage, where vegetation cover can be stripped away and land masses eroded. The analysis also does not consider changes in the structure of the hurricane itself due to landfall infilling phenomenon that may be influenced by landscape features. The physics of this process are not well known and research in this area is required. The analysis was performed for differing configurations of the Biloxi marsh on the Louisiana coast, south of the Mississippi coast.

A base configuration consistent with that applied for the Interagency Performance Evaluation Team (IPET) study and two Biloxi marsh conditions, one degraded and one improved from the base case, are evaluated. The marsh elevations for both the improved and degraded cases were provided by the environmental group at the USACE New Orleans District. Two storms were simulated for each configuration: 1) Hurricane Katrina as it occurred in August 2005, making landfall as a Saffir-Simpson scale Category 3 (CAT3) storm and 2) Hurricane Katrina reduced to a Category 1 (CAT1) storm at landfall. The smaller CAT1 storm was only simulated with ADCIRC without radiation stress forcing. STWAVE simulations were performed for both the CAT3 and CAT1 storms. The analysis

first discusses the friction formulations in the models that impact surge and waves. The peak water levels and waves for each marsh configuration are then compared to the base condition. Finally, results for storms with varying intensity are compared.

2.11.2.1 Landscape Feature Roughness and Frictional Resistance

Coastal landscape features can reduce surge potential by reducing surface winds due to higher sub-aerial surface roughness and slow surge propagation due to bottom friction in shallow flow at the inundation front. The base condition coastal feature landscape land cover type was taken from the USGS National Land Cover Dataset (NLCD) classification raster map based upon Landsat imagery. Each NLCD classification has an associated land roughness length (z_{0land}) and Manning's *n* value as defined by Federal Emergency Management Association (2005). These values are applied in the models as described below to reduce wind and water speeds. The values used for this analysis are summarized in Table 2.11-1. It should be noted that the passage of large storms can alter the landscape, stripping away vegetation cover is some areas and this impact is not considered in this analysis.

Table 2.11-1.
$Z_{0\text{-land}}$ Factors and Manning's n Values for NLCD Classifications

NLCD Class	Description	$Z_{0\text{-land}}$	Manning's n
11	Open Water	0.001	0.020
12	Ice/Snow	0.012	0.020
21	Low Residential	0.330	0.070
22	High Residential	0.500	0.140
23	Commercial	0.390	0.050
31	Bare Rock/Sand	0.090	0.040
32	Gravel Pit	0.180	0.060
33	Transitional	0.180	0.100
41	Deciduous Forest	0.650	0.120
42	Evergreen Forest	0.720	0.150
43	Mixed Forest	0.710	0.120
51	Shrub Land	0.120	0.050
61	Orchard/Vineyard	0.270	0.100
71	Grassland	0.040	0.034
81	Pasture	0.060	0.030
82	Row Crops	0.060	0.035
83	Small Grains	0.050	0.035
84	Fallow	0.050	0.030
85	Recreational Grass	0.050	0.025
91	Woody Wetland	0.550	0.100
92	Herbaceous Wetland	0.110	0.035
95	Cypress Forest	0.550	0.100

The winds input to the ADCIRC and STWAVE models are reduced to account for the higher surface roughness through a directional land masking procedure. Since the wind boundary layer does not adjust to surface roughness instantaneously, wind reduction factors are computed based on the weighted average of roughness coefficients (z_{0land}) within 10 km in the upwind direction. The wind reduction factor (f_r) is calculated as (Powell et al. 1996, Simiu and Scanlan 1986):

$$f_r = \left(\frac{z_{0_{marine}}}{z_{0_{land}}} \right)^{0.0706} \qquad \text{E 2.11-8}$$

where $z_{0marine}$ is the marine roughness length that is computed based on the Charnock relationship (Charnock 1955) and the relationship between the friction velocity and the applied drag law (Hsu 1988):

$$z_{0_{marine}} = \frac{\alpha_c C_d W_{10}^2}{g} \qquad \text{E 2.11-9}$$

where the Charnock parameter (α_c) is set to 0.018, C_d is the air-sea drag coefficient, W_{10} is the wind speed sampled at a 10 m height over a 10 min period, and g is the acceleration due to gravity. As inundation takes place, landscape features are submerged and their roughness is reduced. In the model, the roughness length is reduced according to (Simiu and Scanlan 1986):

$$z_0^{'} = z_{0land} - \frac{d}{30} \qquad \text{for } z_0^{'} \geq z_{0_{marine}} \qquad \text{E 2.11-10}$$

where d is the local water depth. The reduced roughness length is limited to the marine roughness value.

In addition to reducing wind speeds, coastal landscape features can also inhibit wind from penetrating through the features and shelter the water surface from wind stress. Features such as heavily forested canopies allow little momentum transfer from wind fields to the water column (Reid and Whitaker 1976) and thus areas classified as NLCD forest do not apply a wind stress in the model.

The speed at which a storm surge propagates and thus surge water level is affected by coastal landscape features through bottom friction and form drag. Bottom friction is the generated by fluid shear stresses at the water bottom and flow-drag resistance is generated by fluid stresses on objects extending through the water column (FEMA 1985). Bottom friction occurs in relatively shallow areas and bottom friction and flow-drag resistance can occur in vegetated areas. The ADCIRC and STWAVE models presently only account for bottom friction, the effect of form drag can only be approximated by increasing the bottom friction coefficient. The ADCIRC and STWAVE models apply a Manning's-type bottom friction formulation with the bottom friction coefficient specified as:

$$C_f = g \frac{n^2}{d^{1/3}} \qquad \text{E 2.11-11}$$

where n is the Manning roughness coefficient with values based on the USGS land use factors. The Manning n values applied for this analysis are summarized in Table 2.11-1. The values applied in the model for both the Manning n values and the roughness coefficients were validated through

comparison of model hindcast results and measured high water marks for Hurricanes Katrina and Rita.

2.11.2.2 Sensitivity of Peak Water Level and Maximum Waves to Marsh Condition

The CAT3 and CAT1 storms were simulated on a base configuration, a case with Biloxi marsh raised to 1.05 ft NAVD 88 (2004.65) and restored to herbaceous wetland, and a case with Biloxi marsh lowered to -2 ft NAVD 88 (2004.65) and represented as open water. For the degraded case, the entire Biloxi marsh area was lowered and for the restored case only two strips of Biloxi marsh were altered (see Figure 2.11-3). Discussion of the peak water levels refers to the surge-plus-wave simulation results for the CAT3 storm only. Similarly, peak wave height maps for each of the CAT3 simulations were compared to the baseline configuration. In addition, maximum wave height maps were compared for the CAT1 simulations.



Figure 2.11-3. Outline of marsh areas restored (red) and deteriorated (blue)

Biloxi marsh was raised and restored to herbaceous wetland along two 100,000 ft by 15,000 ft strips of marshland for a total raised area of 116 sq mi. The change in bathymetry and frictional resistance slowed surge propagation resulting in an increase in water level seaward of the change and a decrease in water level landward of the change. The greatest change in peak water level was observed landward of the marsh feature where the decrease in peak water level was 0.9 to 1.3 ft (Figure 2.11-4). Changes on the Mississippi coast were less than 1 ft. The percent reduction in peak water level was as much as 8% in the New Orleans area and less than 3% on the Mississippi coast. The original STWAVE grid was also modified to represent the raised Biloxi marsh configuration and changes in maximum wave height are shown in Figure 2.11-5. The greatest change in maximum wave height was observed landward of the marsh feature where the decrease in maximum wave height was 1.0 to 2.0 ft for the CAT3 simulation. No changes in wave height were estimated on the Mississippi coast. Similar result patterns were observed for the reduced Katrina CAT1 simulation. The wave change patterns are consistent with the water level changes suggesting that the waves are depth limited.

The spatial extent where Biloxi marsh was lowered greatly exceeds the area that was raised. The lowered Biloxi marsh area encompassed 507 sq mi and was degraded (lowered) to -2.0 ft (NAVD88 2004.65) and returned to open water. The marsh reduction allows surge to propagate more rapidly, resulting in a rise in peak water level (relative to the original simulation peak water level) that extended beyond the Biloxi marsh region. The Biloxi marsh area increased in peak water level by 2.4 ft at the MRGO-GIWW junction (Figure 2.11-6). Peak water level south of English Turn increased 1.1 ft, Lake Pontchartrain peak water levels increased approximately 0.8 ft, and water levels on the Mississippi coast increased by less than 0.5 ft. The percent increase in peak water level was 8-13% near the New Orleans area levees but was less than 3 percent on the Mississippi coast. A map of changes in maximum wave height is shown in Figure 2.11-7. The greatest change in maximum wave height was observed landward of the marsh feature where the increase in maximum wave height was 2.0 to 4.5 ft for the Katrina CAT3 simulation. Similar result patterns were observed for the reduced Katrina CAT1 simulation. The wave change patterns are consistent with the water level changes suggesting that the waves are depth limited.

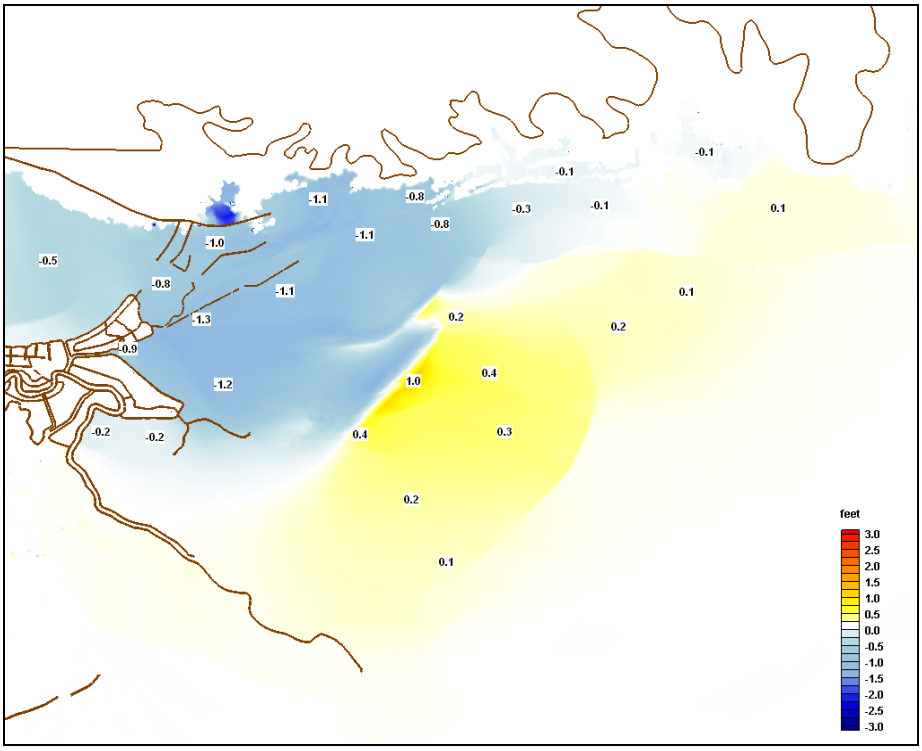


Figure 2.11-4. Difference in peak surge: Biloxi Marsh raised to 1.05 ft minus base configuration.

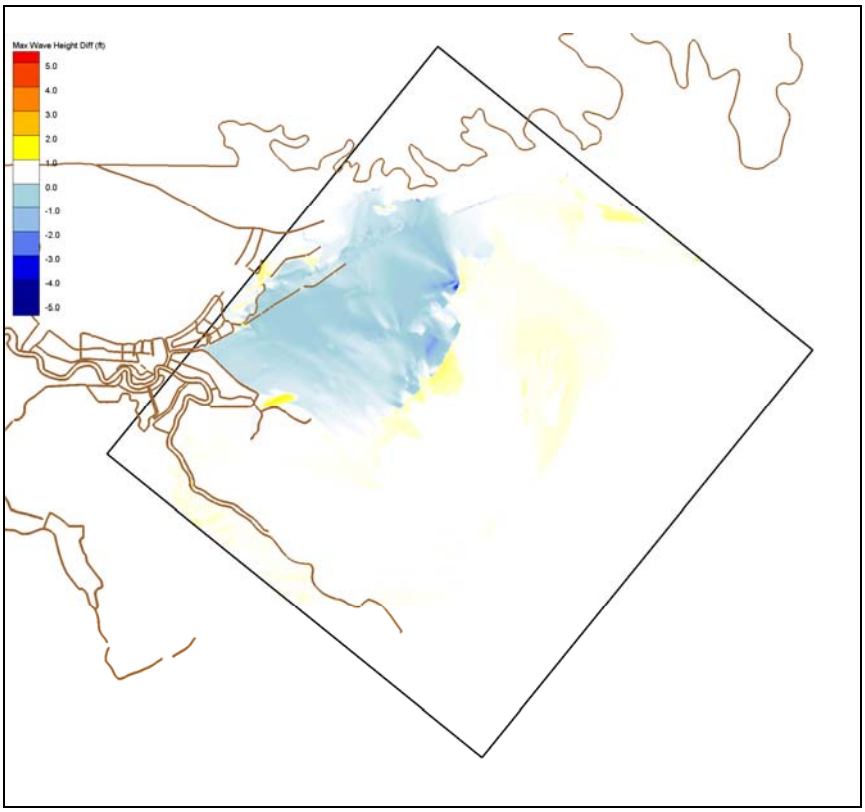


Figure 2.11-5. Difference in maximum wave height for CAT3 simulation: Biloxi Marsh raised to 1.05 ft minus base configuration.

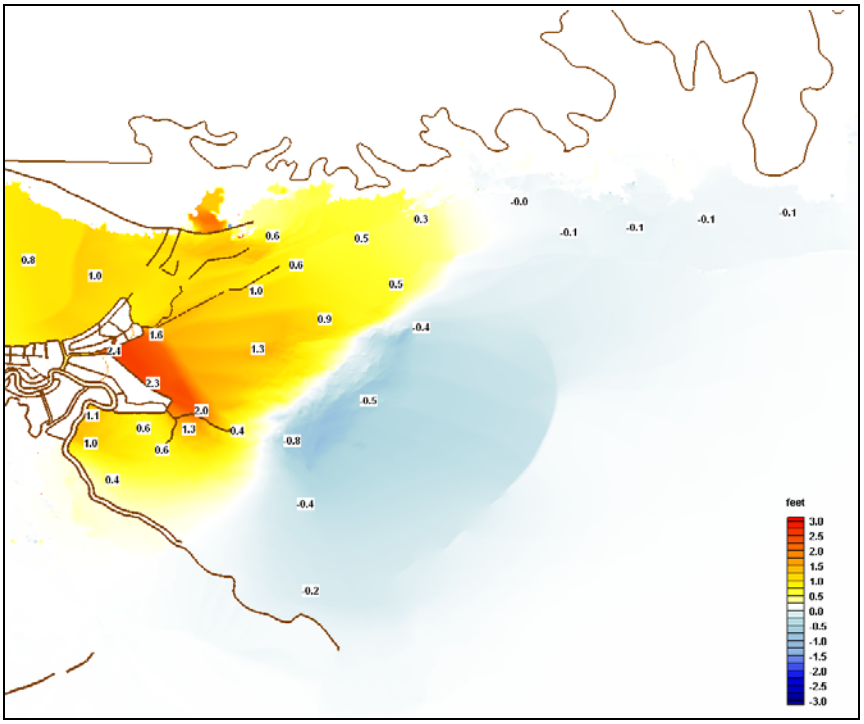


Figure 2.11-6. Difference in peak surge: Biloxi Marsh lowered to -2.0 ft minus base configuration.

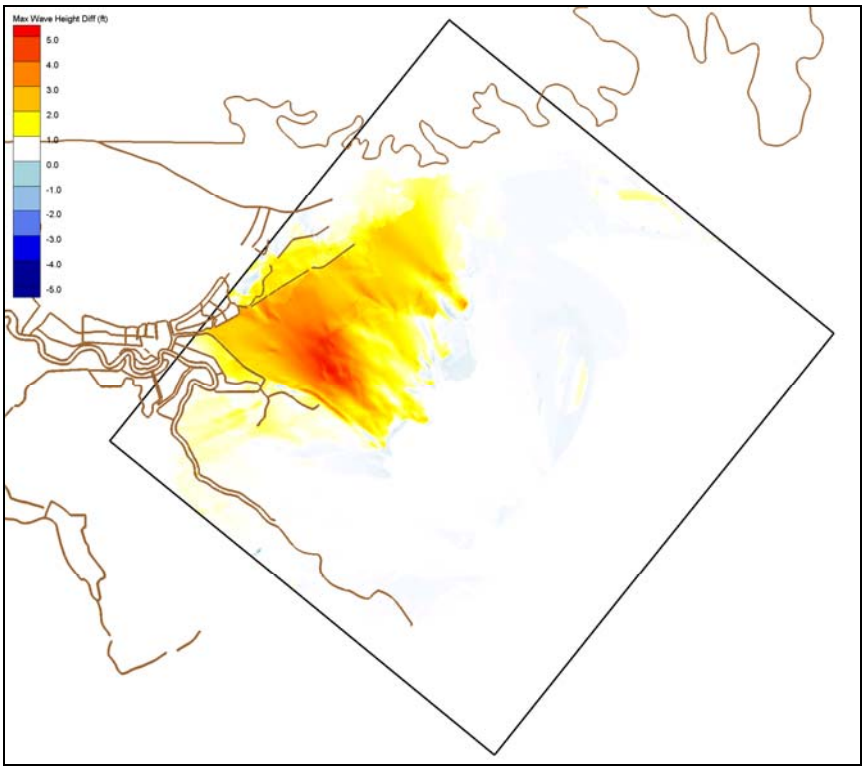


Figure 2.11-7. Difference in maximum wave height for CAT3 simulation: Biloxi Marsh lowered to -2.0 ft minus base configuration.

The CAT3 storm discussed in the previous section was scaled to produce a storm of Category 1 intensity on the Saffir-Simpson scale and thus has less surge potential. Simulations without wave radiation stress forcing were made for the less intense (CAT1) storm. Analysis and comparison of the CAT1 peak water level differences to the CAT3 surge only peak water level differences show similar patterns. Table 2.11-2 lists the peak water level change for the CAT1 and CAT3 storms for comparison. Water level changes on the Mississippi coast were less than 0.5 ft. The most significant difference in peak water level change between the CAT1 and CAT3 storms occurred when the marsh was lowered. The difference in surge for the two storm intensities for the lowered marsh configuration is given in Figure 2.11-8 and Figure 2.11-9. The peak water level is higher for the CAT3 storm, but the high peaks in Biloxi marsh extend over a broader area with the CAT1 storm. In the region further south from the lowered Biloxi marsh area, the CAT3 storm causes greater increases than the CAT1 storm in peak water level. For these cases, the change in peak water level change for a CAT3 storm can be more than double the change in peak water level for a CAT1 storm. A similar trend is observed with the STWAVE results when comparing storm intensity and maximum wave height. An example of the maximum wave height difference for the two storm intensities is given in Figures 2.11-7 and 2.11-10. Note that the maximum wave height change is larger and broader in extent for the CAT3 storm when compared to the CAT1 storm. This trend was especially evident for the lowered marsh configuration simulations performed for this study. For the raised marsh configuration, the area of changes in maximum wave heights is broader in extent, even if the maximum values are comparable for both CAT3 and CAT1 simulations.

Table 2.11-2.
Difference in Surge-only Peak Water Level for the Marsh Change Configuration – Original Marsh Configuration for CAT 1 and CAT3 Storms

Marsh Condition	Maximum Change in Peak Water Level, ft	
	CAT1	CAT3
Restored	-1.2	-1.4
Degraded	1.7	2.7

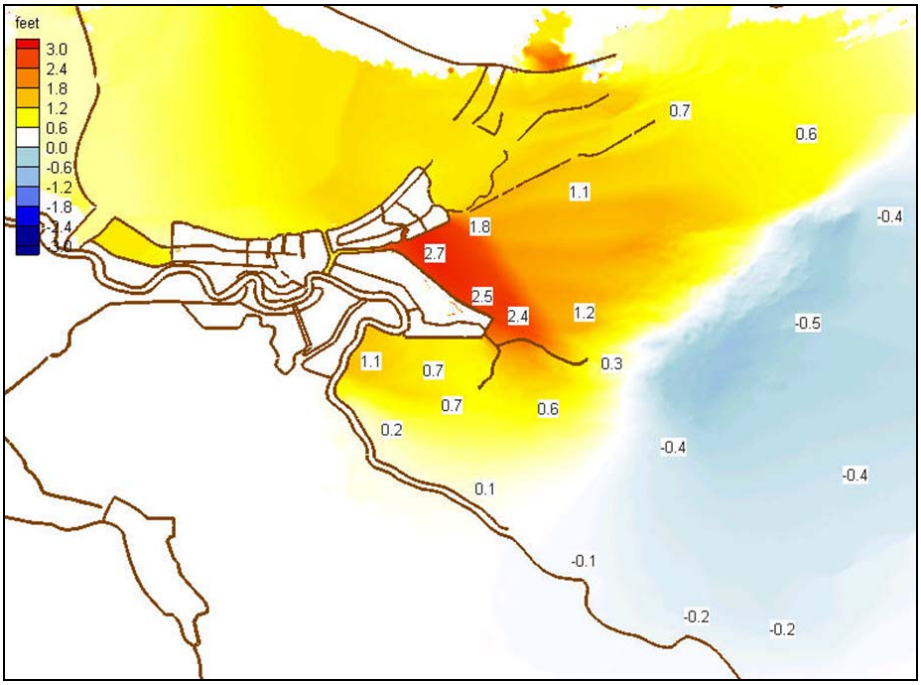


Figure 2.11-8. Difference in peak surge only (no radiations stresses): Biloxi Marsh lowered minus base configuration for a CAT3 storm.

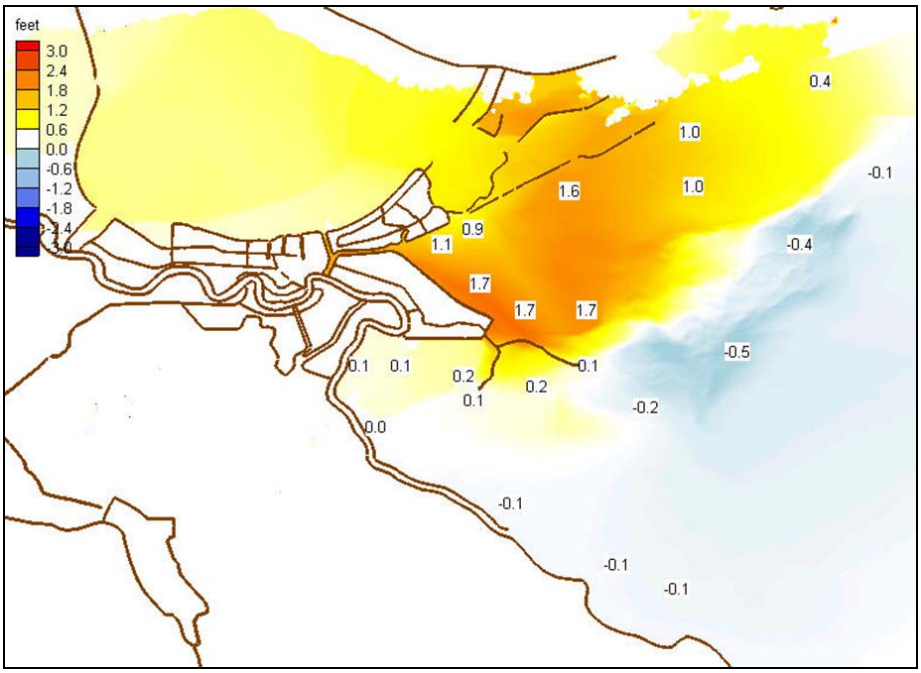


Figure 2.11-9. Difference in peak surge only (no radiation stresses): Biloxi Marsh lowered minus base configuration for a CAT1 storm.

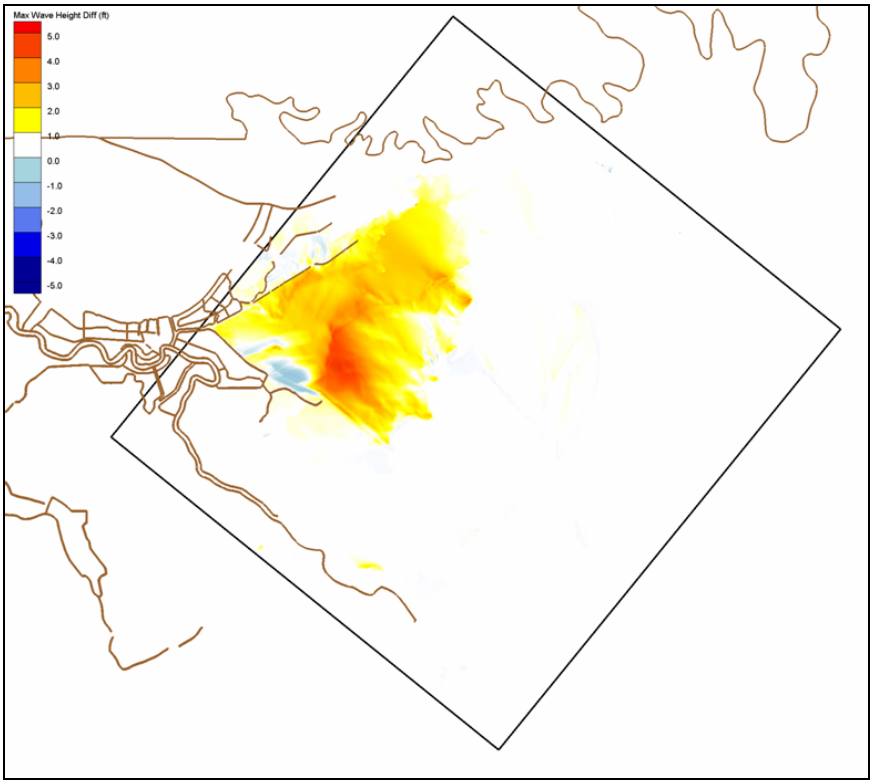


Figure 2.11-10. Difference in maximum wave height: Biloxi Marsh lowered minus base configuration for a CAT1 storm.

2.11.2.3 Summary

The purpose of this sensitivity analysis is to qualitatively assess the potential of coastal landscape features for reducing storm surge and waves for hurricanes with varying intensity. The impact of landscape features on surge propagation is a relatively new application for surge and wave models and an area of active research that suffers from a lack of quality data. The analysis provides valuable information on trends and relative performance but should not be taken as a quantitative assessment of surge and wave reduction. Results indicate that coastal marsh does have surge and wave reduction potential. Restoration and degradation of marsh resulted in decreases (for restoration cases) and increases (for degradation cases) in both surge and waves for both a Category 3 storm on the Saffir-Simpson scale and a less intense Category 1 storm. The magnitude of change was greatest for the more intense storm. The magnitude of change was also correlated with the magnitude of the horizontal extent and elevation changes in the marsh. In general, the wave change patterns are consistent with the water level changes suggesting that the waves are depth limited. Results indicate that the impact of the landscape features is amplified in areas where there are levee pockets, such as at the MRGO and GIWW junction and south of English Turn. Results also indicate that changes in the Biloxi marsh will have little or no impact on water levels and waves for the Mississippi coast.

2.12 Regional Sediment Budget

2.12.1 Purpose

This study evaluated the existing regional sediment transport magnitudes and directions for the Mississippi and Alabama barrier islands fronting Mississippi Sound and the mainland coast, including an analysis of historical long-term barrier island migration. Based on analysis of previous studies, historical bathymetric and shoreline change, and numerical modeling, a suite of sediment budgets was developed. First, a conceptual sediment budget was developed through a review of existing studies; this budget formed the framework for the historical and calculated sediment budgets. Next, a historical sediment budget was developed through analysis of bathymetric and shoreline position change through time. Engineering activities and significant storm events were also documented. A calculated sediment budget was developed based on numerical modeling of regional waves and sediment transport, for the Gulf and Bay shorelines of the barrier islands as well as the mainland coast. The final sediment budget was formulated from all these intermediate budgets, and is presented herein along with a summary of information pertinent to the final budget. Details about the conceptual, historical, and calculated sediment budgets and further discussion of the entire study can be found in Rosati et al. (2007).

2.12.2 Mississippi Coast Physical Setting and Processes

The barrier islands in the project area, Cat, West and East Ship, Horn, Petit Bois, and Dauphin Islands, provide the offshore boundary for Mississippi Sound (Figure 2.12-1). These islands are the first line of defense for the mainland as tropical storms, hurricanes, and cold fronts pass the region. Table 2.12-1 summarizes the tropical storm and hurricane history for locations in and around the study area from 1871 (or 1872) through 2006. Because data were not provided for a city in Hancock County, New Orleans, Louisiana is shown in Table 2.12-1 to provide a western boundary to the study area. Locations in Hancock County are assumed to have storm occurrences similar to those presented for New Orleans and Gulfport.

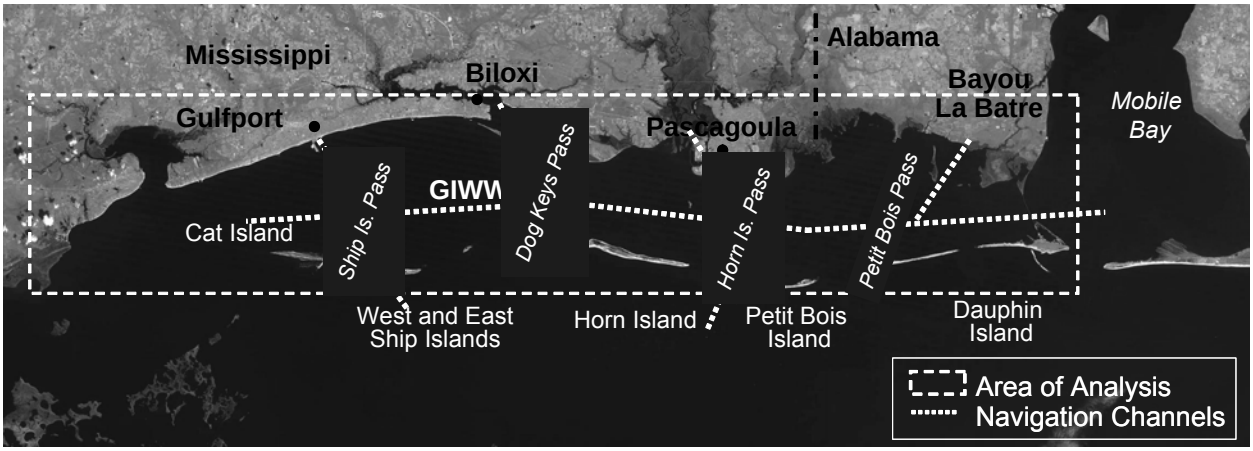


Figure 2.12-1. Mississippi Gulf Coast, showing barrier island system, navigation channels, and the area of study for the regional sediment budget (image courtesy NASA's Earth Observatory, dated 15 Sep 05)

Table 2.12-1.
Storms within 60 miles of Selected Mississippi, Alabama, and Louisiana Cities West of Mobile Bay, 1871/2 through 2006[1]

Location (from west to east)	Year of Storm Occurrence t=tropical storm; b=brush; h=hurricane	Frequency of Occurrence (yr)	
		Brush or Hit	Direct Hit
New Orleans, LA	1879h, 1879t, 1887h, 1888b, 1897b, 1892t, 1893h, 1900tb, 1901h, 1905t, 1907t, 1909h, 1914t, 1915h, 1916b, 1932t, 1934tb, 1936t, 1944tb, 1947h, 1948h, 1949t, 1955t, 1964t, 1965h, 1969b, 1979h, 1985b, 1988t, 1992b, 1998t, 2002t(2), 2004tb, 2005t, 2005h	3.8	12.4
Gulfport, MS	1872t, 1879b, 1881b, 1885t, 1885tb, 1887t, 1892t, 1893h, 1895t, 1900t, 1901b, 1904tb, 1905tb, 1906h, 1907tb, 1912b, 1914tb, 1916h, 1923t, 1926t, 1932b, 1934tb, 1944t, 1947h, 1947t, 1955tb, 1960t, 1965b, 1969h, 1979b, 1985h, 1988b, 1998h, 2002tb, 2002t(2), 2004b, 2005t, 2005h	3.5	15.1
Biloxi, MS	1879b, 1880b, 1881t, 1885t, 1885tb, 1887t, 1892tb, 1893h, 1895h, 1900t, 1901h, 1906h, 1907tb, 1912h, 1916h, 1923t, 1926h, 1932h, 1934tb, 1947h, 1955tb, 1960t, 1969h, 1985h, 1997b, 1998h, 2002t, 2002tb, 2004b, 2005t, 2005h	4.4	11.3
Pascagoula, MS	1872b, 1881t, 1885t, 1885tb, 1887t, 1893h, 1893b, 1895t, 1900t, 1901h, 1902tb, 1904tb, 1906h, 1912h, 1914tb, 1916h, 1923tb, 1926h, 1932h, 1934tb, 1944tb, 1947b, 1950b, 1960b, 1969h, 1979h, 1985h, 1998h, 2002t, 2004h, 2005t, 2005h	3.8	9.7
Dauphin Island, AL	1880b, 1881t, 1882b, 1885, 1887t, 1893h, 1895tb, 1900t, 1901t, 1902t, 1904t, 1906h, 1910h, 1911b, 1912b, 1914tb, 1916b, 1919tb, 1922tb, 1923tb, 1926h, 1932h, 1934t, 1939t, 1944tb, 1947t, 1950h, 1956b, 1959t, 1960tb, 1979h, 1985h, 1985tb, 1995b, 1997h, 1998b, 2002t, 2004h, 2005(2)tb, 2005h	3.3	11.3

[1] http://www.hurricanecity.com/. This database does not have any locations in Hancock County, Mississippi; thus, data for New Orleans, Louisiana are included to provide a western boundary for the study area. Locations in Hancock County are assumed to have storm occurrences similar to those provided for New Orleans and Gulfport.

The frequency of direct landfall is approximately equal for Biloxi, Pascagoula, and Dauphin Island, with a direct hit every 10-11 years. The likelihood for a direct hit decreases to approximately once every 15 and 12 years for Gulfport and New Orleans, respectively. However, all locations listed in Table 1 have historically been brushed or hit with a tropical storm or hurricane approximately once every 3-4 years. Cold fronts, although less intense than tropical storms and hurricanes, occur more frequently at approximately 30 to 40 times per year (Stone et al. 1999).

The barrier islands protecting Mississippi Sound experience a low energy wave climate, with average significant wave height at National Data Buoy Center (NDBC) Buoy 42007 (22 nautical miles south-southeast of Biloxi, in 46 ft depth) averaging 2 ft and 1.3 ft in the winter and summer months, with associated average peak wave periods of 4 to 3.5 sec, respectively. Wave transformation modeling by Cipriani and Stone (2001) indicated that breaking wave heights on the barrier islands range from 1 to 2 ft. Waves in Mississippi Sound are fetch- and depth-limited. The Coastal Studies Institute's Wave-Current Surge Information System (WAVCIS[3]) gage CSI-13 located at Ship Island Pass (23 ft depth) from June 1998 through July 2005 measured an average significant wave height of 0.3 ft and associated average wave period of 2.5 sec.

Tides in Mississippi Sound are diurnal, with a tidal range of 1.5 ft and 1.8 ft for the mean and spring tides at Biloxi, Mississippi[4], respectively. However, the relatively shallow and large area of the Sound create strong currents in the tidal passes between the barrier islands, ranging from 1.63 to 3.3 ft/sec and 5.9 to 11.5 ft/sec on flood and ebb tides, respectively (Foxworth et al. 1962). In the winter months, winds from the same direction and of a sufficient magnitude are capable of lowering water surface elevations in the bays and nearshore from 1-2 ft (U.S. Army Corps of Engineers Mobile District 1984).

For the Gulf barrier island beaches, net longshore sediment transport is from east to west, although local reversals in the net transport occur adjacent to the tidal passes. The primary sources of sediment are longshore sediment transport from east to west, and, potentially, the offshore shelf (Otvos 1979, Cipriani and Stone 2001). Cipriani and Stone (2001) discussed that a well-defined cellular structure exists for each barrier island in which, over historic times, little sand transfer exists between islands. However, dredging records at Horn Island and Ship Island Passes (also called Pascagoula Bar Channel and Gulfport Bar Channel, respectively) suggest that infilling of sand from adjacent barrier islands occurs, indicating the potential for transport of sand between islands. Eastern Dauphin Island, with a Pleistocene core, is more stable than the other barriers although eastern Dauphin Island has been eroding in response to the dominant westerly-directed transport. Based on grain size analysis, Cipriani and Stone (2001) inferred that offshore sources may provide some sediment to central Petit Bois Island. The Mississippi Sound barrier islands range from very well vegetated, with maritime forests on east Dauphin Island, to low elevation barriers that are overwashed and breached during hurricanes. Long-term relative sea level rise for Dauphin Island, Alabama from 1966 to 1997 was 0.12 +/- 0.023 in/year[5].

On the mainland coast, beach change in Harrison County has been dominated by harbor construction, beach restoration and replenishment since 1951 (Byrnes et al. 1993a, 1993b). Cross-shore sediment transport processes dominate beach change, with wave-induced sediment transport processes of secondary importance, typically from east-to-west (Byrnes et al. 1993a, 1993b). Hancock County had beach nourishment in 1993-1994 between Waveland and Bay St Louis and again in 1996 for the Bay St Louis Downtown beach (Schmid 2002). Net longshore transport in Hancock County is generally from northeast to southwest. The bays, distributaries, and bayous of

[3] http://www.wavcis.lsu.edu/, dated 11 December 2006, accessed 11 December 2006.
[4] http://tidesandcurrents.noaa.gov/tides05/tab2ec4.html#107, dated 25 March 2005, accessed 11 December 2006.
[5] http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8735180, dated 10 February 2006, accessed 29 July 2006.

the remaining coast are typically bordered with marsh populated by *Spartina-Juncus* succession (Christmas 1973).

2.12.3 Review of Existing Studies and Dredging Database

Existing studies were reviewed for the project area to provide information about sediment transport processes of the barrier island and mainland coast. This knowledge gained was incorporated into the sediment budget as appropriate. For a full summary of each study that was reviewed, please see Rosati et al. (2007).

Dredging rates for navigation channels within Mississippi Sound were also evaluated in the study. As shown in Figure 2.13-1, the study area is traversed by many navigation channels: two "bar" channels that extend through Horn Island Pass (also called Pascagoula Bar Channel) and Ship Island Pass (also called Gulfport Bar Channel); the Gulf Intercoastal Waterway (GIWW) that runs east-west through Mississippi Sound; and five Sound navigation channels that extend from Gulfport, Biloxi, Pascagoula, Bayou Cassotte, and Bayou La Batre. The SAM dredges these channels on a regular basis. The U.S. Army Corps of Engineers' Navigation Data Center[6] (NDC) has documented all Corps contract and non-contract dredging for all Districts for Fiscal Year (FY) 1990 through 2005. NDC's database for SAM's entire District dredging program is provided in Rosati et al. (2007).

Byrnes and Griffee (2007) culled historical dredging and placement information from published Corps reports and databases to develop annual dredging and placement rates for each of the bar channels. Sediment dredged from the GIWW and other channels extending through Mississippi Sound was side-cast or placed in disposal areas to either side of the channels, and is assumed to shoal primarily from fine sediment that is mobilized in the bay. Thus, these dredging and placement activities in the Sound do not change the sediment budget for the mainland and barrier islands. However, dredging and placement adjacent to the barrier islands (Ship Island Pass/Gulfport Bar Channel and Horn Island Pass/Pascagoula Bar Channel) must be considered in the sediment budget.

Dredging data provided by Byrnes and Griffee (2007) have been analyzed to provide estimated maintenance shoaling rates for each of the Bar Channels as a function of channel depth, width, and length (Table 2.12-2). Of particular interest is the maintenance dredging rate as a function of channel depth, as shown in Figure 2.12-2.

Table 2.12-2.
Summary of Dredging Rates for Navigation Channels Adjacent to Barrier Islands
(modified from Byrnes and Griffee 2007)

Date	Description	New Work (cy)	Maintenance (cy)
Ship Island Pass/Gulfport Bar Channel (Data from 1881-2003)			
Mar 1899–Mar 1948	26-ft deep, 300-ft width, 0.76-mile long channel (1.9-mile length dredged in 1922)	163,401	2,115,576 (43,175 cy/yr) (33,028 cu m/yr)
Mar 1948–Jul 1992	32-ft deep, 300-ft wide, 8 miles long	3,679,044	21,111,495 (476,200 cy/yr) (364,292 cu m/yr)
Nov 1993–Apr 2003	38-ft, 300-ft wide, 8 miles long	9,695,988	5,456,817 (579,485 cy/yr) (443,306 cu m/yr)

[6] http://www.iwr.usace.army.mil/NDC/data/datadrg.htm , updated 25 July 2006, accessed 13 December 2006.

Table 2.12-2.
Summary of Dredging Rates for Navigation Channels Adjacent to Barrier Islands (modified from Byrnes and Griffee 2007) (continued)

Date	Description	New Work (cy)	Maintenance (cy)
1899 to 2003	**Total Dredging**	**13,538,433**	**28,683,888 (275,807 cy/yr) (210,992 cu m/yr)**
Horn Island Pass/Pascagoula Bar Channel (Data from 1881-2005)			
Feb 1897–Mar1948	25-ft deep, 300-ft wide channel	896,748	1,735,817 (34,000 cy/yr) (26,010 cu m/yr)
Mar 1948–Jan 1965	38-ft deep, 325-ft wide, 2.8 mile length	2,910,835	2,711,925 (161,104 cy/yr (123,245 cu m/yr)
Jan 1965–Sep 1993	40-ft deep, 350-ft wide; Impoundment area along the western end of Petit Bois Island	1,305,589	14,772,517 (515,320 cy/yr) (394,220 cu m/yr)
Sep 1993–Nov 2005	44-ft deep, 550-ft wide; Impoundment area along the western end of Petit Bois Island	3,117,658	2,986,712 (245,483 cy/yr) (187,690 cu m/yr)
1897 to 2005	**Total Dredging**	**8,230,830**	**22,206,971 (205,600 cy/yr) (157,284 cu m/yr)**

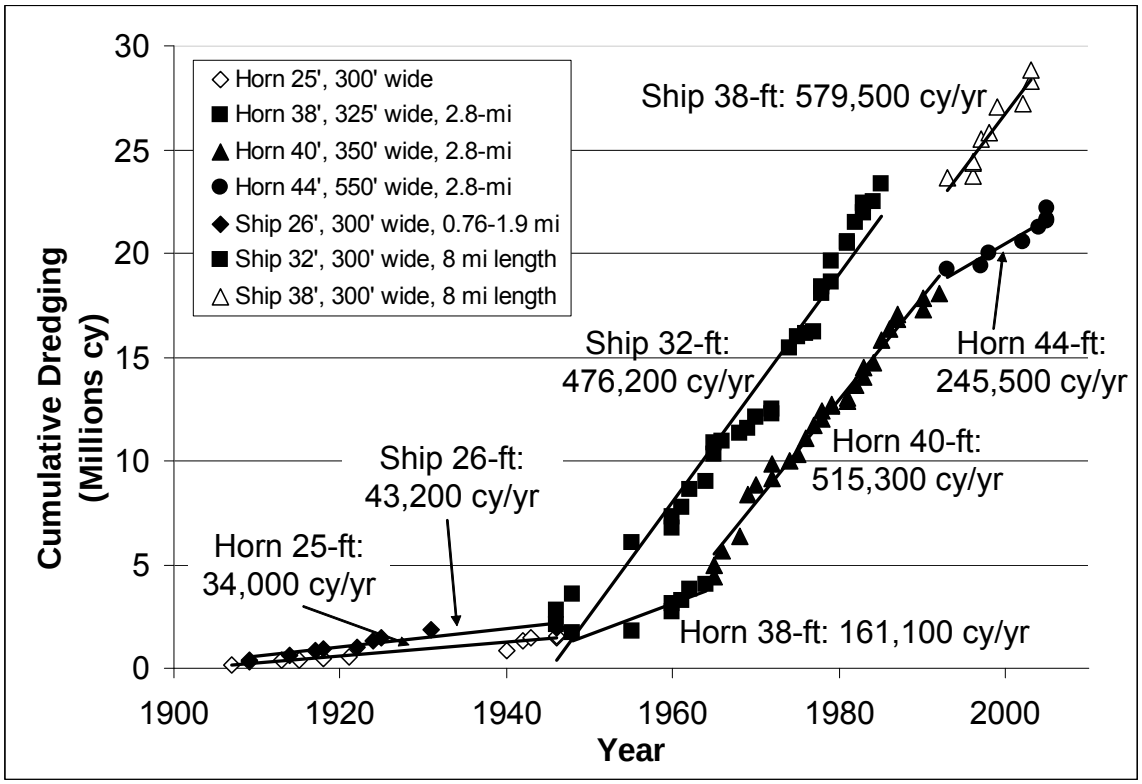


Figure 2.12-2. Cumulative maintenance dredging volumes and associated dredging rates for Horn Island Pass (Pascagoula Bar Channel) and Ship Island Pass (Gulfport Bar Channel)

These data indicate that deepening Ship Island Pass in 1948 by 23% (from 26 to 32 ft depth) and lengthening the channel (from 0.76 and 1.9 miles to 8 miles) increased the maintenance dredging rate by more than an order of magnitude (from 43,200 to 476,200 cy/yr). Dredging rates also increased more than an order of magnitude at Horn Island Pass through several depth increases from 25 to 40 ft, an increase in width from 325 to 350 ft, and length to 2.8 miles (dredging increased from 34,000 to 515,300 cy/yr). However, the dredging rate at Horn Island Pass decreased most recently when the channel was deepened to 44 ft and widened to 550 ft. This decrease in shoaling is opposite to what would be expected and possibly indicates a change in dredging or placement practices at Horn Island Pass. As these channels were deepened, they were also lengthened to provide safe navigation from a similar depth contour offshore. Thus, the deeper channels not only provided a better trap for sand moving alongshore but also resulted in longer channels which captured more of sand that is being transported in the offshore zone.

As mentioned previously, dredging for channels in the Sound do not modify the sediment budget for the barrier islands and mainland coast. The NDC's dredging database has been evaluated to provide a complete regional sediment budget as shown in Table 2.12-3.

Table 2.12-3.
Dredging Rates for Navigation Channels in Mississippi Sound (from SAM and NDC Database)

Location	Dates	Duration (years)	Shoaling Rate (cu yd/yr)	Notes
Gulfport Harbor Channel[1]	Jul 1991 – Sep 2004	8.3	1,151,000	Assume includes GIWW dredging
Biloxi Harbor Channel	Dec 1991 – Aug 2003	12.5	43,600	
Pascagoula Harbor Channel	Aug 1992 – Jan 2005	13.5	3,074,600	Assume includes GIWW dredging in vicinity of Pascagoula
Bayou Cassotte	Sep 1992 – Sep 2000	8	248,500	
Bayou La Batre	May 1996 – Sep 2004	8.3	732,400	Assume includes GIWW dredging

[1] Omitted Gulfport deepening in 1992.

2.12.4 Historical Data Analysis

A second phase of this study developed a historical sediment budget for the barrier islands and adjacent passes based on bathymetric change, shoreline position change, and dredging and placement data. The historical sediment budget is utilized to develop the present-day sediment budget. In this chapter, historical volumetric change, shoreline position change, and dredging data are reviewed. This portion of the study was conducted by Byrnes and Griffee (2007).

Shoreline and bathymetric data were compiled within a Geographic Information System (GIS) for the Mississippi Sound region. This database has associated metadata specifying the coordinate system, vertical datum, measurement units, and timing of data collection for each data set. Data are available for 1846/57, 1916/21, and 1960/71 periods, with coverage of the eastern portion of the study area available for 1984/89.

The primary goal of bathymetric change analysis is to identify regional sediment transport pathways and quantify net sediment volume changes associated with the historical evolution of nearshore morphology and adjacent beaches. Table 2.12-4 provides a summary of bathymetric data available for the Mississippi Sound area. Initial bathymetric surveys of the area were completed for the period 1847/56. All data have been compiled within a GIS framework, so metadata regarding coordinate

system, vertical datum, measurement units, and timing of data collection are provided in the attribute table for each data set. These data, in addition to recorded shoreline changes, have been used to quantify regional sediment dynamics throughout the study area and evaluate the historical sediment budget for the period 1917/21 to 1960/71. Limited coverage offshore of Horn, Petit Bois, and Dauphin Islands for the 1960/71 period limits volumetric change calculations and, ultimately, the historical sediment budget.

Table 2.12-4.
Bathymetry Source Data Characteristics (from Byrnes and Griffee 2007)

Date	Data Source	Comments and Map Numbers
1847/56	USC&GS Hydrographic Sheets 1:20,000	First regional bathymetric survey within the study area. 1847 - H-00191; 1847/48 – H-00192; 1848 – H-00193, H-00194; 1851 – H-00256, H-00261; 1852 – H-00329; 1853 – H-00328, H-00365; 1854 – H-00430; 1855 – H-00485, H-00488, H-00489; 1856 – H-00546.
1916/20	USC&GS Hydrographic Sheets 1:40,000 (all others) 1:80,000 (H-4171)	Second regional bathymetric survey in the study area. 1916/17 – H-03960; 1917 – H-04000; 1917/18 – H-04020, H-04021, H-04023; 1920 - H-04171.
1960/71	USC&GS Hydrographic Sheets 1:10,000 (H-08524, H-08525, H-08560, H-08561, H-08562, H-08642, H-08643, H-08644, H-08645, H-08646, H-08649 to 08652, H-08922, H-08923, H-08925, H-08970, H-09156, H-09177) 1:20,000 (all others)	Third regional bathymetric survey in the study area. 1960 – H-08524, H-08525, H-08562, H-08563); 1960/61 - H-08560, H-08561; 1961 – H-08642; 1961/62 - H-8643 to 08648; 1962 – H-08649 to 08652; 1966/68 – H-08922, H08923; 1967/68 – H-08924, H-08925; 1968 – 08970, H-08971; 1968/69 – H-09004; 1970 – 09103, H-09109; H-09028, H-09156, H-09177; 1971 – H-09200.
1984/89	USC&GS Hydrographic Sheets 1:20,000 (D-00079, F-00324, H-10179, H-10208, H-10226, H-10247, H-10261) 1:40,000 (D-00078, H-10206) 1:80,000 (D-00065)	Survey covering eastern portion of the study area; 1984/87 - D-00065, D-00078; 1985/87 - H-10179; 1985 - H-10206, H-10208; 1986/88 – H-10226; 1987 - H-10247, H-10261; 1988 - D-00079; 1989 - F-00324.

Several insights into forcing processes and engineering activities were observed from the bathymetric change data.

(1) Overall, the barrier islands have eroded on the eastern regions and accreted to the west, indicating the dominant direction of longshore sand transport from east-to-west. Similarly, the Passes between barrier islands have also migrated to the west, as noted by the ebb shoal that erodes to the east and reforms to the west. Thus, the migrating barrier islands naturally “push” the Passes to the west.

(2) Dredging of the ship channels in Mississippi Sound is readily observed in the bathymetric change maps that include the 1960/71 surface, with side-casting and placement of the dredged material shown on either side of the channels. This side-cast sediment does not appear to move within Mississippi Sound.

(3) As the barrier islands have eroded, portions of the barriers have rolled over towards the Sound. For example, East Ship Island and western Dauphin Island have eroded on the Gulf side and reformed in a more northerly location further into the Sound. The processes transporting sand into the Sound is a combination of overwash during storms and inlet formation and possible subsequent closure.

(4) Portions of the barrier islands are relatively stable and maintain position through time (this is observed in Byrnes and Griffee's (2007) shoreline position data). Examples of these locations are the widest portions of Horn, Petit Bois, and Dauphin Islands. These areas are likely more stable ancient Pleistocene formations along which the sand spits which comprise the rest of the barrier island morphology form.

(5) Cat Island is not part of the sand-sharing system that comprises Dauphin, Petit Bois, Horn, and Ship Islands and the Passes that separate these barrier islands. Cat Island is a separate entity and the bathymetric change maps do not indicate that sand from Ship Island naturally bypasses or transports to Cat Island. If there were connectivity between Ship and Cat Island, it would be evidenced by erosion or accretion of morphologic features between the islands.

(6) From the historical shoreline position data (Byrnes and Griffee 2007), it is evident that the barrier islands have experienced cycles of breaching and mending throughout history. For example, Dauphin Island breached in 1917 in response to the 1915 hurricane, and reformed by 1957 slightly further northward (into the Sound) at the location of the washover deposit. Dauphin Island again shows a breach in the 2006 shoreline position data. Similarly, Ship Island breached in response to the 1947 hurricane and the barrier had reformed by 1950. Ship Island has been divided into East and West Ship Islands since another breach formed in the 1960s. These cycles of breaching and reformation indicate that breaches will naturally mend through the dominant longshore sand transport direction to the west, if a sufficient source of sediment is available. The historical data analysis is further discussed in Byrnes and Griffee (2007) and Rosati et al. (2007).

2.12.5 Numerical Modeling

Two numerical models were applied to develop estimates of sediment transport magnitudes and pathways. First, GENESIS shoreline change modeling that was conducted as a part of a larger regional study was incorporated to provide potential longshore sand transport rates for the Gulfside of the barrier islands for representative yearly waves. This model used pre-Katrina shoreline positions. Next, regional wave transformation modeling was conducted with STWAVE to estimate breaking wave height and direction magnitudes for the Gulfside and mainland coast beaches. These wave parameters and the shoreline orientation for sections of the Gulf barrier beaches and mainland coast were used to calculate potential longshore sand transport rates. Potential longshore sand transport rates are those estimated to occur if a sufficient quantity of sand were available for transport. Thus, these calculations do not apply to muddy coastlines or wetland regions of the study area. Finally, STWAVE was also applied to estimate wind-induced wave parameters for the Sound side of the barrier islands and subsequent sand transport on the Sound barrier coast. The methodology and results for this numerical modeling are discussed in Rosati et al. (2007).

2.12.6 Sediment Budget

Using the calculated and historical sediment budgets, and dredging and placement practices from 1993-2005 as presented by Rosati et al. (2007), a present-day (post-Katrina shoreline position) sediment budget has been hypothesized. In formulating this budget, several assumptions were made as follows:

(1) The historical sediment budget (1917/20-1960/71) was weighted more heavily than the calculated sediment budget, because the historical budget is based on actual measured changes in the region. However, for portions of the barrier islands that have changed morphology since the 1917/20 to 1960/71 period, or would be modified by a change in dredging or placement practices, the calculated sediment budget was given preference. The calculated sediment budget was adopted

for eastern Dauphin Island because volume change data have not yet been released, pending acceptance of the Dauphin Island mitigation study.

(2) In the absence of historical data, the calculated sediment budget and observed morphologic response were adopted for the mainland coast.

(3) Dredging and placement practices from 1993 to 2003/2005 were adopted for Ship Island Pass and Horn Island Pass, and the barrier island response to these activities was hypothesized. Dredging rates for Gulfport, Biloxi, and Pascagoula Harbor Channels, and Bayou Cassotte and Bayou La Batre were adopted as shown in Table 2.12-3. The source of sediment for these channels in Mississippi Sound was assumed to be fine-grained sediment that is mobilized during storms and wind events.

The hypothetical present-day sediment budget is shown in Figures 2.12-3 through 2.12-10, in which P=placement of dredged material, R=dredging or removal of sand, and sand fluxes are shown in thousands of cubic yards per year. It is emphasized that this sediment budget is only one of many possible solutions that could represent typical present-day conditions.

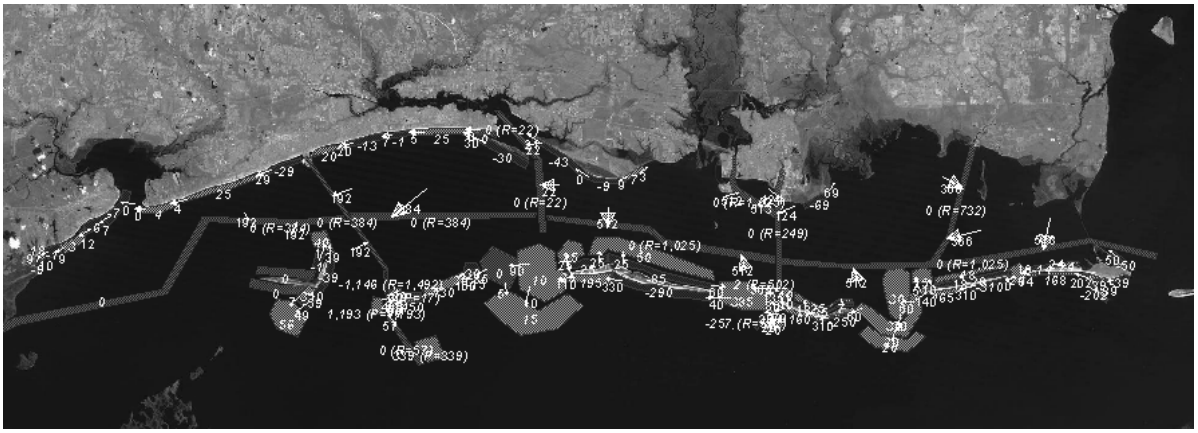


Figure 2.12-3. Overview of hypothetical present-day sediment budget (thousands of cy/yr)

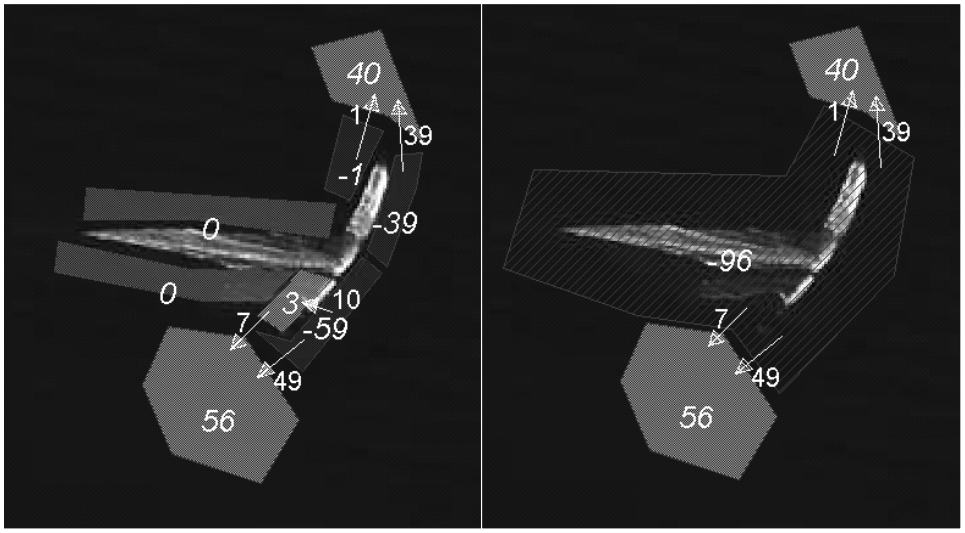


Figure 2.12-4. Hypothetical present-day sediment budget and macrobudget: Cat Island thousands of cy/yr).

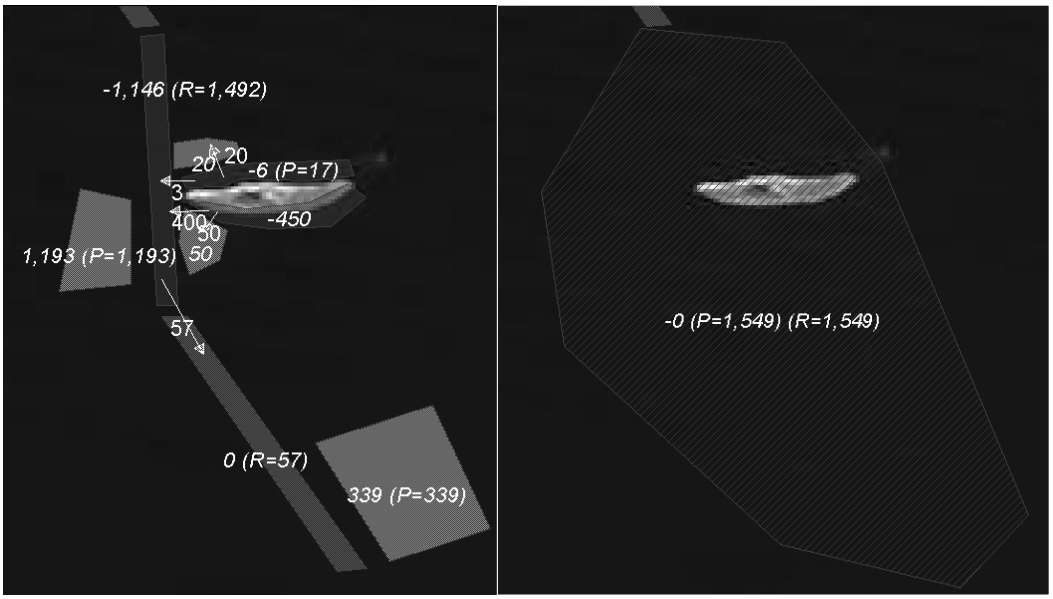


Figure 2.12-5. Hypothetical present-day sediment budget and macrobudget: West Ship Island and Ship Island Pass (thousands of cy/yr).

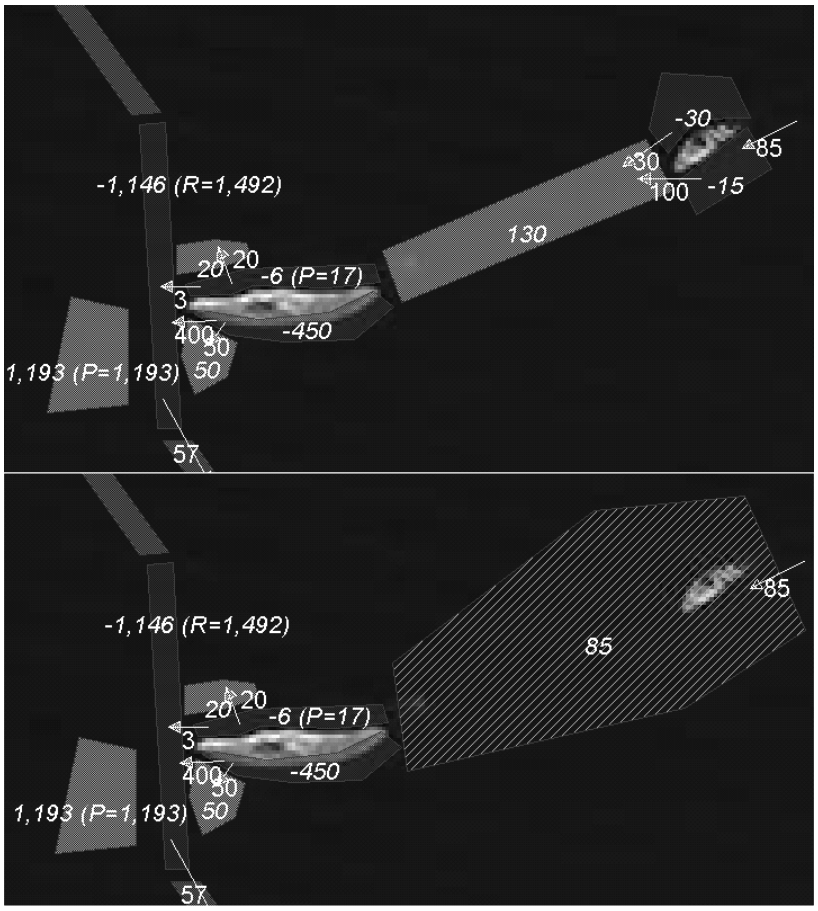


Figure 2.12-6. Hypothetical present-day sediment budget and macrobudget: East Ship Island and Camille Cut (thousands of cy/yr).

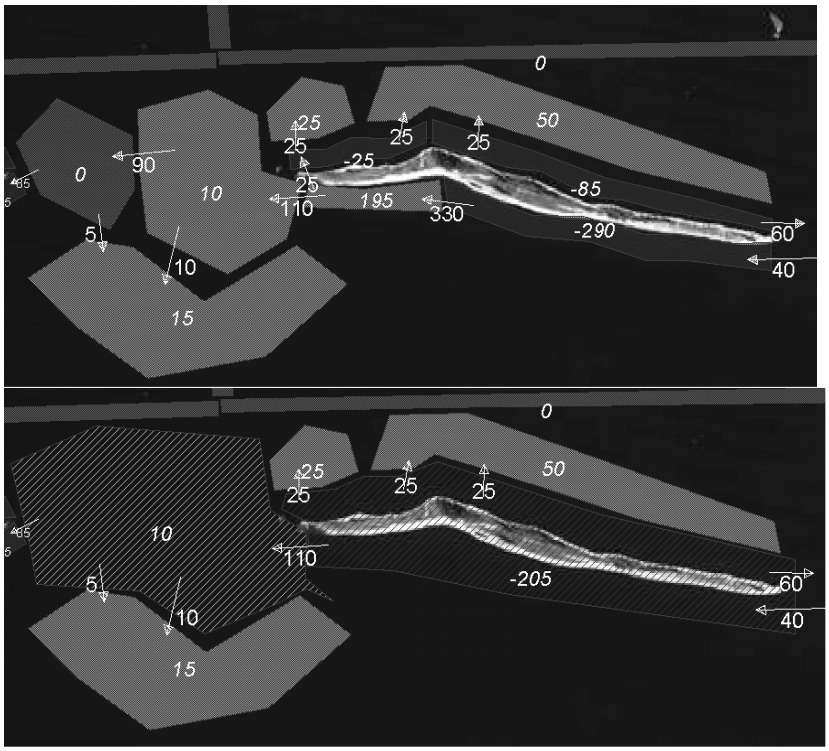


Figure 2.12-7. Hypothetical present-day sediment budget and macrobudget: Horn Island and Dog Keys Pass (thousands of cy/yr).

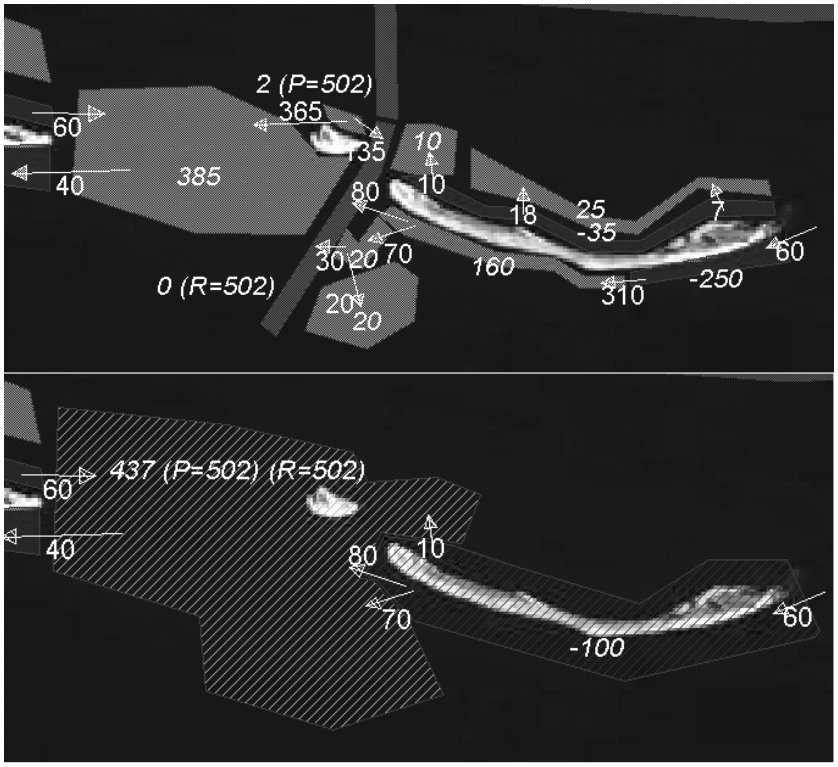


Figure 2.12-8. Hypothetical present-day sediment budget and acrobudget: Petit Bois Island and Horn Island Pass (thousands of cy/yr).

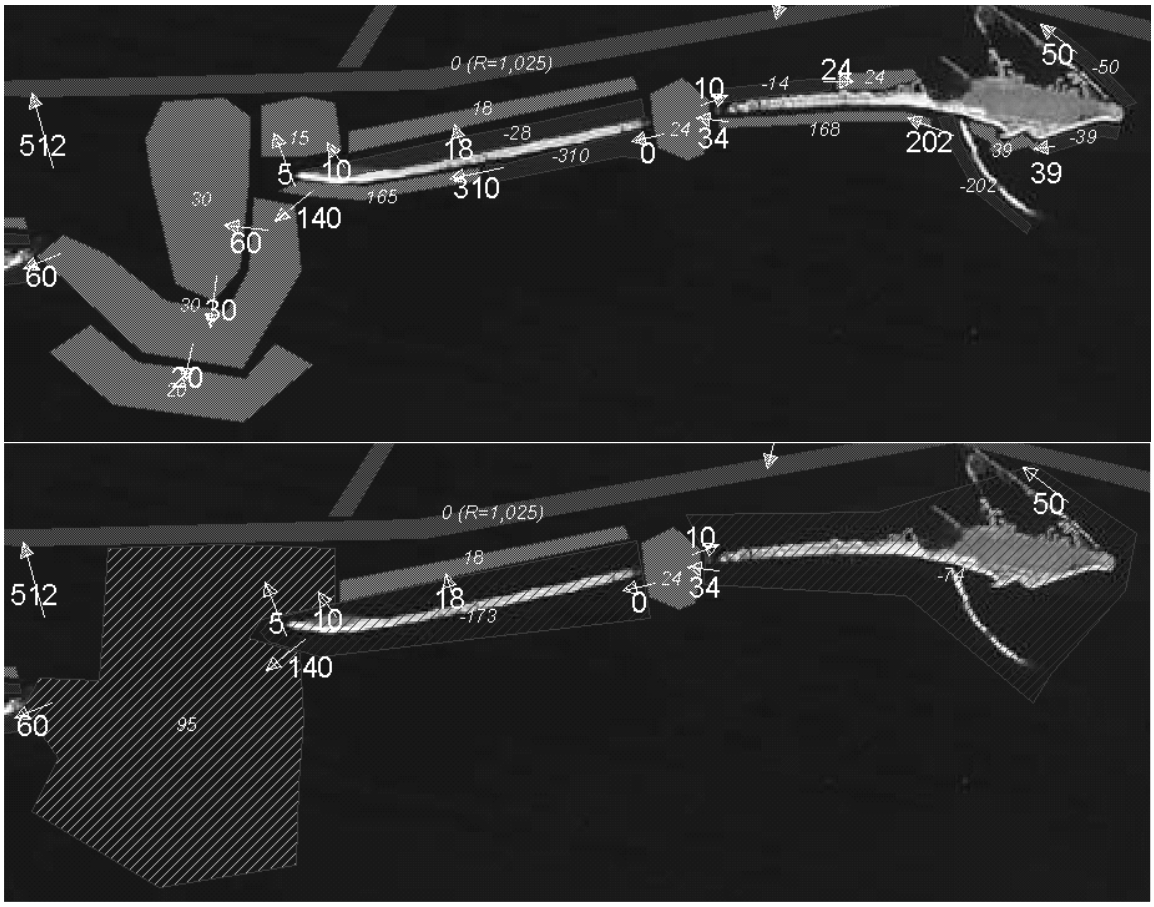


Figure 2.12-9. Hypothetical present-day sediment budget and macrobudget: Dauphin Island and Petit Bois Pass (thousands of cy/yr).

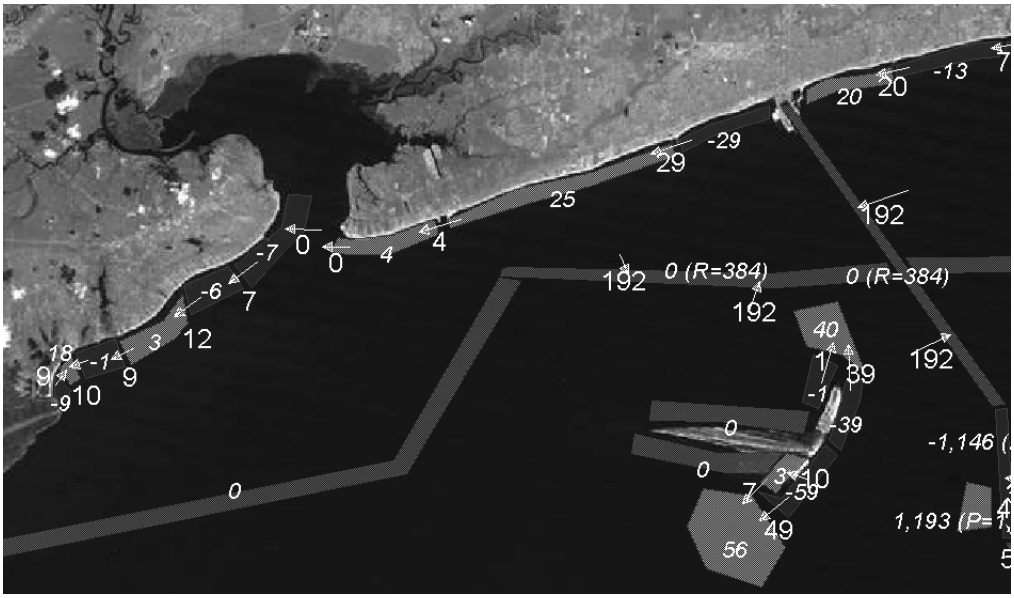


Figure 2.12-10. Hypothetical present-day sediment budget: Hancock County, Gulfport Harbor Channel, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

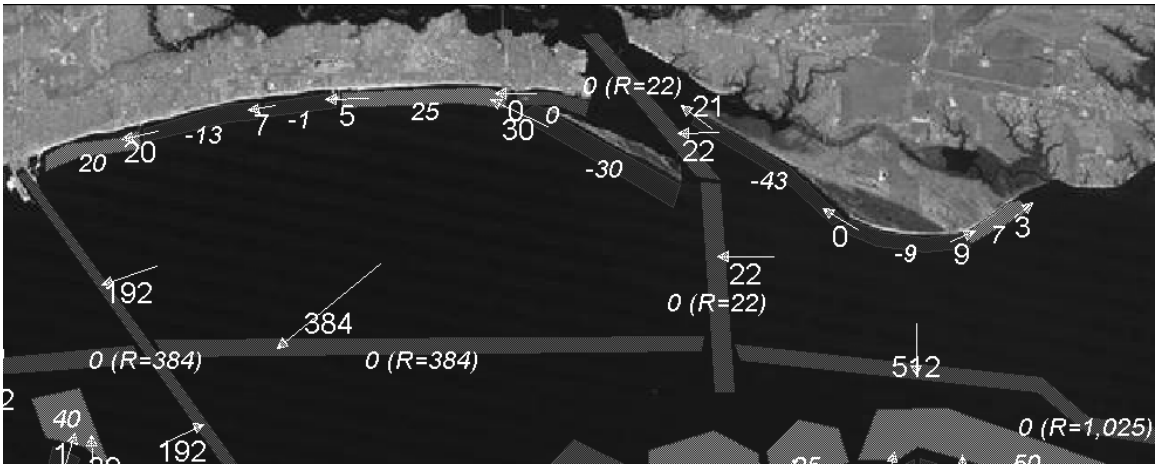


Figure 2.12-11. Hypothetical present-day sediment budget: Harrison County, Pascagoula Harbor Channel, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

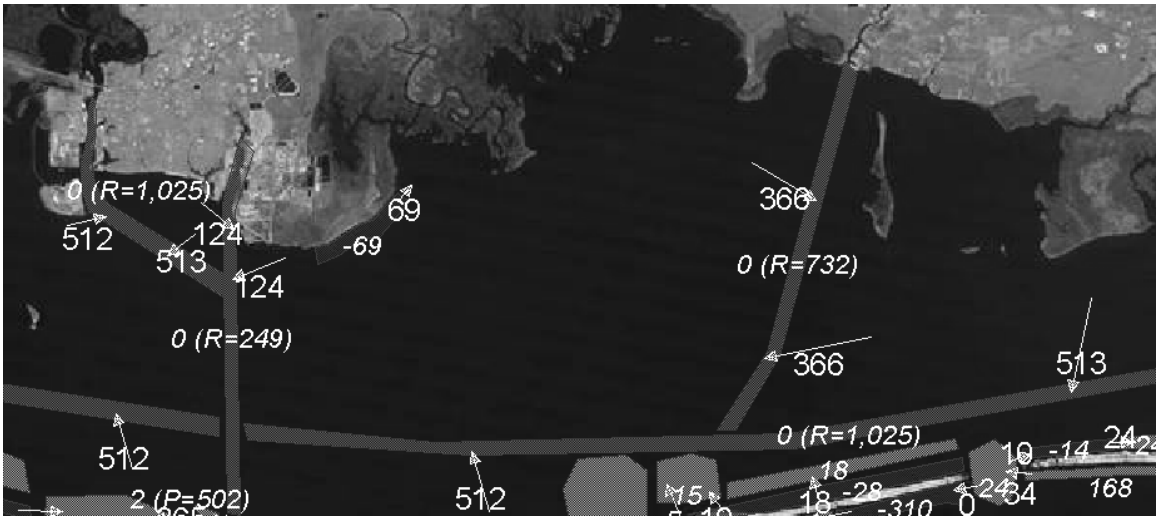


Figure 2.12-12. Hypothetical present-day sediment budget: Jackson County, Bayou La Batre, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

Knowledge gained through this study and recommendations that follow include the following:

(1) Cat Island is not a part of the barrier island littoral system represented by Dauphin, Petit Bois, Horn, and East and West Ship Islands. Cat Island is a separate morphologic feature that is naturally eroding due to waves, storm surge, and relative sea level rise in the region. Dredged sand that is placed in the littoral zone to the west of Ship Island Pass most likely will not be transported to Cat Island. Even in the absence of any engineering activities in Mississippi Sound, there is no evidence that sand from Ship Island would ever reach Cat Island.

(2) The net longshore sand transport rate for the barrier islands is from east-to-west. The barrier islands are migrating towards the west and, as they move west, also move the Passes between islands in a westerly direction. The source of sand for this region is the Mobile Pass ebb tidal shoal and the sandy shelf and shoreline to the east of Mobile Pass. Ship Island is the terminus of the longshore sand transport system in this region. Thus, the regional shortage of littoral sand will be most profoundly observed at Ship Island. We do observe disintegration of this barrier island, especially since Hurricane Katrina in 2005. We recommend that restoration of any barrier islands in

Mississippi Sound begin with Ship Island. In addition, we recommend back-passing sand dredged from Ship Island Pass, placing this sand either in Camille Cut, near East Ship Island, or in Dog Keys Pass. Sand can be placed in the surf zone (3 to 6-ft depths) and the natural longshore sand transport process will rebuild the island and begin to mend breaches.

(3) The historical sediment budget from 1917/20 to 1960/71 includes bathymetry change, shoreline position change, and dredging and placement practices representative of this period. However, data for the 1960/71 period are very sparse offshore of the barrier islands. This lends some uncertainty to the historical budget. In addition, Ship Island Pass and Horn Island Pass were deepened (and Horn Island was widened) in 1992/1993. Since that time, dredging rates have increased from those that occurred during the 1917/20 to 1960/71 period. Thus, the historical sediment budget is not representative of present-day dredging and placement activities, and has uncertainty with respect to bathymetric change offshore of the barrier islands. We recommend measurement of modern bathymetry (to 30 or 40-ft depths) and formulation of a sediment budget characterizing the period from 1917/20 (which has sufficient bathymetric coverage) to present-day.

(4) The historical analysis indicated that Horn Island has not experienced washover deposition across the entire island and has only been breached on a part of terminal spit during Hurricane Katrina (personal communication, Ms. Linda Lillycrop, May 2005). This cross-shore stability implies that the elevation and width of this barrier island might be a good template to evaluate for possible future restoration of the Mississippi Sound barrier islands.

(5) Wave modeling indicated that the mainland coast experiences a greatly reduced wave climate due to sheltering by the barrier islands fronting Mississippi Sound, as well as the Chandeleur Islands, and the Mississippi River's Bird's Foot delta. Restoration of the barrier islands could also consider lengthening the islands to recreate a previous historical footprint to provide additional wave protection for the mainland coast.

2.13 Flood Damage Analysis Model HEC-FDA

The Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) program uses risk-based analysis methods for evaluating flood damage and flood damage reduction alternatives. The program relies on hydrologic, hydraulic, and economic data input. Uncertainties in these data are input and used by the model for computing annual damages. The program's risk-based analysis methods conform to Corps of Engineers policy regulations (Ref. 1, 2) and technical procedures (Ref. 3).

Version 1.2.3b dated August 2007 was used. This is a customized version of the current official release version 1.2 dated March 2000. The official version computes uncertainty using the method of order statistics as described in ETL 1110-2-537. Because uncertainty distributions for the synthetic portion of the stage-frequency curves used for these evaluations were developed using methods different than order statistics, customization by the HEC was required in order to permit user-specified stage-frequency uncertainty as discussed in Section 2.13.2. Detailed model information is contained in the HEC-FDA User's Manual (Ref. 4).

This section of the Engineering Appendix deals primarily with the model's hydrologic and hydraulic input. The Economic appendix describes the economic input and results. The MsCIP Main Report describes how the model output was examined and used in the plan formulation process.

2.13.1 Model Overview

Generally, HEC-FDA computes flood damages for a given area by integrating the flooding source's annual stage-frequency curve with that area's structure inventory's stage-damage curve, resulting in

a damage-frequency curve. The stage-frequency curve reflects the annual probability of a stage, or water surface elevation, being equaled or exceeded and the resulting damage-frequency curve represents the annual probability that a given dollar amount of damage will be equaled or exceeded. Uncertainty is accounted for by sampling the stage-frequency and stage-damage curves throughout their respective uncertainty ranges using an iterative numerical process called Monte Carlo simulation and the expected annual damage (otherwise known as the probability weighted average annual damage) with uncertainty is determined. Expected annual damage is the mean estimate of annual damage obtained from the resultant annual damage probability distribution. There are numerous permutations of economic output according to the plan (including the no-action plan and alternative plan(s)), year, and subject area. MsCIP economic input and output is discussed in detail within the economic appendix.

2.13.2 Methodology

HEC-FDA models were developed and model simulations were carefully constructed and executed to systematically evaluate flood damage risk and the effectiveness of various storm damage reduction measures, individually and combined, for reducing flood damage risk. All plans and measures were evaluated against a range of sea level rise scenarios (no rise, 'expected' rise, and 'high' rise).

2.13.2.1 Planning Sub-units

FDA models were developed for each coastal Mississippi county: Hancock, Harrison, and Jackson counties). Each county represents a planning unit, and each was further delineated into planning sub-units (PSU). Each planning sub-unit is an HEC-FDA 'damage reach.' The planning subunits are shown in Figures 2.13-1 through 2.13-3. The planning units were numbered only for bookkeeping purposes. The PSU's were extended inland to early (Fall 2006) estimates of the inland limit of surge-induced flooding and do not cover the entirety of each county. Political boundaries, source of flooding, topography, development density, potential surge inundation limits, and preliminary Lines of Defense (LOD) alignments were also considered when delineating the sub units. Where these factors did not clearly dictate where PSU boundaries might exist, or where the planning units were so large as to bring into question the whether the flooding threat for that planning unit might be reasonably approximated by a single stage-frequency curve, circa 2001 hurricane surge atlases (Ref. 5) were used to interpret where they might be located such that that PSU's representative stage-frequency curve would be representative of the surge still water elevation to +/- 1 foot. There are ten PSU's in Hancock County, 19 in Harrison County, and 26 in Jackson County.

2.13.2.2 Stage-Frequency Curve Overview

The source of flooding is Mississippi Sound with the primary cause being severe tropical system disturbance of that water body. Stage datum is the North American Vertical Datum of 1988 (NAVD '88). Stage-frequency curves were developed for each PSU from (a) long-term Mobile District tide gage data for Biloxi no. 02480350, Gulfport no. 02481341, and Pascagoula no. 02480301 through the 2005 calendar year; and (b) hydrodynamic simulation modeling conducted at the Engineer Research and Development Center (ERDC) in Vicksburg, MS. USACE tide gage records are discussed in Chapter 1.3, and the hydrodynamic modeling effort is described in Chapter 2. The USACE Gulfport, Biloxi, and Pascagoula tide locations correspond to hydrodynamic model 'save points' (a location for which detailed hydrodynamic output was obtained) 47, 15, and 14 respectively. The observed data were plotted at the median plotting position based on the period of record of each gage and graphically fit, while hydrodynamic plotting positions were determined by statistical analysis of the computed inundation surface as described by the save points; the resultant frequency curves were joined graphically resulting in a composite stage-frequency curve for each save point

location. The observed data generally constitute that portion of each stage-frequency curve between the 99.9 percent and 25 percent annual chance exceedance stages, while the ERDC results composing the balance of the curves out to the 1 in 1000 annual chance event. Each stage-frequency curve then is composed partly of one of the three gage data sets, and partly from one 'save point' output file.

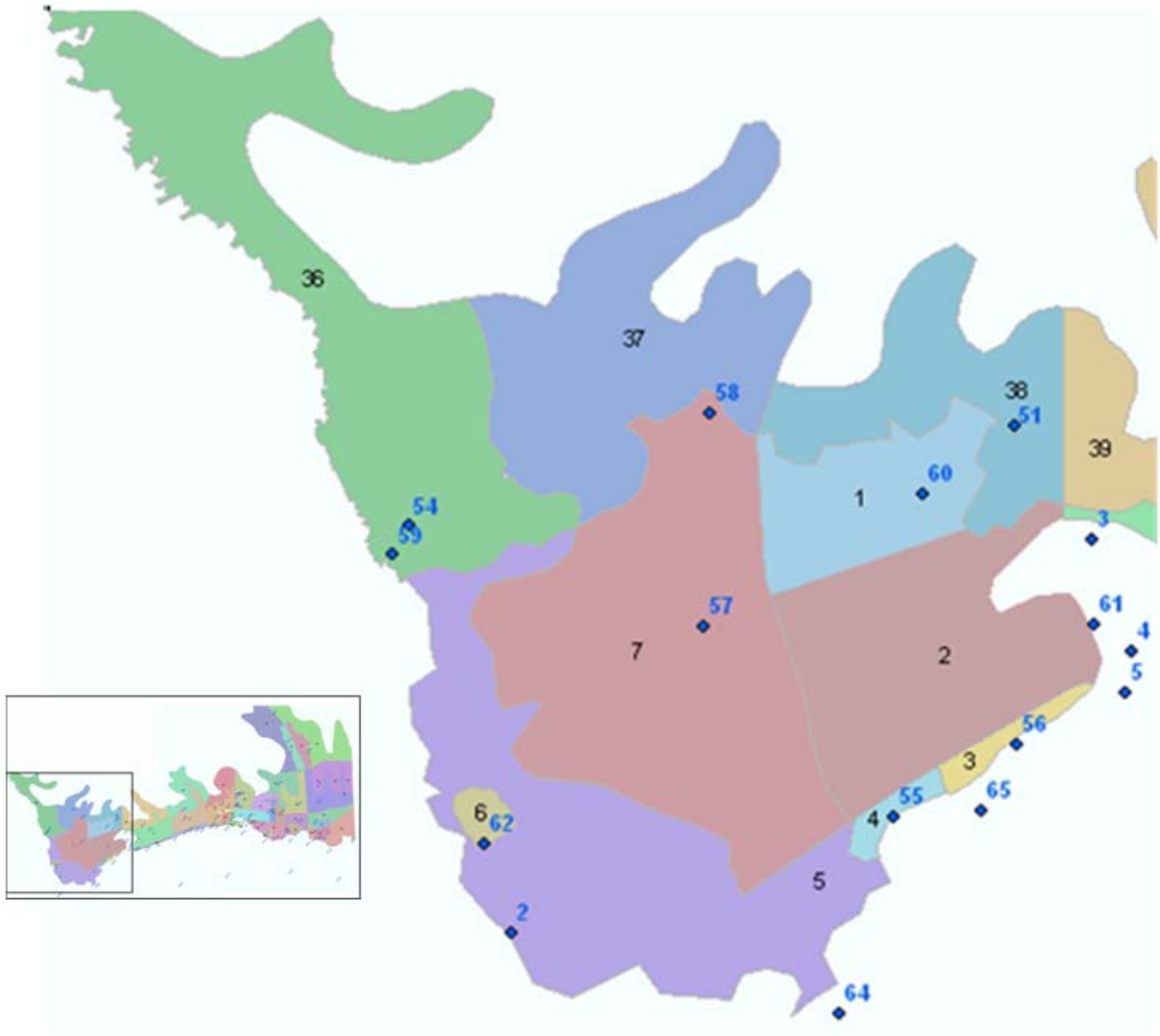
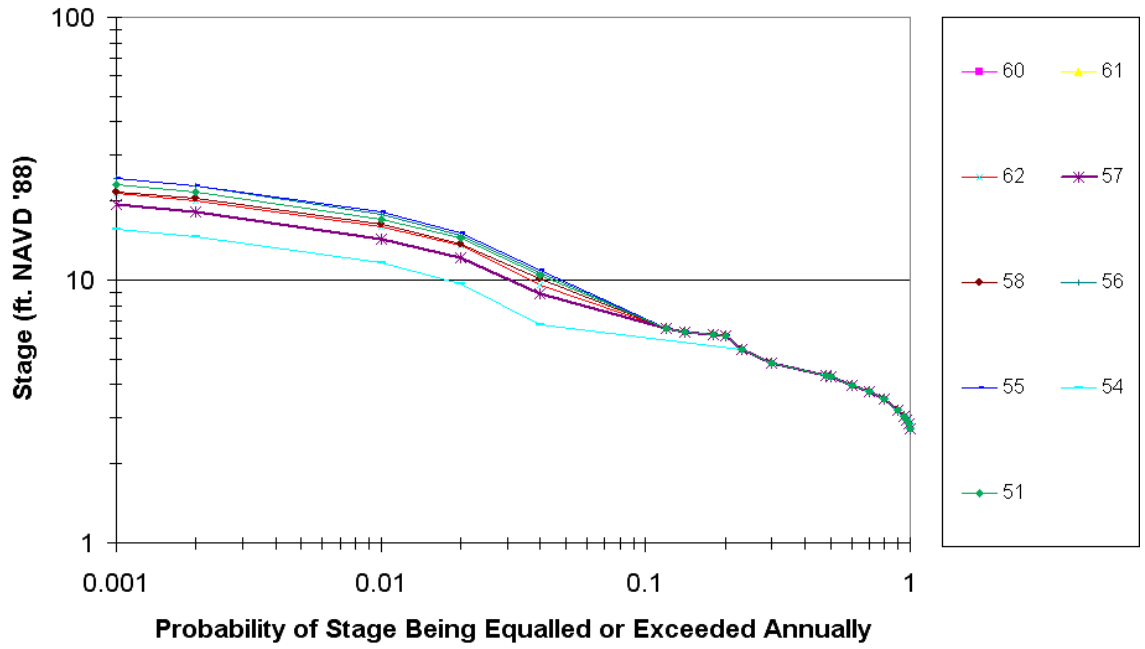


Figure 2.13-1. PSU's and Save Points, Vicinity of Hancock County



Note: Save points referenced to USACE Gulfport gage.

Figure 2.13-2. Composite Stage-Frequency Curves, Hancock Co. Save Points

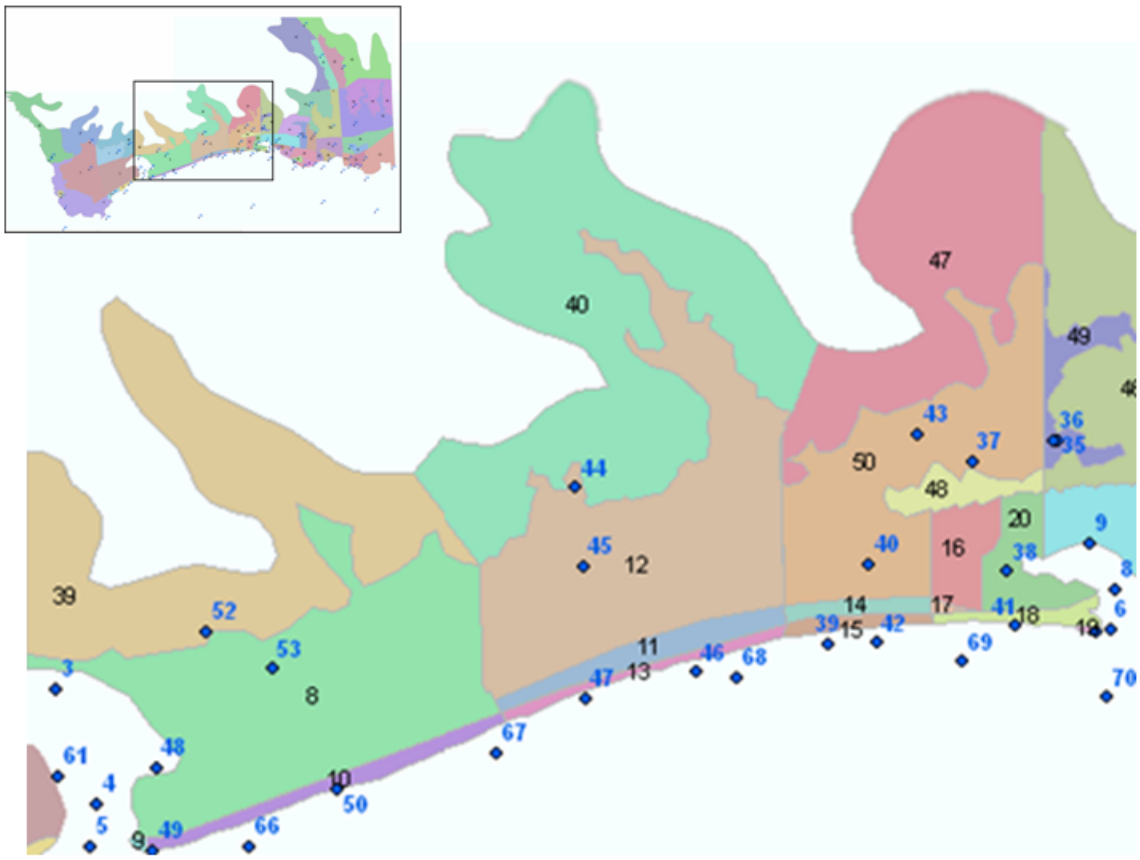


Figure 2.13-3. PSU's and Save Points, Vicinity of Harrison County

USACE technical guidance (Ref. 6) recommends the method of order statistics for computing uncertainty for graphical, synthetic, or composite frequency curves. Stage uncertainty at +/- 1 and +/- 2 standard deviations was computed by the method of order statistics using HEC-FDA Version 1.2 dated March 2000. Uncertainty for that portion of the curve described by hydrodynamic modeling results were estimated at one standard deviation by recently developed statistical methods described by Resio et. al. (Ref. 7). Uncertainties obtained by both methods were merged graphically. HEC-FDA Version 1.2 was modified by the HEC in order to allow direct input of these composite stage-frequency uncertainties.

The stage-frequency curves represent an estimate of the probability of a 'still water elevation' being equaled or exceeded in a calendar year. Waves are not explicitly accounted for in the stage-frequency curves; in other words, the observed or computed portions of each stage frequency curve have not been adjusted upward for surge-coincident wave amplitude[7]. This simplifying assumption is necessary for a variety of reasons, the most compelling being that (1) while participatory scientists agreed that existing shoreline and inundated area wave prediction methods are archaic and in need of revision, there is presently no regionally unified agreement as to how to treat them; (2) surge modeling evaluations do not provide for coincident unsteady freshwater inflow and (3) the level of effort required to develop representative wave information, particularly over inundated inhabited/developed areas where wave behavior is complex and highly variable, exceeded the scope and time available for this effort. While these issues may be overcome to various degrees by careful examination, such effort exceeds the scope and overall level of detail of this investigative phase. The impact of this assumption is that damages and benefits may be somewhat understated. The adopted method used does allow for a consistent evaluation between plans and is consistent with the overall level of study detail.

Each PSU's stage frequency curve was adjusted for future relative sea level rise as required by adding the computed sea level rise to the present stage for a given frequency. Adopted relative sea level rise predictions were derived from IPCC circa 2001 sea level rise predictions and are shown in Table 1.6-9.

The contribution of riverine or rainfall-runoff flood phenomena is not explicitly reflected in the FDA stage-frequency curves with the exception of tributary runoff and its contribution to Bay St. Louis and Biloxi Bay stage as a result of the surge barriers. This exception only applies for certain 'with-project' scenarios. That runoff should be neglected for FDA purposes at this stage of analysis is necessary one, given the relatively flat terrain and large number of sub-basins for which no previous hydrologic studies exist, and should not obscure coastal storm damage problems or opportunities. Should certain storm damage reduction measures be selected for further consideration, additional consideration will be given to quantifying the coincident nature of riverine flooding and coastal surge. Note that runoff has not been neglected in the conceptual design of the lines of defense, which provide dedicated water conveyances for the 24-hour, 25-year event rain event (no hurricane), and pumping for runoff coincident with hurricane storm events, as discussed in the Interior Drainage sections of Chapter 3.

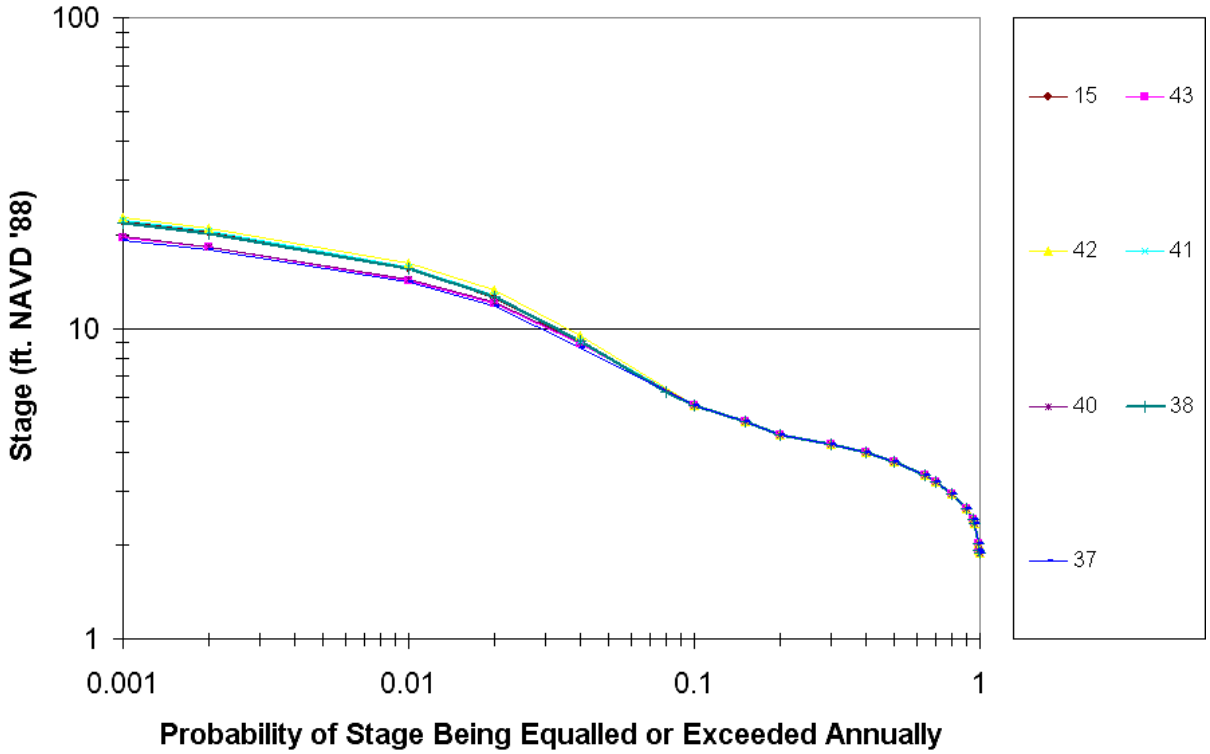
2.13.2.3 Assignment of Stage-Frequency Curves to Planning Sub Units

One stage-frequency curve is assigned to each Planning Sub Unit (PSU). Stage frequency curve components and assignments are displayed by Planning Unit (i.e. county) and PSU in Table 2.13-1. PSU (black numbering) and save point locations (blue numbering) are shown for Hancock, Harrison, and Jackson counties in figures 2.13-1, 2.13-3, and 2.13-6 respectively. Composite without-project stage-frequency curves are shown for Hancock County in Figure 2.13-2; for Harrison County in figures 2.13-4 and 2.13-5, and for Jackson County in figures 2.13-7, 2.13-8.

[7] The contribution to surge due to wave radiation stresses is accounted for as discussed in Chapter 2.

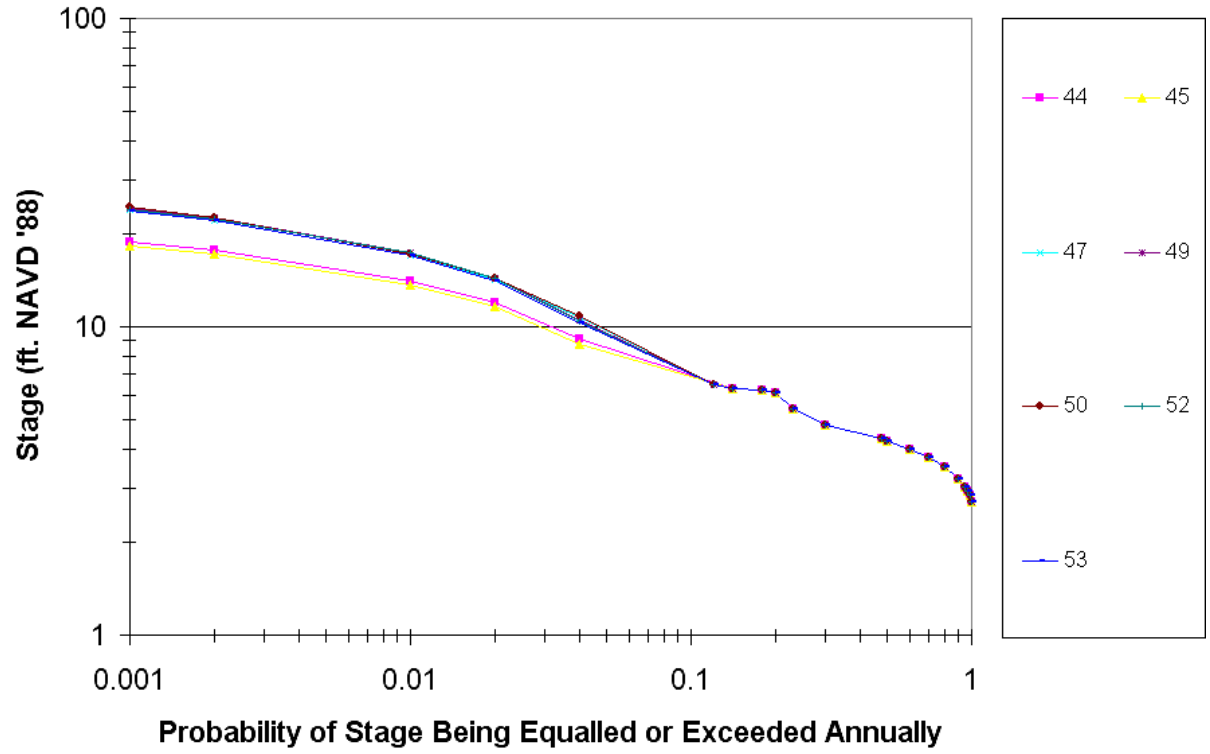
Table 2.13-1.
Stage-Frequency Curve Components and Assignments

County	PSU Number	Assigned Tide Gage	Assigned Save Point Number	County	PSU Number	Assigned Tide Gage	Assigned Save Point Number
Hancock County	5	Gulfport	62	**Jackson County**	21	Biloxi	9
	2	Gulfport	61		22	Biloxi	33
	1	Gulfport	60		23	Biloxi	29
	36	Gulfport	54		24	Biloxi	32
	6	Gulfport	62		25	Biloxi	25
	3	Gulfport	56		26	Biloxi	1
	4	Gulfport	55		27	Biloxi	30
	37	Gulfport	58		28	Biloxi	30
	7	Gulfport	57		29	Pascagoula	30
	38	Gulfport	51		30	Pascagoula	27
Harrison County	8	Gulfport	53		31	Pascagoula	26
	9	Gulfport	49		32	Pascagoula	23
	10	Gulfport	50		33	Pascagoula	17
	11	Gulfport	47		34	Pascagoula	18
	12	Gulfport	45		35	Pascagoula	20
	13	Gulfport	47		41	Biloxi	28
	14	Biloxi	42		42	Pascagoula	17
	15	Biloxi	42		43	Pascagoula	24
	16	Biloxi	38		44	Pascagoula	19
	17	Biloxi	42		45	Pascagoula	18
	18	Biloxi	41		46	Biloxi	35
	19	Biloxi	15		49	Biloxi	35
	20	Biloxi	38		51	Pascagoula	21
	39	Gulfport	52		52	Pascagoula	22
	40	Gulfport	44		53	Pascagoula	11
	47	Biloxi	43		54	Pascagoula	21
	48	Biloxi	37				
	50	Biloxi	40				



Note: Save points referenced to USACE Biloxi gage.

Figure 2.13-4. Composite Stage-Frequency Curves, Harrison Co. Save Points



Note: Save points referenced to USACE Gulfport gage.

Figure 2.13-5. Composite Stage-Frequency Curves, Harrison Co. Save Points (cont.)

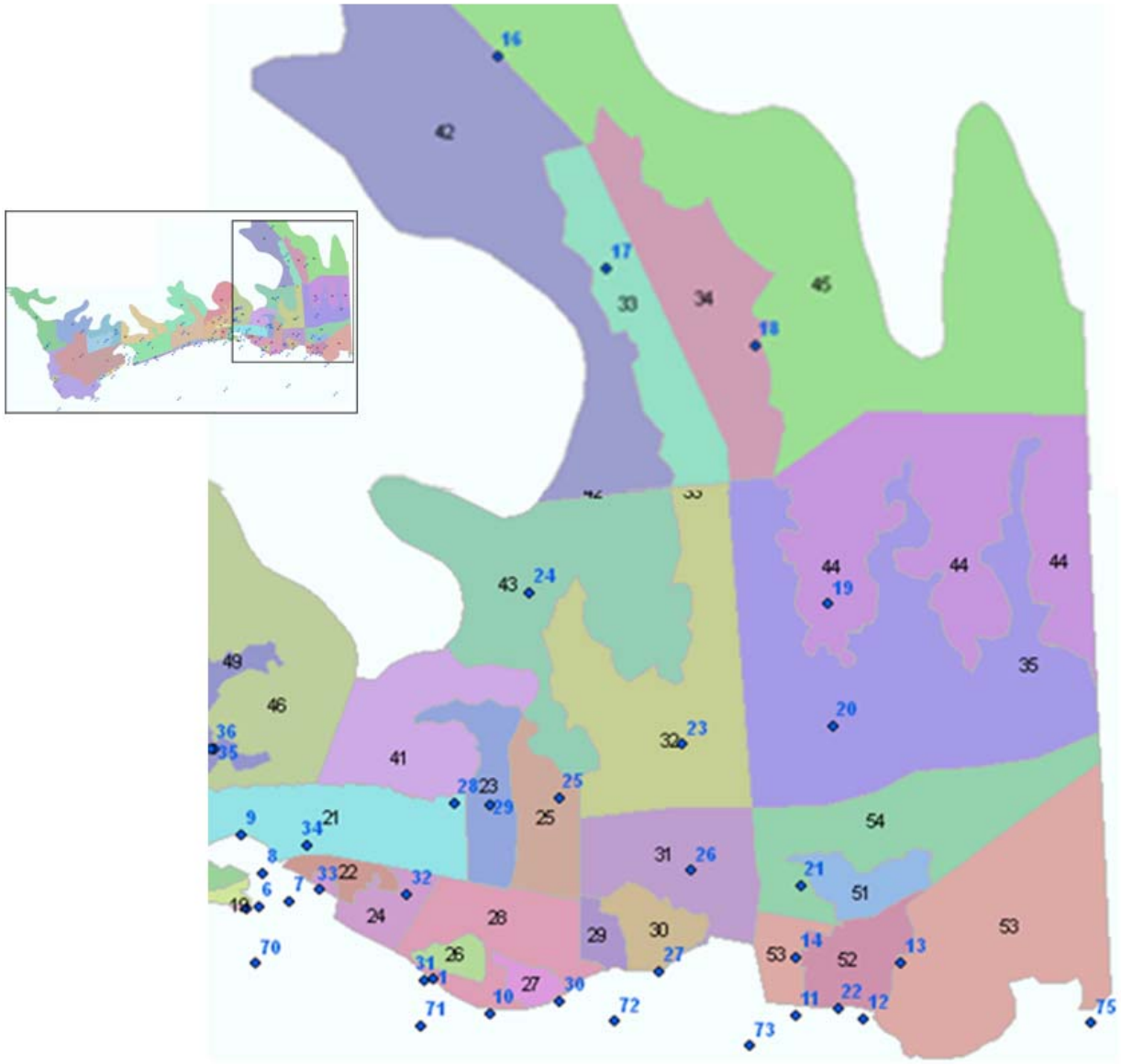
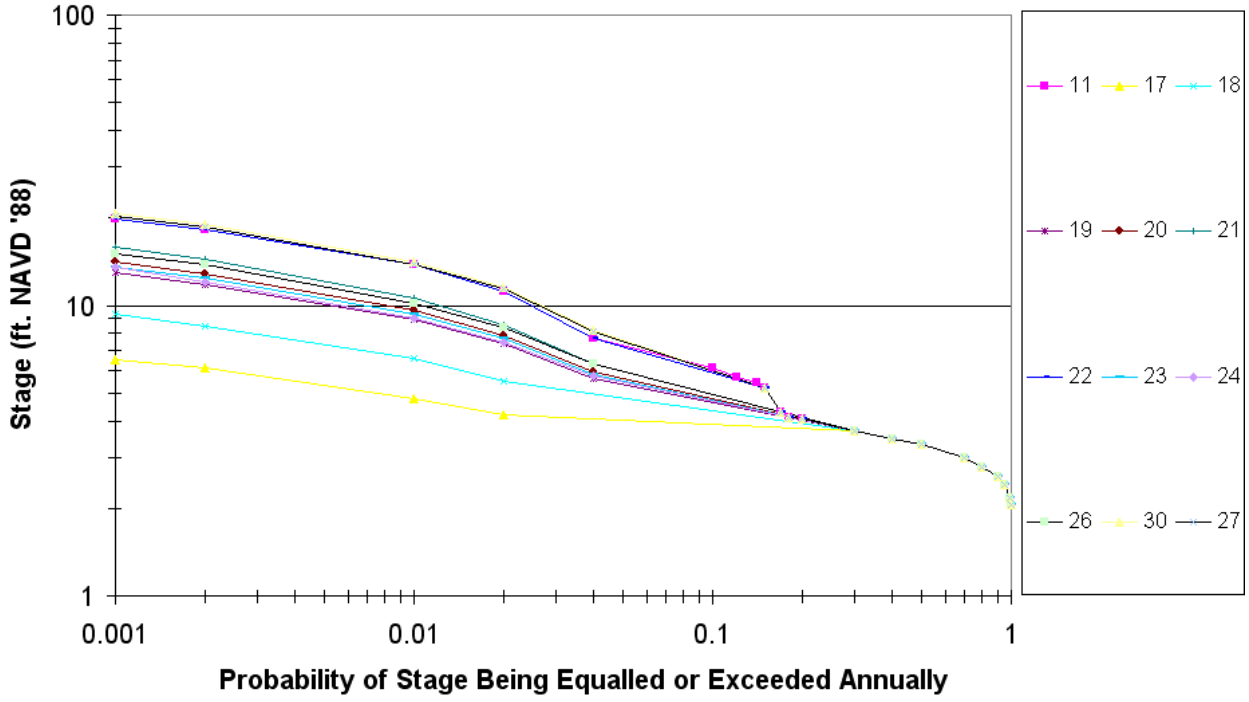
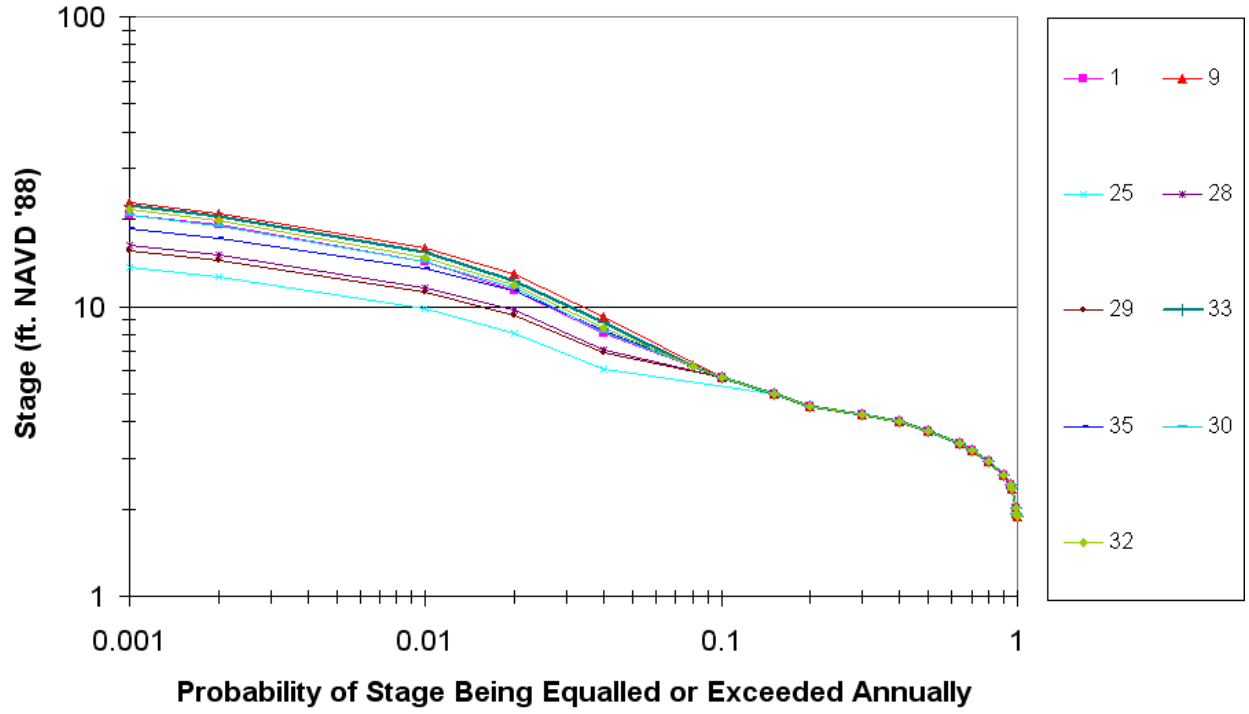


Figure 2.13-6. PSU's and Save Points, Vicinity of Jackson County



Note: Save points referenced to USACE Pascagoula gage.

Figure 2.13-7. Composite Stage-Frequency Curves, Jackson Co. Save Points



Note: Save points referenced to USACE Biloxi gage.

Figure 2.13-8. Composite Stage-Frequency Curves, Jackson Co. Save Points (cont.)

2.13.2.4 Scenarios

A number of scenarios, or plans, were evaluated. Scenarios include the existing condition; the future without-project; and the future with-project. The existing condition is the assumed condition for the base year 2012. The future without-project is an 'average' of future conditions over the project lifetime, which in this case is presumed to be 100 years. Existing condition and without-project evaluations differ only in their assumed structure inventories, which were varied to evaluate the sensitivity of computed damages to reconstruction patterns. Without-project conditions were also evaluated against 'expected' and 'high' sea level rise scenarios to test damage sensitivity to sea level rise uncertainty. Existing condition and without-project scenarios are shown in Table 2.13-2.

Table 2.13-2.
Existing Condition and Without-Project Scenario HEC-FDA Simulations

Run	County	Structure Inventory	MLFY (2111) Sea Level Scenario
1	Hancock	EC	Existing Sea Level
2	Harrison	EC	Existing Sea Level
3	Jackson	EC	Existing Sea Level
4	Hancock	Residential	Existing Sea Level
5	Hancock	Commercial/Condo	Existing Sea Level
6	Hancock	Residential	'Expected'
7	Hancock	Commercial/Condo	'Expected'
8	Hancock	Residential	High Sea Level Rise
9	Hancock	Commercial/Condo	High Sea Level Rise
10	Hancock	Residential	Existing Sea Level
11	Harrison	Commercial/Condo	Existing Sea Level
12	Harrison	Residential	'Expected'
13	Harrison	Commercial/Condo	'Expected'
14	Harrison	Residential	High Sea Level Rise
15	Harrison	Commercial/Condo	High Sea Level Rise
16	Harrison	Residential	Existing Sea Level
17	Jackson	Residential	'Expected'
18	Jackson	Residential	High Sea Level Rise

The future with-project condition represent an average of future conditions over the project lifetime with the incorporation of storm damage reduction measures, individually or in combination, in place. A number of model evaluations were structured in order to test the effectiveness of any one measure (e.g. Line of Defense 4) in the absence of all other measures for reducing without-project expected annual damages. The evaluations also provide for a cursory evaluation of measure performance with respect to uncertainty as to the rate of future sea level rise. The intent of structuring the model runs in this manner was to help identify measures that may warrant further consideration. Generally, the primary modeling differences between with-project conditions for a given planning unit rest (a) in the structural inventories attributed to the base year and most likely future year (MLFY); (b) the treatment of stage-frequency curves to reflect the presence of storm damage reduction measures; and (c) stage-frequency curve adjustments for sea level rise. Structure inventory assumptions are described in the Economics appendix.

With-project HEC-FDA evaluations are shown in Table 2.13-3. The simulations are grouped by county. Each measure is tested against a sea level rise scenario. The measures are assumed to remain 'as-built' (i.e. they are not significantly changed over their lifetime, and are not raised

according to the sea level rise that is assumed). Additional measures (e.g. Menge Avenue, Hancock Co. ring levee, etc.) have since been added under this program but have not been fully developed for economic evaluations at press time for this document; future versions of this document will be revised to reflect evaluation of the additional measures.

Table 2.13-3.
HEC-FDA Individual Measures Scenario Simulations

Run	County	Measure	MLFY (2111) Sea Level Scenario	Run	County	Measure	MLFY (2111) Sea Level Scenario
1	Hancock	LOD4-20'	Existing Sea Level	42	Harrison	LOD4-20'	'High' sea level
2	Hancock	LOD4-30'	Existing Sea Level	43	Harrison	LOD4-30'	'High' sea level
3	Hancock	LOD4-40'	Existing Sea Level	44	Harrison	LOD4-40'	'High' sea level
4	Hancock	Seawall	Existing Sea Level	45	Harrison	Seawall	'High' sea level
5	Hancock	Pearlington 20'	Existing Sea Level	46	Harrison	Nonstruct 1	'High' sea level
6	Hancock	Pearlington 30'	Existing Sea Level	47	Harrison	Nonstruct 2	'High' sea level
7	Hancock	Nonstruct 1	Existing Sea Level	48	Harrison	Turkey Ck.	'High' sea level
8	Hancock	Nonstruct 2	Existing Sea Level	49	Jackson	LOD4-20'	Existing Sea Level
9	Hancock	SHORELINE	Existing Sea Level	50	Jackson	LOD4-30'	Existing Sea Level
10	Hancock	LOD4-20'	'Expected' sea level	51	Jackson	LOD4-40'	Existing Sea Level
11	Hancock	LOD4-30'	'Expected' sea level	52	Jackson	Seawall	Existing Sea Level
12	Hancock	LOD4-40'	'Expected' sea level	53	Jackson	Ring Dike 20'	Existing Sea Level
13	Hancock	Seawall	'Expected' sea level	54	Jackson	Ring Dike 30'	Existing Sea Level
14	Hancock	Pearington 20'	'Expected' sea level	55	Jackson	Nonstruct 1	Existing Sea Level
15	Hancock	Pearlington 30'	'Expected' sea level	56	Jackson	Nonstruct 2	Existing Sea Level
16	Hancock	Nonstruct 1	'Expected' sea level	57	Jackson	Bayou Cumbest	Existing Sea Level
17	Hancock	Nonstruct 2	'Expected' sea level	58	Jackson	LOD4-20'	'Expected' sea level
18	Hancock	Shoreline	'Expected' sea level	59	Jackson	LOD4-30'	'Expected' sea level
19	Hancock	LOD4-20'	'High' sea level	60	Jackson	LOD4-40'	'Expected' sea level
20	Hancock	LOD4-30'	'High' sea level	61	Jackson	Seawall	'Expected' sea level
21	Hancock	LOD4-40'	'High' sea level	62	Jackson	Ring Dike 20'	'Expected' sea level
22	Hancock	Seawall	'High' sea level	63	Jackson	Ring Dike 30'	'Expected' sea level
23	Hancock	Pearington 20'	'High' sea level	64	Jackson	Nonstruct 1	'Expected' sea level
24	Hancock	Pearlington 30'	'High' sea level	65	Jackson	Nonstruct 2	'Expected' sea level
25	Hancock	Nonstruct 1	'High' sea level	66	Jackson	Bayou Cumbest	Existing Sea Level
26	Hancock	Nonstruct 2	'High' sea level	67	Jackson	LOD4-20'	'High' sea level
27	Hancock	Shoreline	'High' sea level	68	Jackson	LOD4-30'	'High' sea level
28	Harrison	LOD4-20'	Existing Sea Level	69	Jackson	LOD4-40'	'High' sea level
29	Harrison	LOD4-30'	Existing Sea Level	70	Jackson	Seawall	'High' sea level
30	Harrison	LOD4-40'	Existing Sea Level	71	Jackson	Ring Dike 20'	'High' sea level
31	Harrison	Seawall	Existing Sea Level	72	Jackson	Ring Dike 30'	'High' sea level
32	Harrison	Nonstruct 1	Existing Sea Level	73	Jackson	Nonstruct 1	'High' sea level
33	Harrison	Nonstruct 2	Existing Sea Level	74	Jackson	Nonstruct 2	'High' sea level
34	Harrison	Turkey Creek	Existing Sea Level	75	Jackson	Bayou Cumbest	Existing Sea Level
35	Harrison	LOD4-20'	'Expected' sea level				
36	Harrison	LOD4-30'	'Expected' sea level				
37	Harrison	LOD4-40'	'Expected' sea level				
38	Harrison	Seawall	'Expected' sea level				
39	Harrison	Nonstruct 1	'Expected' sea level				
40	Harrison	Nonstruct 2	'Expected' sea level				
41	Harrison	Turkey Ck.	'Expected' sea level				

2.13.2.5 Scenario Stage-Frequency Curves

As discussed previously, the stage-frequency curves used in HEC-FDA analyses were composed from observed tide gage data and from hydrodynamic modeling results. In support of the HEC-FDA effort, the hydrodynamic modeling evaluated the existing condition; Line of Defense (LOD) 4 alone; and LOD 3 plus ring levees. Additional simulations could not be accomplished for this program. The LOD's and ring dikes were coded into the hydrodynamic terrain database of their respective hydrodynamic models as 'infinitely high walls', thus obtaining an estimate of the height of the LOD required to contain a given annual chance event from model output nodes located seaward of each LOD. LOD's 3 and 4 are discussed in detail in Chapter 3.

Existing condition stage-frequency curves (adjusted for sea level rise as required) were used for all damage reaches in many of the measure evaluations listed in Table 2.13-3.

For future with-project HEC-FDA evaluations involving individual measures, stage-frequency curve development required use of either existing condition hydrodynamic model output, or LOD hydrodynamic model output, or both, depending upon the location of both the PSU and that PSU's hydrodynamic model save point with respect to the line of defense. Additional consideration was required if the PSU was subject to induced runoff storage due to Bay St. Louis or Biloxi Back Bay closure structures. The following paragraphs describe the methodology used to develop stage frequency curves for the with-project scenarios involving individual measures.

- *Save Point and PSU behind levee or ring-dike.* For example, consider PSU 7 and its representative save point (57) in Hancock County as shown in Figure 2.13-1. This PSU is located behind both of the conceptual LOD3 and 4 alignments. This case is typical of many inland PSU's that do not border Biloxi Bay or Bay St. Louis. For this circumstance, the existing condition stage-frequency curve is used and PSU is coded into HEC-FDA as being protected to the prescribed LOD crest elevation. The existing condition stage-frequency curve is used because the with-LOD save point is essentially 'dry' due to the infinite wall approach in the hydrodynamic modeling. The interior water surface elevation is assumed to equal the stage-frequency curve stage for all events exceeding the levee crest elevation.

- *Save Point in front of levee and PSU behind levee or ring dike.* Consider PSU 11 and its representative save point (47) in Harrison County as shown in Figure 2.13-3. This PSU is also located behind the prospective LOD 3 and 4 alignments, but it's representative save point is outside (seaward) of the LOD's. This case is typical of nearshore and ring-levee PSU's. The stage-frequency curve was developed from observed gage data and the appropriate ERDC LOD model output and coded into HEC-FDA as being protected by a levee to the prescribed LOD crest elevation. As with the previous case, the interior water surface elevation is assumed to equal the stage-frequency curve stage for all events exceeding the levee crest elevation.

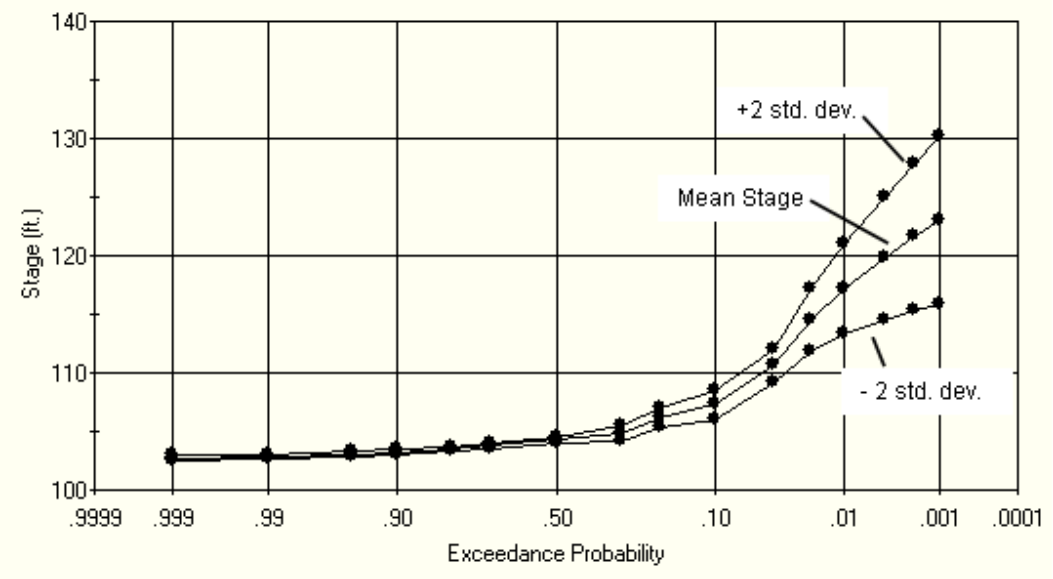
- *Save Point and PSU behind levee and PSU is subject to induced stage due to closure structures across bays.* As with the '*Save Point and PSU behind LOD'* situation, this situation also utilizes the existing conditions stage-frequency curve but the HEC-FDA levee routine cannot be invoked because streamflow into Bay St. Louis and Biloxi Bay will cause their water surface elevations to rise when the surge barriers are closed to prevent hurricane surge inundation. Existing condition frequency curves (e.g. Figure 2.13-9) were transformed (e.g. Figure 2.13-10 for the LOD4 at 20' crest elevation) graphically using the following assumptions:

    - The surge barriers would be operated for extreme hurricanes only, on average once every twenty years (e.g. hurricanes resembling H. Katrina, H. Betsy, H. Camille, or the 1947 or 1915 hurricanes etc.)

- Closure of the barriers would result in Bay St. Louis and Biloxi Bay water surface elevations rising to elevation 6.8 ft. and 8.4 ft NAVD ’88, respectively based on preliminary hydrologic analyses (see Chapter 3.4).
- Should the crest elevation of the barrier be such that it overtopped, the representative existing condition stage would rapidly be attained.

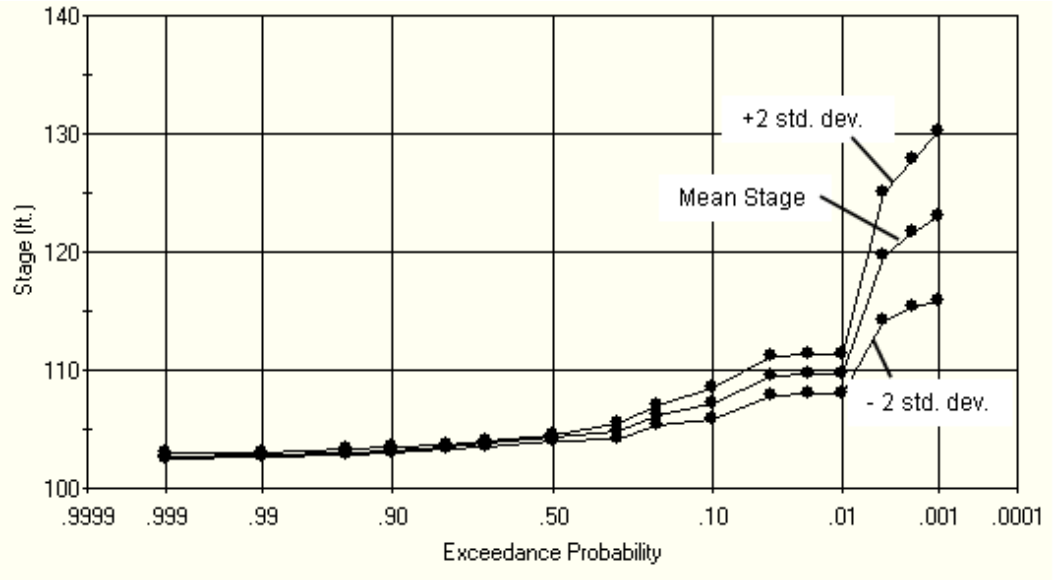
As mentioned previously, Most Likely Future Year (MLFY) stage frequency curves were adjusted for future sea level rise by adding the predicted rise to stage for a given frequency.

Flood damage evaluation results are reported in the Economics Appendix.



Note: 100 ft. added to stage for HEC-FDA computational purposes.

Figure 2.13-9. Existing Condition Frequency Curve, PSU 1 Save Point 60, Hancock Co.



Note: 100 ft. added to stage for HEC-FDA computational purposes.

Figure 2.13-10. Transformed Frequency Curve, PSU 1 Save Point 60, Hancock Co.

2.13.3 References

USACE (2000). Planning Guidance Notebook. Engineer Regulation ER 1105-2-100. Department of the Army, US Army Corps of Engineers, Washington, D.C. 22 April 2000.

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USACE (1998). HEC-FDA Flood Damage Reduction Analysis User's Manual. Hydrologic Engineering Center. Davis, CA. March 1998.

FEMA, USACE (2001). Hurricane Surge Atlas. Harrison County, Hancock County, Jackson County, Mississippi. Federal Emergency Management Agency Region 4 and US Army Corps of Engineers, Mobile District. January 2001.

USACE (1997). Uncertainty Estimates for Nonanalytic Frequency Curves. Engineering Technical Letter ETL 1110-2-537. US Army Corps of Engineers. Washington, DC. 31 October 1997.

Resio, D.T. (2007). White Paper on Estimating Hurricane Inundation Probabilities. Version 11. US Army Corps of Engineers, Engineer Research and Development Center. Vicksburg, MS. April 2007.

2.14 Lines of Defense Crest Elevation Analyses

Evaluations were conducted to estimate the required levee crest elevation in order to provide protection to the one in one hundred (1%), one in five hundred (0.2%), and one in one thousand (0.1%) annual chance exceedance surge events.

Typical levee and elevated roadway sections are shown in Figures 2.14-1 and 2.14-2. The crest elevations shown on the typical levee section were used to generate levee cost-height curves, and should not be interpreted to be design elevations. Design elevations follow from performance and cost effectiveness objectives as discussed in the main report.

Resultant crest elevations are a function of the surge still water elevation, wave height, wave period, levee slope, levee surface roughness, nearshore depth, nearshore slope, and the seaward levee side slope. Still water elevations for the given events were obtained for the nearest representative save points using the same ERDC results comprising the synthetic portions of the composite stage frequency curves. ERDC also provided mean estimates of the 1%, 0.2%, and 0.1% significant wave height (Hs) and peak period (Tp) estimates based on statistical analyses of with-project (either LOD3 or LOD4) STWAVE model results. Wave characteristics were computed independently of surge characteristics. Surge elevation, Hs, and Tp determinations are given in Chapter 2.9 of this appendix. Nearshore depth and geometry was estimated from a limited number of beach profiles (i.e. sections normal to the shoreline) obtained by Mobile District; and/or from interpretation of existing USGS topographic maps; and/or from interpretation of post-Katrina, LIDAR-derived topography. Levee side-slopes were assumed to be 3 to 1 (horizontal to vertical) with a mowed grass face except as noted in following paragraphs.

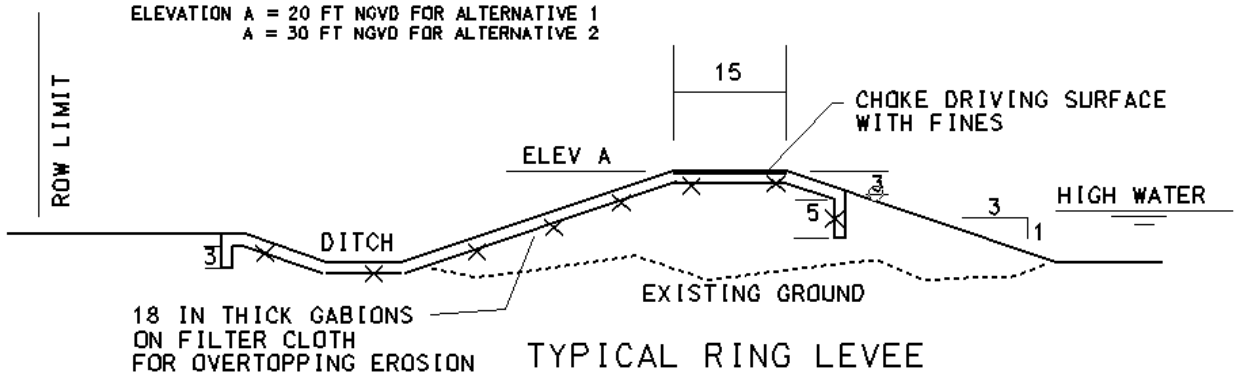
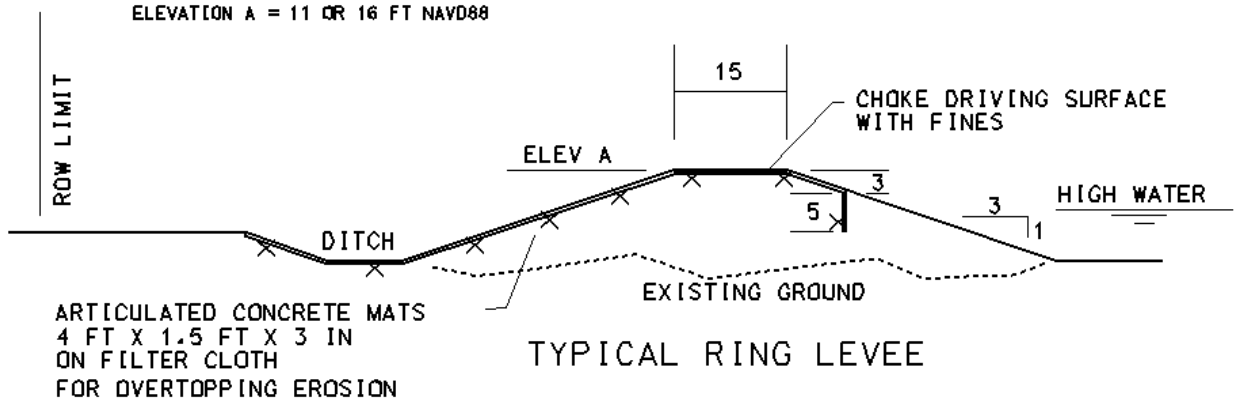


Figure 2.14-1. Typical Section, Levees



Source: ERDC, Steven Hughes

Figure 2.14-2. Typical Section, Elevated Roadway

Computations generally followed those prescribed in a recent, though draft, USACE Technical Letter (Ref. 1). Crest elevations for a given event assumed coincident occurrence of percent chance event surge and wave characteristics; in other words, the crest elevation computations for the 1% event assumed coincident occurrence of the mean 1% Hs, 1%Tp, and 1% surge elevations. Because Tp and Hs percentiles were computed independently of surge elevations, this assumption is thought to yield somewhat conservative results (Ref. 1). Computations were performed using Table VI-5-11 (van der Meer and Janssen's equation) of the Coastal Engineering Manual (CEM) Professional Edition software, version 2.0.1.1. All gamma factors in the underlying equation were assigned a value of unity. The presence of other potentially complementary project features, such as sand dunes and berms, was neglected.

Adequate protection was defined for these preliminary purposes as the crest elevation for which the computed average overtopping rate for each event was on the order of 0.01 cubic feet per second per foot (cfs/ft), which is equivalent to an average overtopping discharge rate of 10 cfs per 1,000 feet of levee. This rate is less than the 0.1 cfs/ft which is currently being considered as an appropriate

threshold for well-designed and constructed coastal levee defenses, but this higher rate is best applied in conjunction with conditional probability methods; the lower rate assumed herein was judged appropriate for these preliminary purposes given the limited spatial extents of model output and the deterministic methods otherwise employed.

The information available for these computations allows for just a few spot estimates of requisite levee elevations. Those elevations presented in following paragraphs should be understood to be applicable to a discreet location and not interpreted to describe the crest elevation of any particular line of defense throughout its entire length. Should a levee or other structural line of defense measure be selected for additional investigation, a much higher density of well positioned surge, wave, and geometric information would be needed in order to adequately define the required levee profile along its length for the desired level of performance. These computations are deterministic thought in most instances the results are expected to agree reasonably with results determined through a probabilistic conditional probability simulation.

2.14.1 Line of Defense 3

Computed crest elevations for locations along LOD 3 are given in Table 2.14-1. Crest elevations given are reported in feet NAVD ’88 datum. Locations at which the elevations were computed are shown in Figures 2.14-3 through 2.14-11. Computed crest elevations range from elevation 13 feet to 53 feet over the range events. For the one in 100 chance events, computed crest elevations range from 13 to 37 feet, with most locations yielding elevations in the high teens to mid twenties. In some instance, such as the Harrison County elevated roadway, the computed elevation is on the order of 36 feet. Locations that yield these types of results would be inherently difficult to defend due to large surge depths, severe storm wave climates, and the absence of a shallow foreshore. The typical levee section is inappropriate where results such as these arise, which would probably be better defended perhaps by a levee with some or all of the following features: (a) a frontal berm seaward of the primary levee prism; (b) a flatter seaward slope (6 to 1 or greater); and (c) a roughened, hardened slope in lieu of grass. Such features would reduce the required height at a given location for a given event overtopping rate. Where possible, the levee height may also be reduced by removing the structure landward from the shoreline to an upslope location beyond the wave breaking zone. For example, the results in Table 2.14-1 suggest that the levee crest elevation at Pascagoula might be reduced from 37 feet to 19 feet by removing the levee from the shoreline to an alignment in the vicinity of Washington Avenue. Similar findings and recommendations apply when interpreting LOD 4 levee performance and attributes.

Table 2.14-1.
Computed Structure Crest Elevations, LOD 3

Feature and Location	Annual Event Chance		
LOD-3	**1 in 100**	**1 in 500**	**1 in 1000**
Hancock County			
Pearlington Levee	20	30	34
Bay St Louis Levee	22	38	42
Hancock Elevated Road, 11.0	N/A[1/]	N/A[1/]	N/A[1/]
Harrison County			
Harrison Elevated Road, 16.0	36[2/]	50[2/]	N/A[3/]
Jackson County			
Ocean Springs Elevated Road, 11.0			
Ocean Springs Levee	20	27	29
Gulf Park Estates	24	35	40
Gulf Park Estates Alter.	20	25	29
Belle Fontaine	29	41	45
Bell Fontaine Alter.	20	29	33
Gautier	32	41	43
Pascagoula			
South Shore	37	39	53
Bayou Cassotte	18	23	26
River near tide gage	16	24	27
Moss Point	13	19	21
Pascagoula – Washington			
At Washington Ave.	19	28	31
Bayou Cassotte	18	23	26
River near tide gage	16	24	27
Moss Point	14	19	21
Pascagoula Moss Pt. Alter			
Moss Point Alt.	14	19	21
Bayou Cassotte	18	23	26
River near tide gage	16	24	27
South Shore	37	39	53
Pascagoula – Washington/MP			
Moss Point Alt.	14	19	21
Bayou Cassotte	18	23	26
River near tide gage	16	24	27
At Washington Ave.	19	28	31

Notes: 1/ This feature is given a discrete elevation. El. 11 ft. is approximately the 1 in 25 annual chance still water elevation. Feature was dropped from consideration. 2/ This feature is also given a discrete elevation. Crest el. of 16 ft. is between the 2% (1 in 50 chance) and 1% (1 in 100) still water elevation. This feature was also dropped from consideration. 3/ Not computed due to excessive crest elevations required at this location for lesser events.

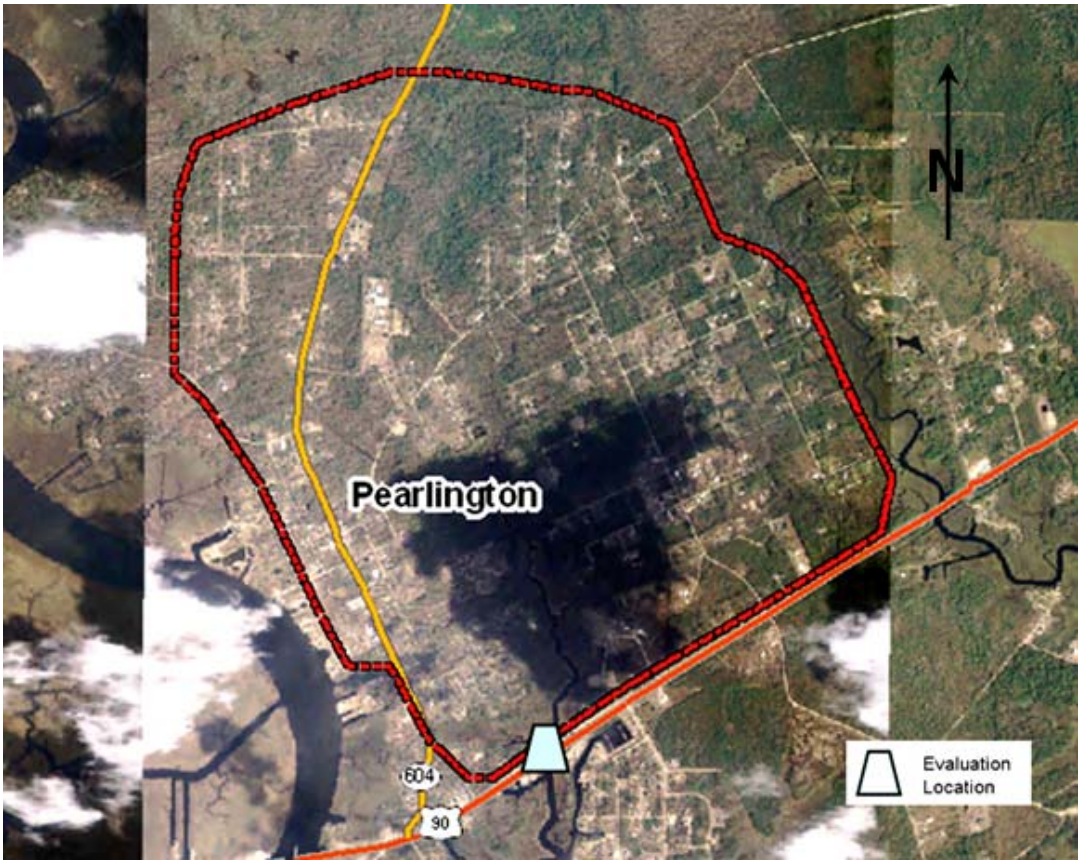
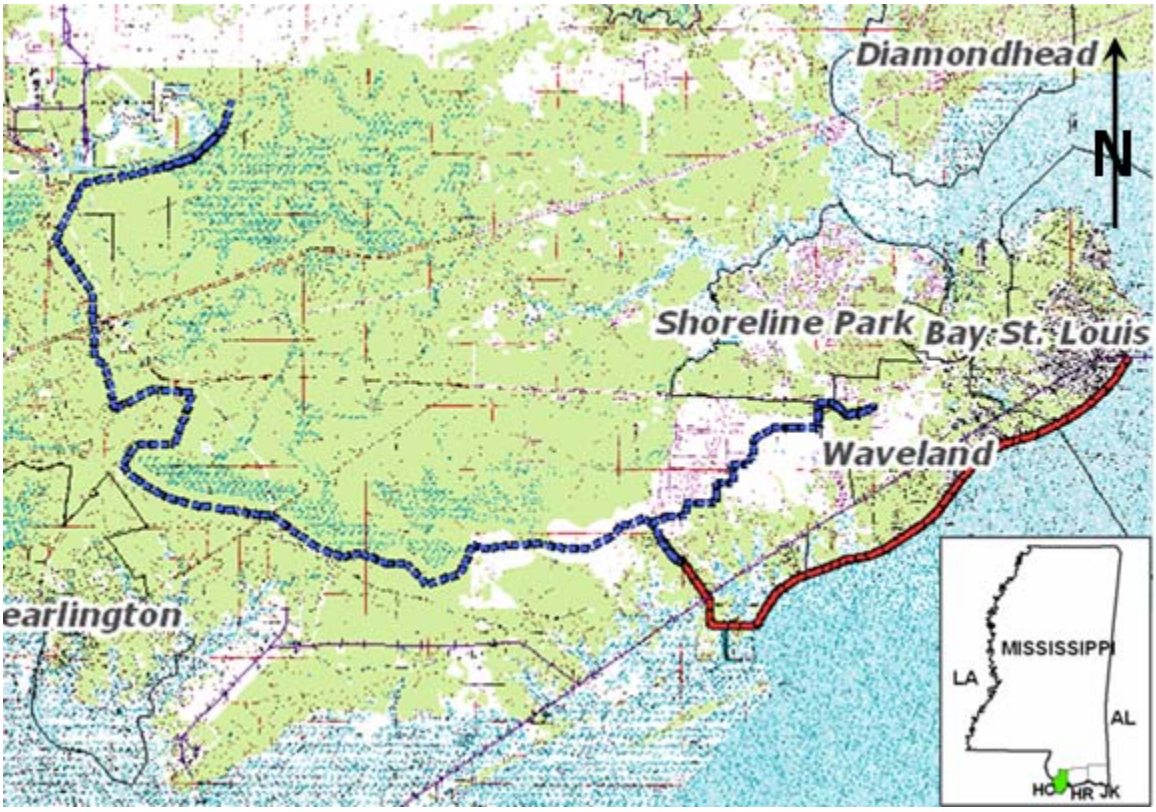


Figure 2.14-3. Hancock County, Pearlington Ring Levee



Figure 2.14-4. Hancock County, Bay St. Louis Ring Levee



NOTE: LOD3 shown linked to inland LOD4 feature.

Figure 2.14-5. Hancock County, Elevated Roadway and LOD4



Figure 2.14-6. Harrison County, LOD3 at Pass Christian



Figure 2.14-7. Jackson County, Ocean Springs Ring Levee



Figure 2.14-8. Jackson County, Gulf Park Estates Ring Levee

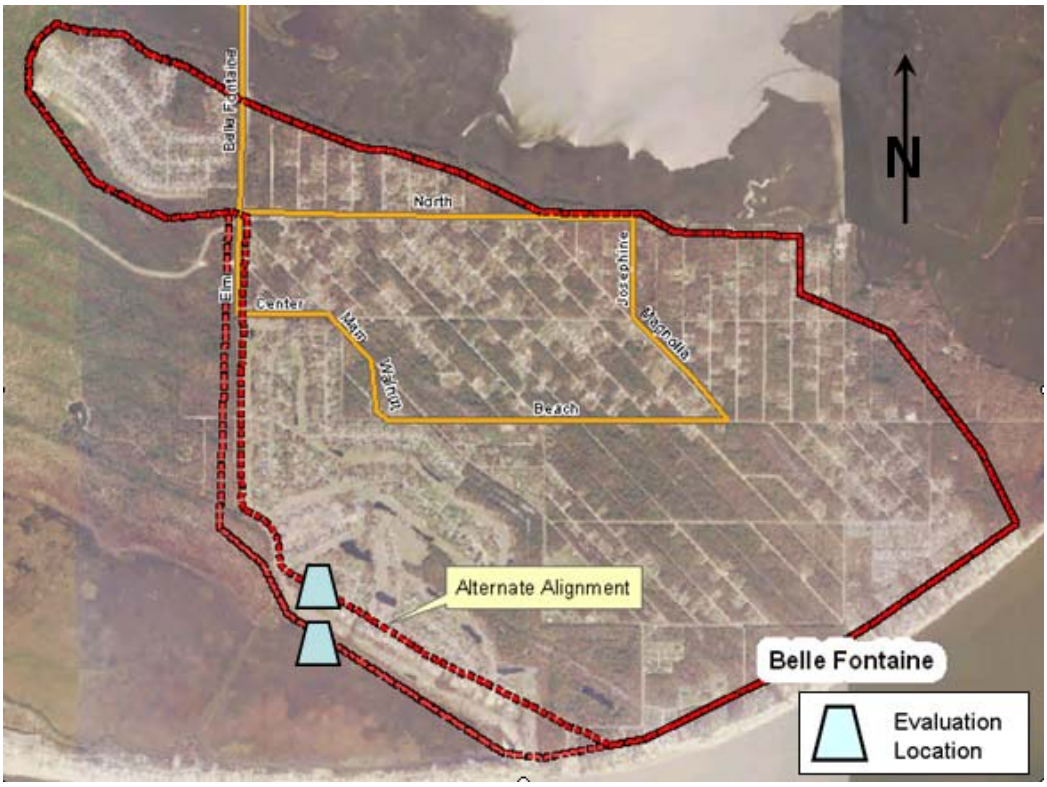


Figure 2.14-9. Jackson County, Bellefontaine Ring Levee

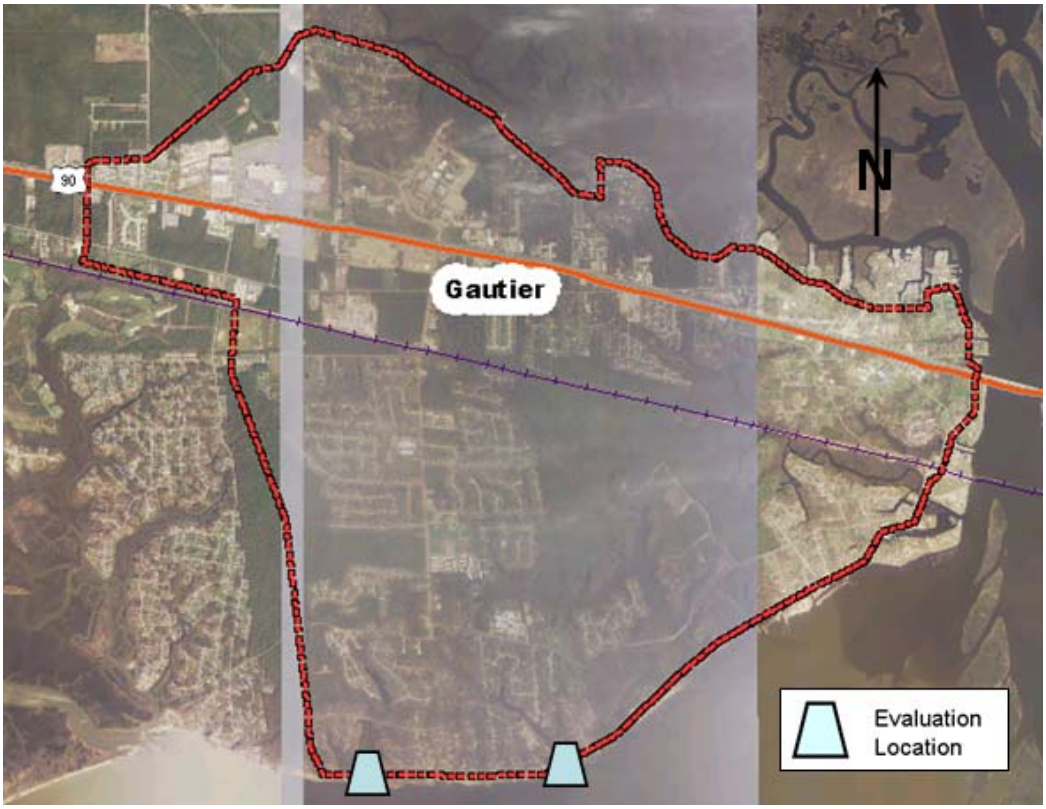


Figure 2.14-10. Jackson County, Gautier Ring Levee

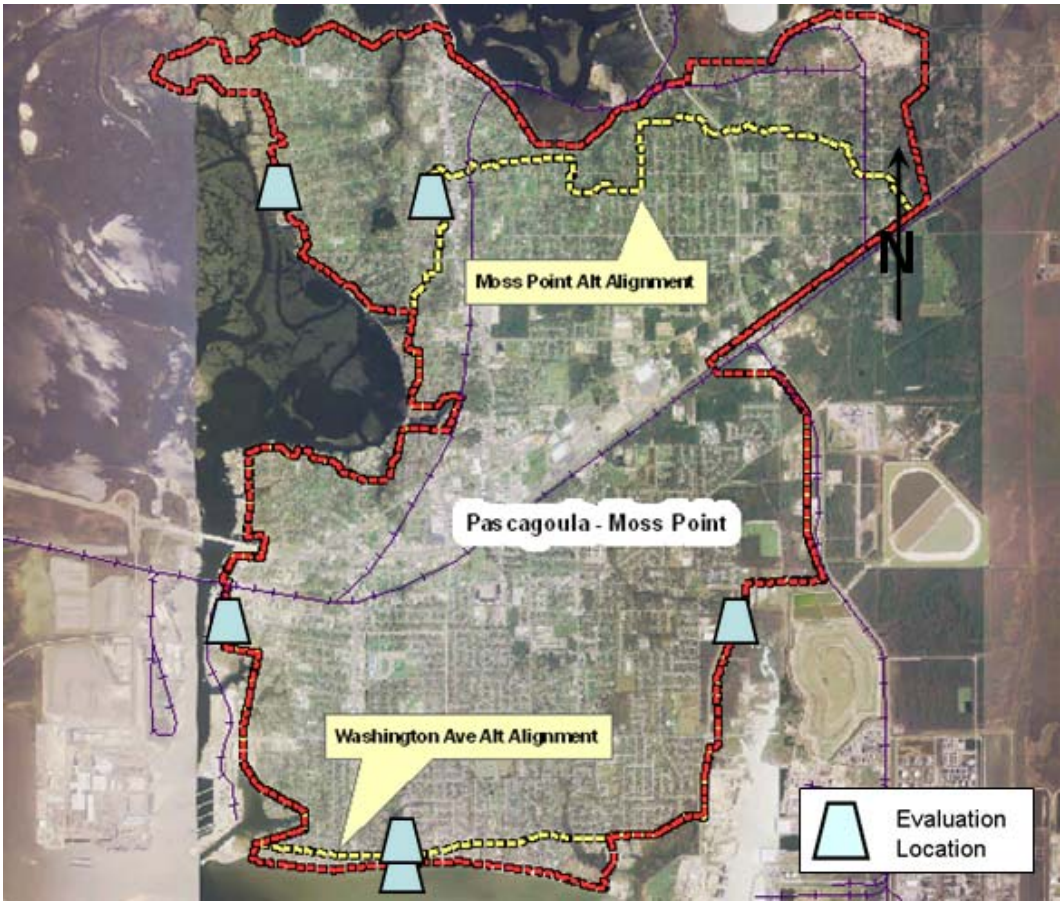


Figure 2.14-11. Jackson County, Pensacola/Moss Point Ring Levee

2.14.2 Line of Defense 4

Computed crest elevations for locations along LOD 4 are given in Table 2.14-2. Crest elevations given are reported in feet NAVD '88 datum. Locations at which the elevations were computed are shown in Figures 2.14-12 through 2.14-16. Computed levee crest elevations range from elevation 18 feet to 50 feet over the range events. For the one in 100 chance events, computed crest elevations range from 13 to 35 feet, with most locations yielding elevations in the high teens to mid twenties. Here, as also with LOD3, the given crest elevation for the 1 in 100 annual chance event is on the order of 30 to 35 feet; such results suggest that the typical levee cross-section geometry is not practicable at the given location and would benefit from modification and/or from a change in alignment to a more quiescent location.

The surge barriers are of novel geometry in their at-rest and deployed condition and empirical overtopping rate relations do not apply to them. Crest elevations for the surge barriers were computed using Table VI-5-13 (Franco and Franco's equation) of the Coastal Engineering Manual (CEM) Professional Edition software, version 2.0.1.1. This equation is most applicable to vertical wall structures. As with the levees, the elevations given assume an acceptable overtopping rate of 0.01 cfs/ft without consideration to interior (i.e. landward of the barrier) flooding attributes. It is possible that a larger overtopping rate might be structurally and operationally acceptable for these features, which would result in a lower crest elevation and lower construction costs. Design refinement awaits further study as desired.

Table 2.14-2.
Computed Structure Crest Elevations, LOD 4

Feature and Location	Annual Event Chance		
LOD-4	**1 in 100**	**1 in 500**	**1 in 1000**
Hancock County			
Clermont	35	47	50
Bay St. Louis Levee	22	29	32
Harrison County			
Pass Christian Harbor	21	29	31
Biloxi West	20	26	29
Biloxi Casino Row	20	29	34
Menge Ave	20	28	30
Jackson County			
Jackson County - Ocean Springs	18	25	28
Surge Barriers			
Bay St. Louis Closure Structure	30	44	49
Biloxi Bay Closure Structure	31	43	47

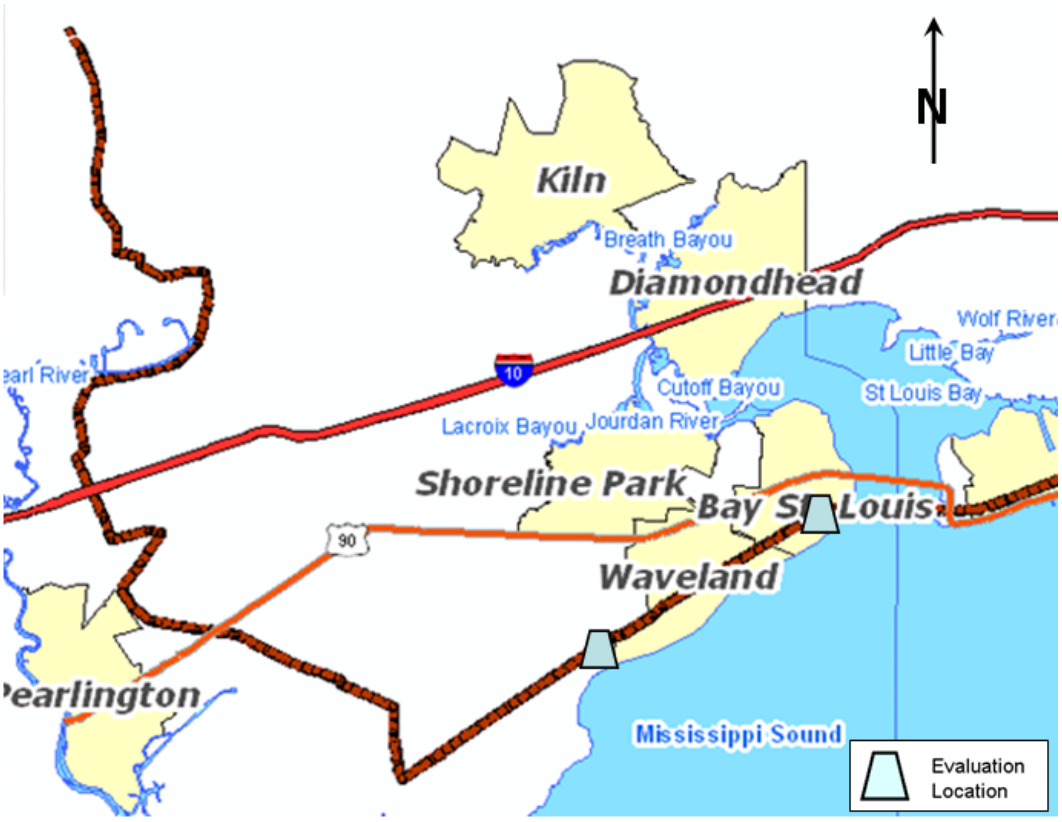


Figure 2.14-12. Hancock County Inland Barrier



Figure 2.14-13. Harrison County Inland Barrier



Figure 2.14-14. Jackson County Inland Barrier

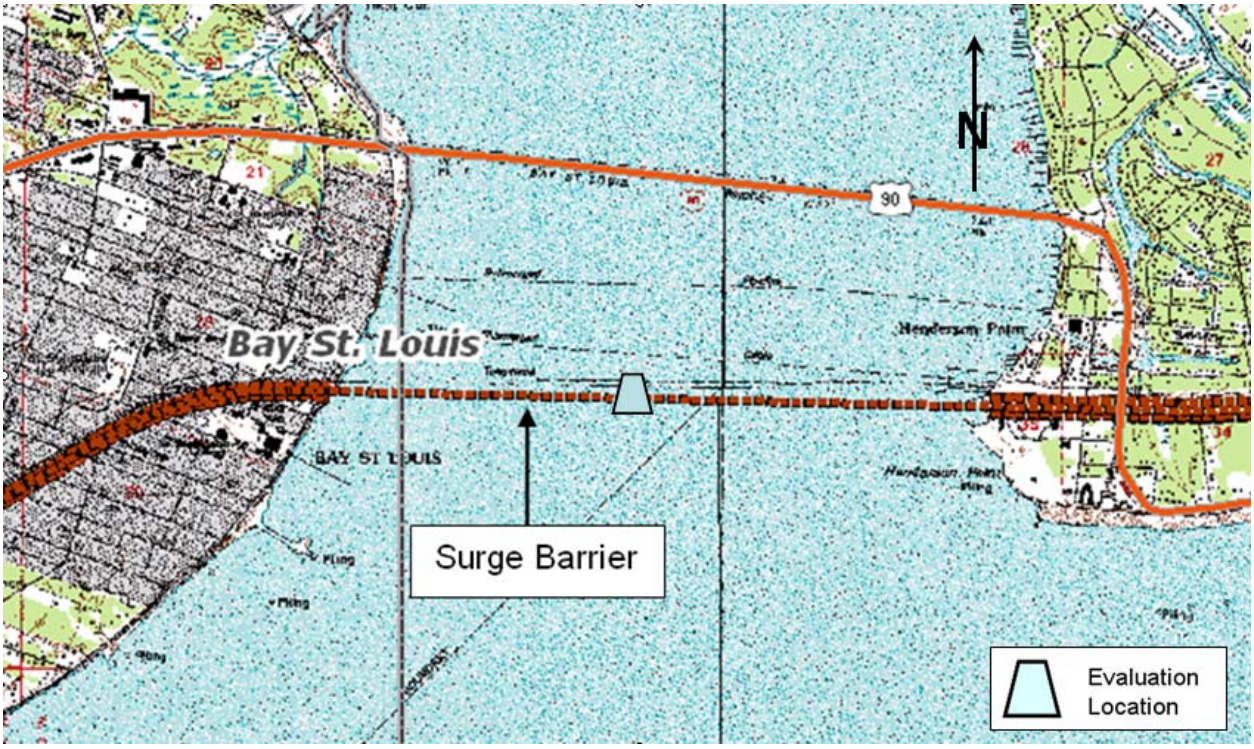


Figure 2.14-15. Bay St. Louis Surge Barrier

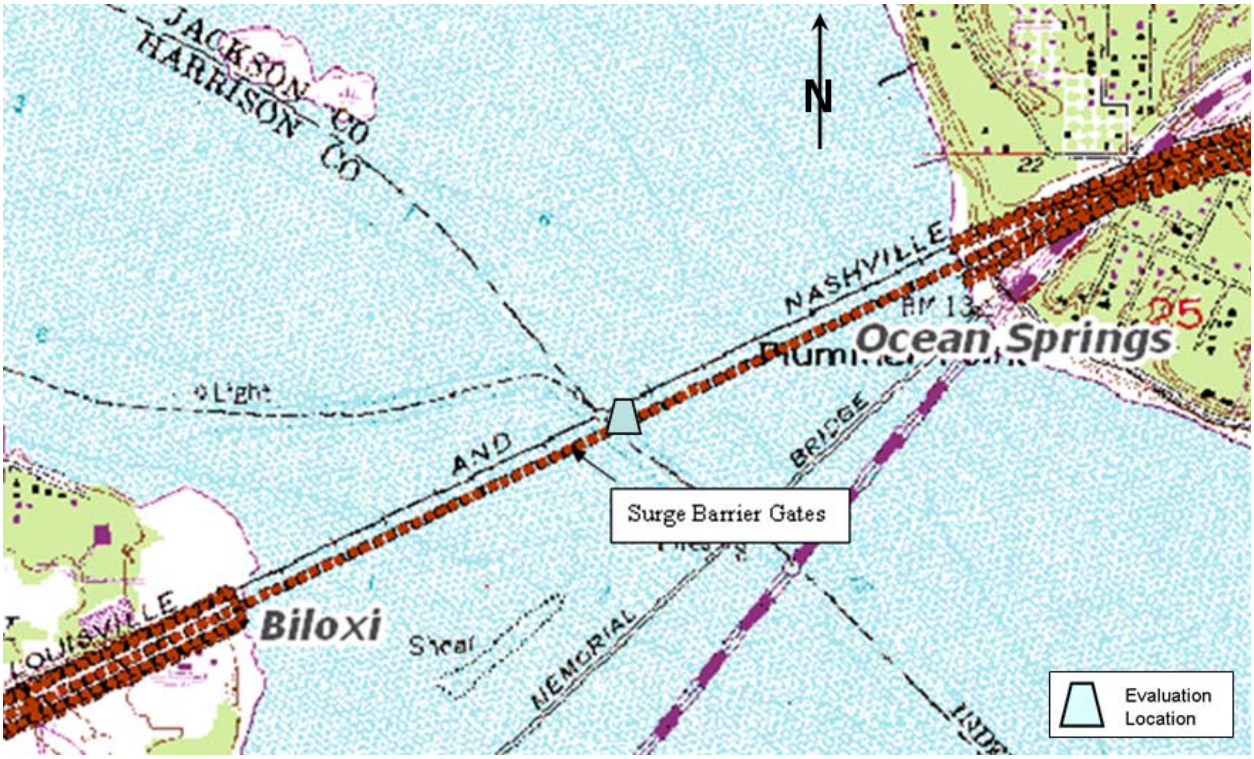


Figure 2.14-16. Biloxi Bay Surge Barrier

2.14.3 References

USACE (2007). Certification of Levee Systems for the National Flood Insurance Program (NFIP). Technical Letter No. 1110-2-570. US Army Corps of Engineers, Washington, DC. 7 August 2007.

PART 3. LINES OF DEFENSE

3.1 Line of Defense 1 – Offshore Barrier Islands

3.1.1 General

The coastline of mainland Mississippi is bordered on the south by the Mississippi Sound, a shallow body of water that separates the coast from four barrier islands that lie several miles to the south as shown in Figure 3.1.1-1. These barrier islands are located along a littoral drift zone that moves sand westward creating three elongated islands and then westward toward Cat Island, where littoral currents are not as well defined. The birds-foot delta system from the Mississippi River has extended through the historic littoral system, cutting off the sediment transport. Cat Island had the same origin than the other islands, but now being re-shaped by wave action and lack of new sediments moving into the system. Wave action has created a beach on the eastern side of the island forming a distinctive T-shape. From west to east, the islands are Cat, Ship (now actually two islands, West and East Ship Island), Horn and Petit Bois. As noted above, Ship Island has been breached by prior hurricanes and now is actually two small islands, West Ship Island and East Ship Island, with a shallow sand bar between the two. Since Hurricane Camille in 1969, this breach has existed with varying amounts of natural rebuilding between later storms and is now known as Camille Cut. The western ends of both Petit Bois and West Ship Islands have migrated westward and are now against maintained deep-water navigation channels and the continuing littoral drift of the sand into the channels is causing an artificial termination of the migration. A small, new island has emerged on the west side of the channel from Petit Bois Island, created from the dredged sand coming from the island that is disposed of on the west side of the channel.

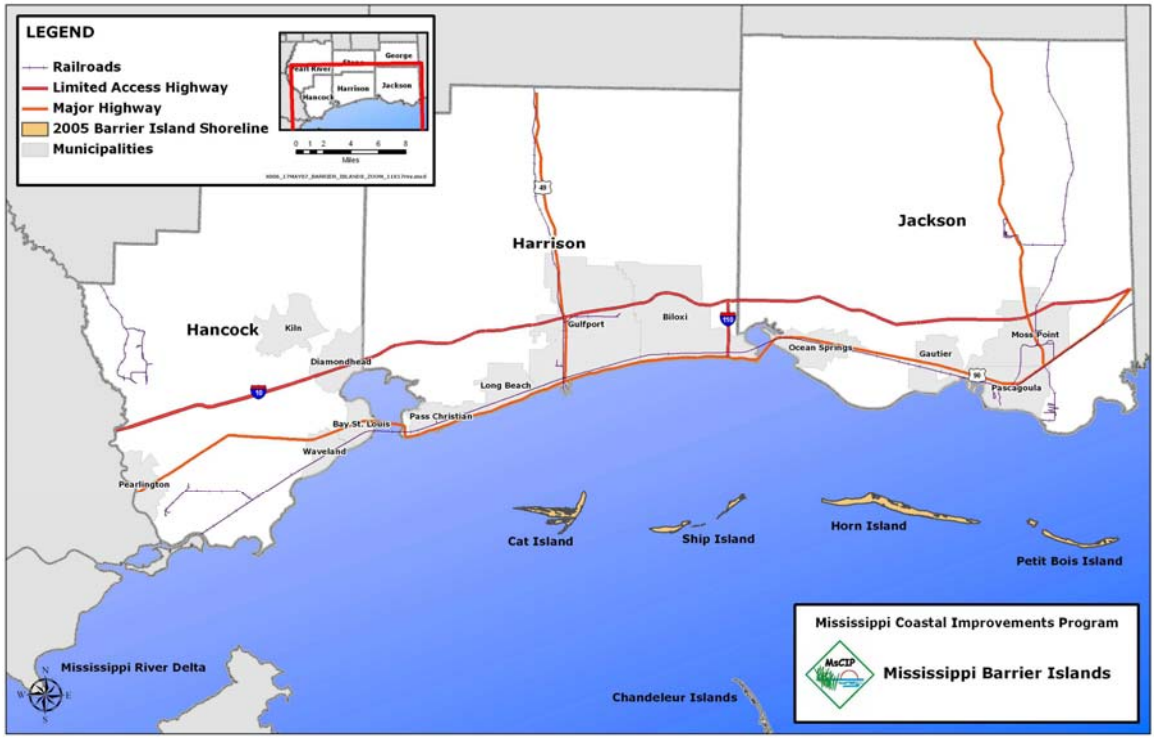


Figure 3.1.1-1. Location of the Mississippi Barrier Islands

Immediately following Hurricane Katrina, most of the effort was spent protecting human life and securing structures throughout the impacted areas on the mainland; therefore, few assessments of the vegetation impacts exist, especially on the barrier islands. For the barrier island system, most all of the marsh vegetation recovered several months following Hurricane Katrina. The predominant vegetation that has long-term impacts consists of those pines found in the maritime forests. It is estimated that about 75% of these pine species were killed following the hurricane season of 2005, with most of that attributable to Hurricane Katrina. Figure 3.1.1-2 is a photograph taken on Horn Island after Hurricane Katrina that shows the loss to the pine trees. The emergent marsh habitat is thriving so well it actually looks as though hurricanes never passed through the barrier island system. The sea oats are still found in small patches due to the reduced dune system. Any option that includes the planting of marsh vegetation will have to consider the current population of nutria that inhabits the islands. These exotic animals from South America can destroy attempts to establish marsh planting and any program should include the control of these rodents.



Figure 3.1.1-2. Photo of interior of Horn Island. Note the mature pine trees that were killed from the effects of salt water that covered the island during Hurricane Katrina.

In 1998, Hurricane George played a role in destroying many of the sand dunes on the islands. Although a relatively small storm, the constant pounding of the waves along the beaches eroded most of the dunes on the southern shores which were the higher elevations on the islands. Along with the destruction of the dunes was the loss of the associated vegetation and habitat. Figure 3.1.1-3 is a photo of the south beach of Horn Island where hurricanes have destroyed the dune system.

Prior to Hurricane Katrina, the State of Mississippi was working on a coastal storm protection plan that included restoring the barrier islands to the condition that existed prior to Hurricane Camille. The general assumption was that there would have been less damage along the coast from Hurricane Katrina if the islands had been in this improved condition. This was also included in the Mississippi Governor's Hurricane Katrina Recovery Plan which called for restoring the islands to a pre-Camille footprint. This concept was included in the hurricane protection study as LOD-1.



Figure 3.1.1-3. Photo of the south beach at Horn Island. Pre-existing dunes have been destroyed by numerous hurricanes over the last several years.

To determine the effects of the islands in reducing the surge damage to the mainland, a number of storms were selected to model against the chain of islands in a pre-Camille and a post-Katrina configuration. The post-Katrina condition can be considered a baseline condition for the modeling and the pre-Camille condition would be an improved condition. The pre-Camille footprint of the islands was obtained from historical records and an assumption was made as to a top of dune elevation and a typical island width. During the modeling process, the island sizes were held constant and not allowed to be destroyed. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. In general, the islands were modeled with a 2000-foot width and with an elevation 20.0 dunes, but may be in a slightly different position. Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. This area is the most protected from the restored islands and this protection may result in only up to a 10% reduction in storm surge. The effect of this protection diminishes rapidly to the west from Jackson County. An important aspect of the islands shown by the modeling is the reduction of the large sea waves as they advance towards the mainland. Reduction in wave height up to several feet is realized by the presence of the islands. Loss of Ship Island would leave a portion of the heavily developed Harrison County shoreline subject to these larger waves.

All of Petit Bois, Horn, and Ship Islands and part of Cat Island are within the boundaries of the Gulf Islands National Seashore under the jurisdiction of the National Park Service. The park boundaries are shown in Figure 3.1.1-4. In most cases, the boundary extends one mile from the shore of the island. Petit Bois and Horn Islands have also been designated as Wilderness Areas by the U.S. Department of the Interior and have a higher degree of protection than the other islands.

The formation of Camille Cut has created problems for the National Park Service due to the location of two historically important sites. Fort Massachusetts is located on the northern shore of West Ship and

the French Warehouse is located on the northern shore of East Ship Island. Both of these sites are endangered by on-going erosion of the shoreline with Mississippi Sound. Another site known as the Quarantine Station has already been lost to erosion. These sites are shown in Figure 3.1.1.-5. This photo was taken after Hurricane Katrina, but, would be similar to conditions after Hurricane Camille.



Figure 3.1.1-4. Boundaries of the Gulf Islands National Seashore

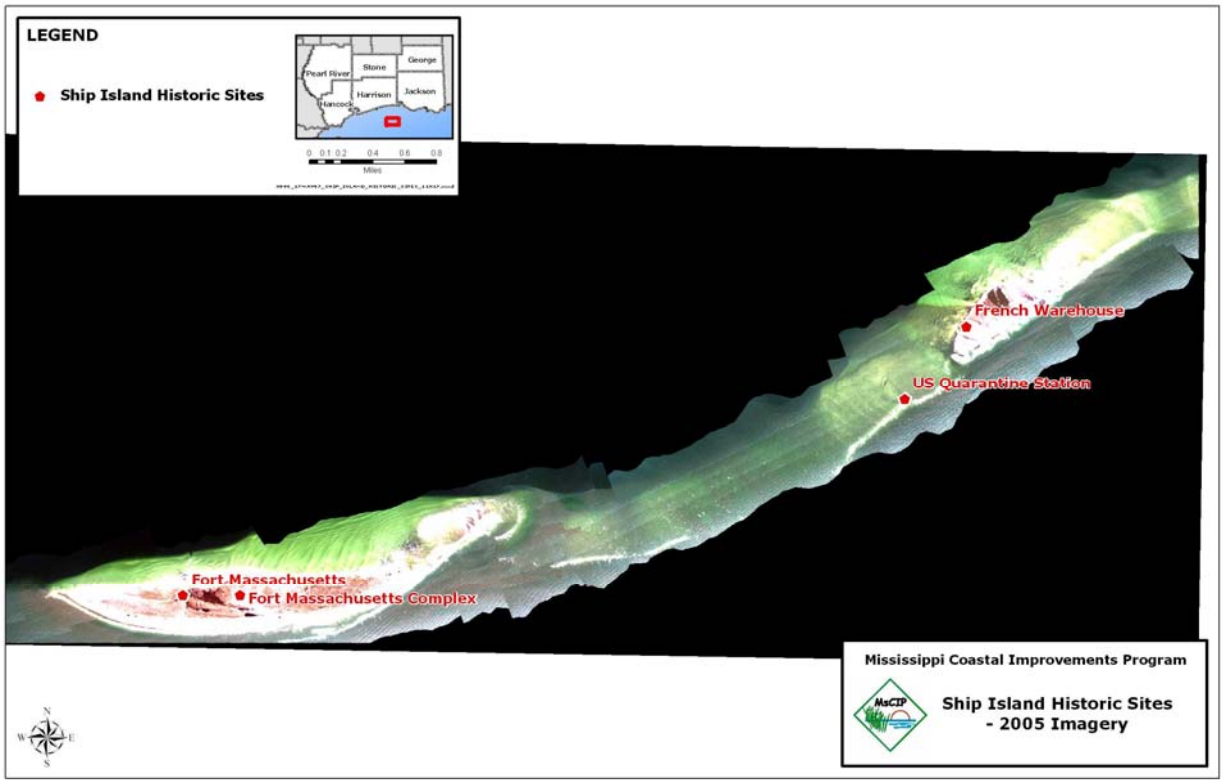


Figure 3.1.1-5. Aerial photo of West and East Ship Island taken in 2005 after Hurricane Katrina showing the locations of listed historical sites separated by Camille Cut.

Fort Massachusetts was originally built on the western tip of Ship Island. The westward migration of sand along the southern shore and erosion of the northern shore now has put the fort almost a mile from the western tip of the island, but dangerously close to being in the Sound. Several emergency beach re-nourishments have taken place over the last 35 years to protect the fort from wave action during winter storms. At present, the NPS is again requesting that the Corps place sand along the shore near the fort in conjunction with dredging operations at the Gulfport navigation channel. This emergency placement of sand is being repeated about every five to six years.

The French Warehouse site has not had any sand placement on its shoreline in the past. The erosive process is slower at that location, but now there are concerns from the NPS about the integrity of the site. Unlike the location of the fort, the warehouse site is covered by maritime forest which may be slowing the erosion of the shore.

The Corps was asked to visit Fort Massachusetts with the NPS during July, 2007 to look at the present erosion problem and to discuss any possible long-term solutions to the loss of sand along the shoreline. The immediate erosion problem will require re-nourishment of the beach adjacent to the fort similar to the past protection projects. Any type of hardened structural feature as protection for the fort was not desired by the NPS nor was this recommended by the Corps. There was a breakwater placed north of the fort in the past (prior to the barrier islands becoming a National Seashore under the NPS) and seems to be compounding the erosion problems. The problem of a long-term fix may be tied to closing the three mile wide breach known as Camille Cut between West and East Ship Island. Review of historical footprints of the islands indicates that after the breach caused by Hurricane Camille, the westward migration of sand was continuing, but that the sand supply was being depleted before it reached West Ship Island. Aerial photos show the formation of a sand spit that extends westward from East Ship Island. The volume of sand that is creating this spit is being depleted from reaching West Ship Island. The photos also show that a deeper channel has formed a pass between the eastern end of West Ship Island and the western end of the spit. It appears that an ebb tidal delta at this pass moves the sand southward where it is removed from any migration along the northern shore of West Ship Island. The sand continues to supply the south beach and extends the western tip of the island in its migration. The loss of the sand from the littoral drift along the northern shore of West ship Island has resulted in erosion of that shoreline. Figure 3.1.1-6 shows an excellent aerial view of this process. Note the boat on the northern side of the pass.



Figure 3.1.1-6. Aerial photo of West and East Ship Island taken in 2001. Note the sand spit extending westward from East Ship Island and the pass between the two islands.

A positive by-product of filling of the Camille Pass would be to provide a longer term solution to the erosion on the northern shores of West Ship Island. This will require modeling to better understand the benefits that are believed to be associated with this plan. The costs will be substantial due to the large quantities of high quality sand that will be required to fill the breach. Initial estimates for sand requirements are approximately 8 million cubic yards. The fill would be expected to prevent the continuing loss of sand to West Ship Island, but it is also understood that the islands are a dynamic system, ever changing to nature's forces. Different types of dune vegetation planting would also be included to restore habitat on the newly created land.

3.1.2 Restoration of the Offshore Barrier Islands

3.1.2.1 General

Soon after Hurricane Katrina, it was reported that many residents in Mississippi were of the opinion that if the islands had been in the condition that existed prior to Hurricane Camille, there would have been less damage along the coast from Hurricane Katrina. This initial concept was also included in the Mississippi Governor's Restoration Plan which called for restoring the islands to a pre-Camille footprint. Changes in the footprints are shown in Figures 3.1.2.1-1 through 3.1.2.1-4.

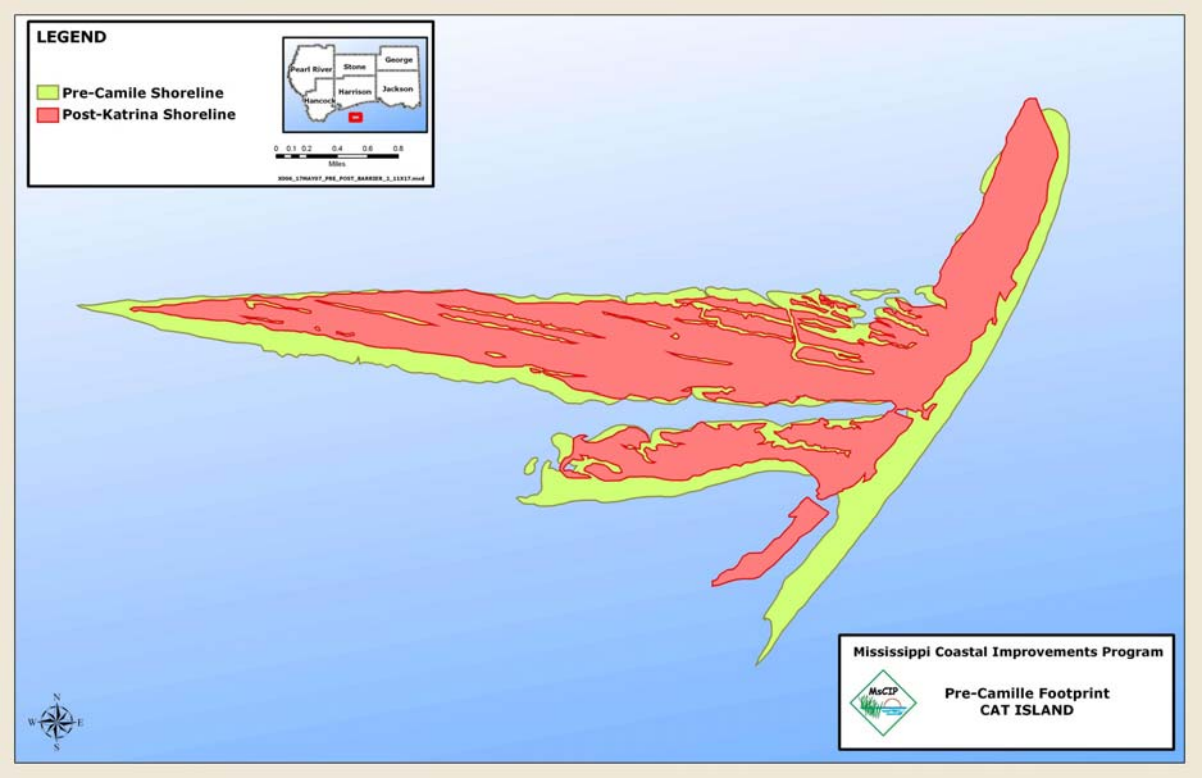


Figure 3.1.2.1-1. Changes in footprint of Cat Island from pre-Camille to post-Katrina

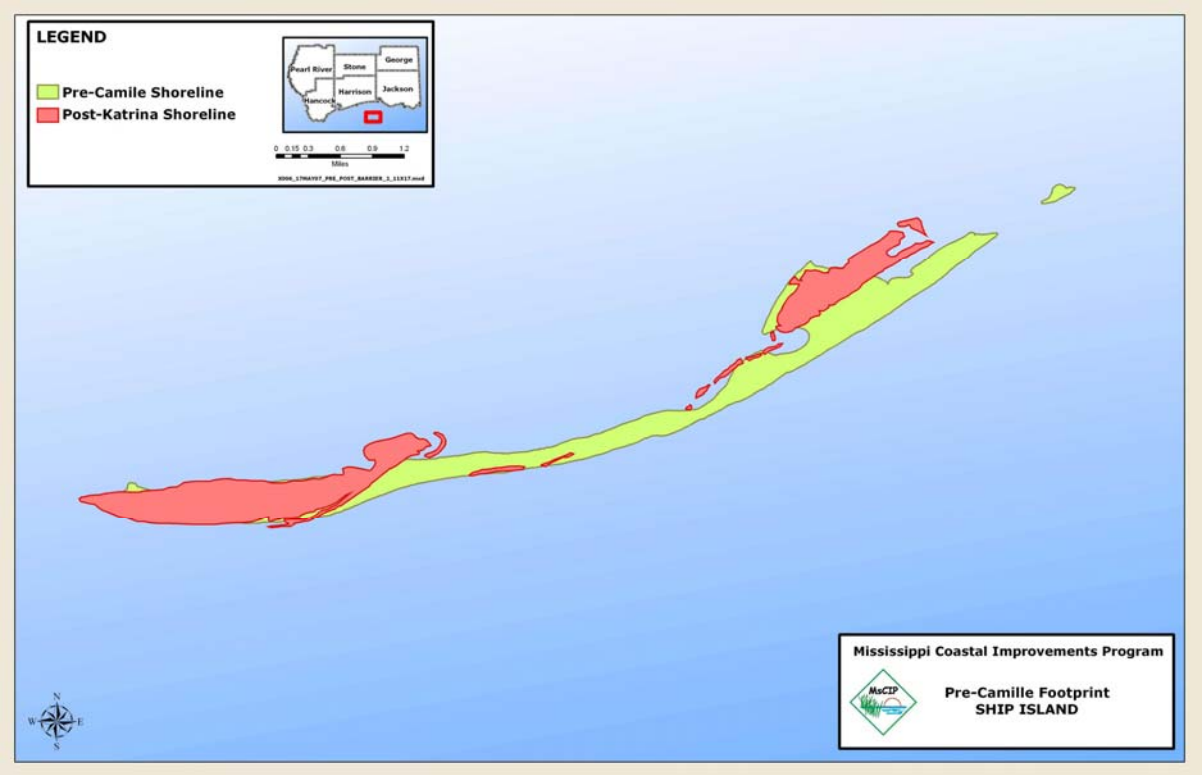


Figure 3.1.2.1-2. Changes in footprint of Ship Island from pre-Camille to post-Katrina

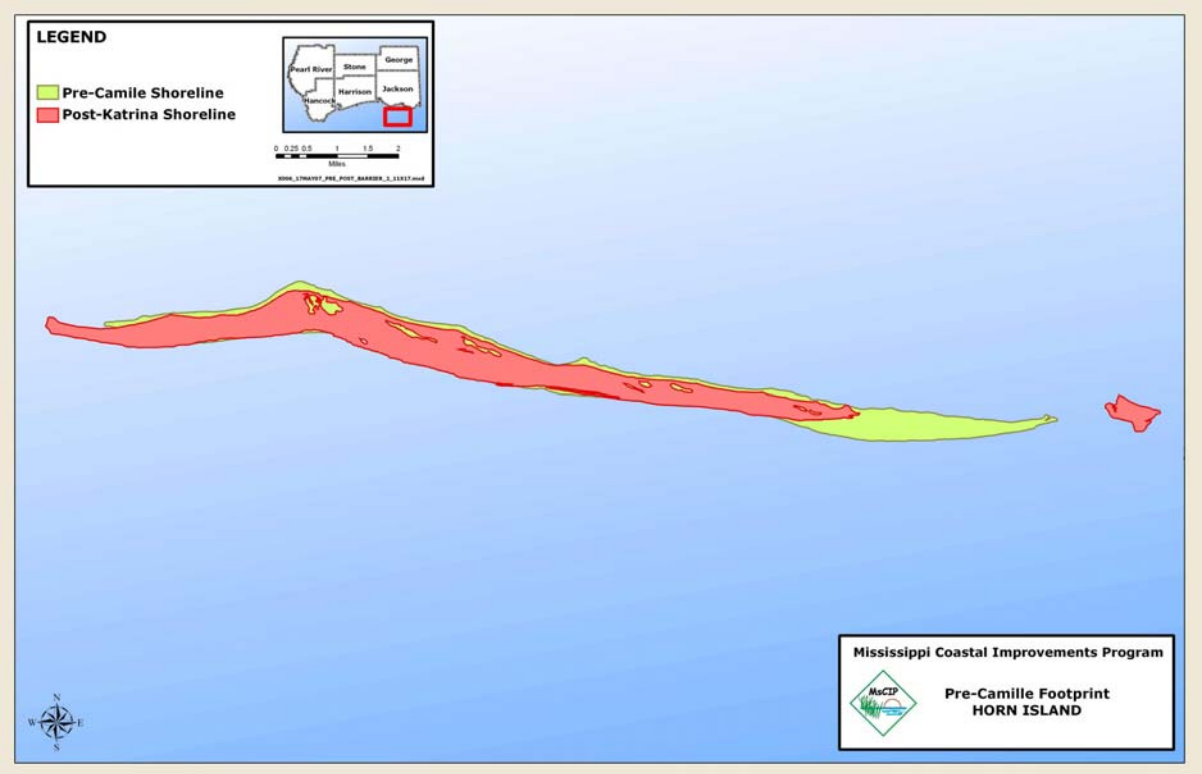


Figure 3.1.2.1-3. Changes in footprint of Horn Island from pre-Camille to post-Katrina

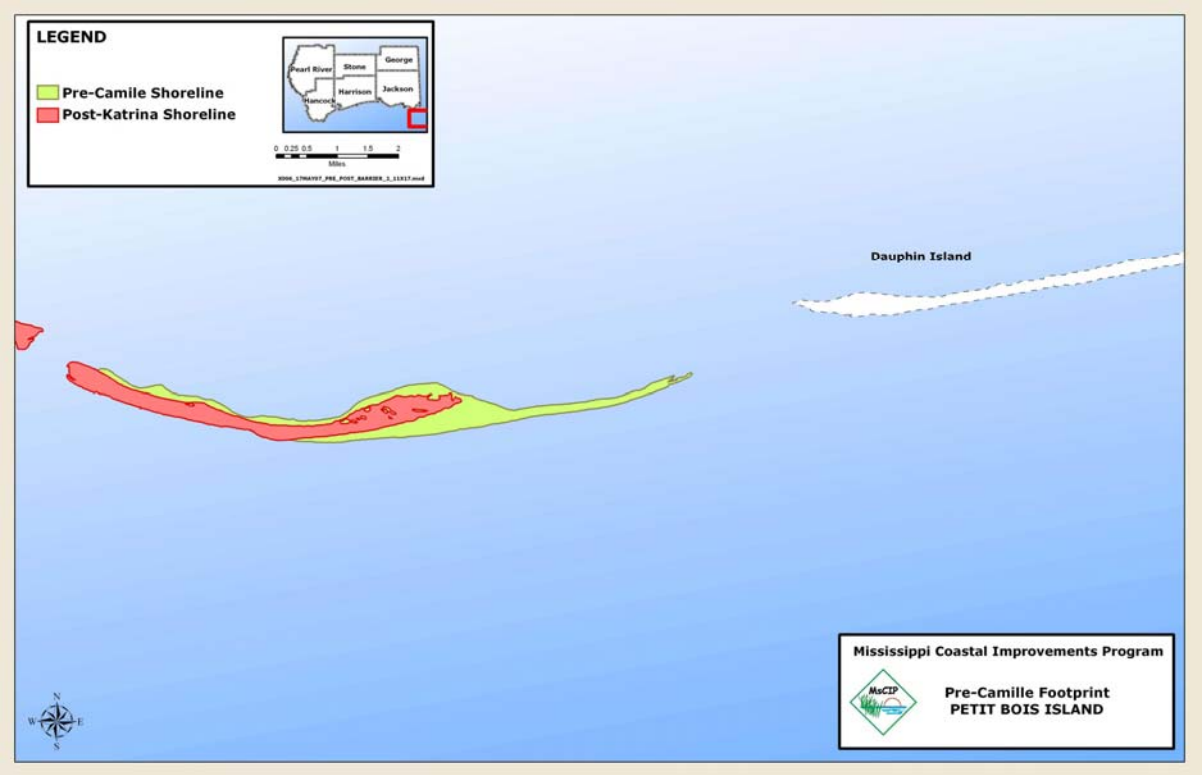


Figure 3.1.2.1-4. Changes in footprint of Petit Bois Island from pre-Camille to post-Katrina

As discussed in Section 3.1.1, a number of storms were selected to model against the chain of islands in a pre-Camille and a post-Katrina configuration. The post-Katrina condition can be considered a baseline condition for the modeling and the pre-Camille condition would be an improved condition. The pre-Camille footprint of the islands (USGS, 2007) was obtained from historical records and an assumption was made as to a top of dune elevation of 20 feet. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. This increase in size generally increased their length and maintained their typical width.

Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. This area is the most protected from the restored islands and this protection may result in only up to a 10% reduction in storm surge. As was shown in Figure 2.1-6, the effect of this protection diminishes rapidly to the west from Jackson County. With the consideration that these islands are within the National Park Service and that Petit Bois and Horn Islands are designated Wilderness Areas, any improvements to these islands may be politically difficult based on the limited benefits.

Another consideration to help restore the islands is to supplement the sand into the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This sand would not be put on the islands, but in areas between the islands where the currents that make up the littoral drift zone could transport the sand to the islands where the natural process of island building could take place. There, waves and wind could cause accretion on the islands. This may mitigate the loss of land mass at the islands that has been occurring since Hurricane Camille. The source of these sands may be from inland sources or from offshore borrow areas. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system.

A positive affect that the islands have is to provide a natural off-shore breakwater for the large sea waves that are generated from hurricanes. For this to occur, the islands only need to be a low stretch of sand or even a shallow sandbar. The presence of the islands and the relatively shallow water of the Mississippi Sound between the islands and the mainland prevent the sea waves from maintaining their considerable size as they move towards the mainland. Sea waves, often reported at heights of 40 feet and higher in large storms, would break as they approach the chain of islands. The open water between the islands and the mainland, generally ten miles or more, would have enough fetch for waves to regenerate, but at a much lower height due to the shallower water. The generally accepted relationship between water depth and wave height is that the wave can sustain itself at a height that is one half the depth of the water.

An environmental impact of the islands continuing to diminish in size is to allow salinity increases in the Mississippi Sound. Mississippi Sound would be classified as a 'bar-built' estuary as opposed to a 'drowned river valley' (like Mobile Bay). The physics of bar-built estuaries is very different from others and you would expect to see broad zones of 'salinities' with the estuary which respond greatly to both river flow and wind conditions. Should the 'bars' go away, then the estuary is totally lost because in general an estuary is considered part of the coast as opposed to forming the coast. Under current conditions, the islands provide a natural boundary between the water's salinity [~33 parts per thousand (ppt)] of the open Gulf of Mexico and the brackish water found in Mississippi Sound. Salinity in the Sound during low flow periods range from 10 to 30 ppt. Highest salinities occur just south of Pascagoula and Gulfport and the lowest salinities in the Lake Borgne-Pearl River area. Several studies have investigated the impacts of diverting freshwater to promote reversing a historic increase in salinity in the Mississippi Sound/Biloxi marshes area in order to support fresher marshes and oyster reef health and productivity thus enhancing both their economic value and the ecological services they provide. Oysters are sensitive to specific ranges of salinity. Additional modeling and study would be required to determine impacts to salinity from the loss of the barrier islands.

One restoration option for the barrier islands would be to re-establish the vegetation that was destroyed by Hurricane Katrina. This option could involve environmental restoration of the existing islands through adding sand dunes on the beaches along with planted vegetation, planting of marshes and maritime forests, and planting sea grasses in the near-shore areas of the islands. This plan would not involve adding any land mass to the islands other than the possibility of adding to the dune system. The addition of vegetation from sea oats up to trees would aid in reducing erosion of the sand from wind thus helping in maintaining the stability of the islands. The vegetation would also aid in preventing erosion by water in the event that the islands get overtopped by storm surge in a large hurricane. Sources of this sand could be from the beach area behind the dunes or from sources off the island. Historically, large areas of sea grass existed north of the islands. Much of this sea grass is now gone and the loss of these areas have been mapped. Replanting the grasses and other vegetation will aid in establishing valuable habitat that was lost from the ecological system. Figure 3.1.2.1-5 shows the extent of vegetation on Horn Island prior to Hurricane Katrina.



Figure 3.1.2.1-5. Aerial photo of Horn Island. The darker areas are vegetation consisting of maritime forest and marsh grasses.

As discussed in Section 3.1.1, an additional restoration option has been added that will fill and close Camille Cut between West and East Ship Island. In addition to providing some storm damage reduction, this option will provide some protection to two historical sites on West and East Ship Island, respectively. This option will require additional study to model the desired results of slowing erosion near the two sites. During coordination with the NPS, agreements have been reached that will provide positive affects to the barrier islands. These proposals have been incorporated into an alternative based on LOD-1 Options C and G. This alternative consists of adding sand into the littoral zone and closing the breach between West and East Ship island. This alternative is fully described in a separate appendix based on this combination of options titled the Comprehebsive Barrier Island Restoration Plan. A working paper that documents the NPS position on the barrier islands (NPS, Sept. 2007) along with other cooperating agencies is included in the Barrier Island Appendix. An important result of the NPS agreement was that any work that involved direct placement of any sand into Camille Cut would be a one-time event without additional O&M sand placement. In accordance with 2006 NPS Management Policies (see Barrier Isalnd Appendix Chapter 2, the NPS Vision Statement Section III), the NPS has concluded that this one time placement of sand would most directly counteract the long term reduction in sand supply which has resulted in Ship Island being dimished to the point where it may have lost the ability to restore and maintain itselt s in the historical past. Natural re-building and maintenance of the barrier islands in the long term would then be supported by the continuing placement of sand back into the littoral zone during future maintenance dredging of navigation channels. Areas where continuing beneficial placement could be employed will be identified during additional sediment transport modeling conducted during the Engineering and Design phase prior to a contract award.

3.1.2.2 Location

The barrier islands of Mississippi are located 10 to 15 miles south of the mainland. Currently, there are five islands in the chain that extends for 45 miles west from a point south of the Alabama – Mississippi state line along the coast. Currently, Ship Island exists as two islands separated by Camille Cut. It was breached during Hurricane Camille in 1969 and remains today as West and East Ship Island. Two maintained navigation channels pass through the chain of islands. The Gulfport channel passes near the west end of West Ship Island and the Pascagoula channel passes near the end of Petit Bois Island. The present day location of the channels prevents any further westward migration of either island.

3.1.2.3 Existing Conditions

As is typical of most barrier island systems, the Mississippi islands are an ever-changing and dynamic landscape. Data shows that the islands have lost approximately 20 to 25 percent of their land mass since pre-Camille times. The islands have been heavily influenced by the various hurricanes including even the lower intensity ones. Hurricane George, in 1998, even though a small hurricane, proved to be devastating to the islands due heavy erosion from waves. Many of the higher dunes systems on the islands were destroyed and much of the elevation the islands once had is gone. Most of the islands are now very susceptible to over-wash during storms. Another result of being submerged during Hurricane Katrina was the loss of much of the maritime pine forest that existed on the islands. The trees, mostly now dead from the salt water submergence, played a major role in preventing erosion both from wind and any surges against the islands.

The westernmost island, Cat Island, has a similar origin from the other islands in the chain, but isolated from the littoral current by a historical birds-foot delta from the Mississippi River that cut off the path of the historical littoral zone. A change in wave climate has formed a T-shaped configuration. Sorting of the sediments has created a beach on the east facing portion of the island. Results of the sediment budget completed as part of this study indicates that little or no sand is being added to Cat Island from the littoral drift system that supplies sand to the other islands in the chain. The remainder of the islands have a westward drift that is more pronounced from the eastern-most Petit Bois Island and decreasing respectively to the west to West Ship Island.

3.1.2.4 Coastal and Hydraulic Data

The barrier islands protecting the Mississippi Sound experience a low energy wave climate, with average significant wave height at National Data Buoy Center (NDBC) Buoy 42007 (22 nautical miles south-southeast of Biloxi, in 45 ft depth) averaging 2.0 and 1.3 feet in the winter and summer months, with associated average peak wave periods of 4.0 to 3.5 s, respectively. Wave transformation modeling by Cipriani and Stone (2001) indicated that breaking wave heights on the barrier islands range from 1.0 to 2.0 feet. Waves in the Mississippi Sound are fetch and depth-limited. The Coastal Studies Institute's Wave-Current Surge Information System (WAVCIS) gage CSI-13 located at Ship Island Pass (23 foot depth) from June 1998 through July 2005 measured an average significant wave height of 0.3 feet and associated average wave period of 2.5 sec.

Tides in the Mississippi Sound are diurnal, with a tidal range of 1.5 and 2.8 feet for the mean and spring tides at Biloxi, Mississippi, respectively. However, the relatively shallow and large area of the Mississippi Sound create strong currents in the tidal passes between the barrier islands, ranging from 1.6 to 3.3 feet/sec and 6.0 to 11.5 feet/sec on flood and ebb tides, respectively (Foxworth et al. 1962). In the winter months, winds from the same direction and of a sufficient magnitude are capable of lowering water surface elevations in the bays and nearshore from 3.6 to 2.0 feet (U.S. Army Corps of Engineers Mobile District 1984).

For the Gulf barrier island beaches, net longshore sediment transport is from east to west, although local reversals in the net transport occur adjacent to the tidal passes. The primary sources of sediment are longshore sediment transport from east to west, and, potentially, the offshore shelf (Otvos 1979, Cipriani and Stone 2001). Cipriani and Stone (2001) discussed that a well-defined cellular structure exists for each barrier island in which, over historic times, little sand transfer exists between islands. However, dredging records at Horn Island and Ship Island Passes (called Pascagoula Bar Channel and Gulfport Bar Channel, respectively) suggest that infilling of sand from adjacent barrier islands occurs, indicating the potential for transport of sand between islands. Eastern Dauphin Island, with a Pleistocene core, is more stable than the other barriers although eastern Dauphin Island has been eroding in response to the dominant westerly-directed transport. Based on grain size analysis, Cipriani and Stone (2001) inferred that offshore sources may provide some sediment to central Petit Bois Island. The Mississippi Sound barrier islands range from very well vegetated, with maritime forests on east Dauphin Island, to low elevation barriers that are overwashed and breached during hurricanes. Long-term relative sea level rise for Dauphin Island, Alabama from 1966 to 1997 was 0.12 inch/year +/- 0.02 inch/year.

3.1.2.5 Option A – Restore Pre-Camille Island Footprint

As part of the Seven Step Strategy developed by the Governor of Mississippi, an option was developed to look at restoring the barrier islands to a pre-Camillr footprint. The pre-Camille footprint of the islands was obtained from historical records and the amount of area that has been lost to coastal erosion since that time was computed. Without accurate topography of the islands an assumption was made that some dunes had a top of elevation of 20 feet. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. Figures 3.1.2.1-1 through 3.1.2.1-4 showed the changes in the land mass of the islands from a pre-Camille condition to a post-Katrina condition. It was also recognized that NPS support for this option was unlikely due to conflicts with that agencies 2006 Management Policies and statutory responsibilities.

Several approaches to restoration of the islands were considered. This option will only include new land mass that is being added to the islands by using sand dredged and transported from an off-shore location. The shaping of the sand into beaches, dunes and marsh areas will not affect the existing islands other than that narrow strip of land that will form the boundary between the existing island and the new land mass. This option can be used in combination with other options under this line of defense should it be desired to restore habitat on the existing islands.

Restoration of Ship Island to a pre-Camille configuration includes closing the post-Katrina, 3-mile long breach to a 2000-foot width and with elevation 20.0 dunes, along with some rebuilding of the other islands to a larger land area. The land mass of each of the islands was estimated in a pre-Hurricane Camille condition using historical aerial photography. The difference in the size of the islands was then computed based on post-Hurricane Katrina aerial photography. The results of this are as follows:

The difference in the land mass over this period was then converted to an acreage that it would take to restore the size of the footprint. The width of the islands was maintained with the additional land mass being added as length. Each of the surface areas was converted to a quantity by using an average water depth of seven feet and raising the sand up to elevation of 10.0. It was assumed that approximately 25 percent loss of the material would occur during the process of placement.

Sand of sufficient quality in the quantities required for this type of project is not known to occur in close proximity to the islands. Proposed geophysical studies may locate sources near the existing islands. Prior studies of the St. Bernard Shoals (Oral Communication, USGS, 2006) are probably the best source of the sand. Additional studies and sampling will be required to ensure the source. As

previously described, St. Bernard Shoals are a series of submerged barrier islands. The average water depth over the shoals is 60 feet which puts the sand within reach of a hopper type dredge, however the water depth near the islands is too shallow for the draft of hopper dredge that would be used in this type of operation. In order to accomplish this, a basin would be dredged near each of the islands to discharge the sand being transported from the borrow area. Any suitable sand (if encountered in sufficient quantities) would be added as part of the fill, otherwise the material will be transported to approved disposal areas per the Regional Sediment Management guidelines. Using this procedure, the hopper dredge could enter the basin and bottom dump the sand. This would be much faster than pumping off the sand. Doing this would also allow the basin be placed outside the boundaries of the National Seashore. As the basin is filled, a suction dredge would be mobilized to the site and using this type of the equipment, the sand could be moved to the area where the material is needed to create additional land mass. As the sand is placed on the new land mass, it would be sculpted into dunes and swales which would vary from sea level up to heights of 20 feet. The amount of new land mass at each of the islands would be approximately the same as the amount shown as lost in Table 3.1.2.5-1. The anticipated amount of sand required for each island is as follows:

Cat Island – 14,600,000 cubic yards

Ship Island – 21,240,000 cubic yards

Horn Island – 21,240,000 cubic yards

Petit Bois Island – 9,300,000 cubic yards

Table 3.1.2.5-1.
The Amount of Land Mass Lost from each of the Mississippi Barrier Islands from pre-Camille conditions to post-Katrina Conditions

Island	Pre-Camille (acres)	Post-Katrina (acres)	Land Loss (acres)
Cat	2,344	1,957	387
Ship	1,172	631 (East and West)	541
Horn	3,612	3,077	535
Petit Bois	1,329	1,098	231

As the new land mass is added to the existing islands, portions of the new island will be planted with various type of vegetation to provide habitat and to aid against erosion. Review of photographs of the islands prior to Hurricane Katrina has provided data on the percentages of the islands that were associated with maritime forest, marsh, dunes, and open beach. The percentage of maritime forest varied among the islands from one percent up to 23 percent. For the new land mass of the islands under Option A additions, it was decided to use a quantity of 20 percent of the land mass for planting the trees consisting of longleaf pine. The lower elevations of the new land mass would be planted with emerging marsh species that would cover 38 percent of the area. This would include Spartina alterniflora, Spartina patens, and Juncus romerianus. Dunes planted with sea oats would make up two percent of the area and the beach areas would be left as open berms. With time, the dunes would transform themselves into a more natural state as wind shifted the sand and the planted vegetation established itself similar to the dunes shown in Figure 3.1.2.5-1.

3.1.2.5.1 Interior Drainage

The type of work anticipated for adding sand to increase the land mass of the islands will not require any type of drainage system. The addition of sand under this operation will be with dredge pipe discharge and all water will be allowed to run back to the sea.



Figure 3.1.2.5-1. Typical sands dunes on gulf coast barrier island

3.1.2.5.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. When the sea level returned to present condition, sediments filled the river channels and started to cover the area that would become the Mississippi Sound. Sandy deposits that had been transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with these deposits.

The actual Sound formed as an estuary after littoral drift of sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand is typically medium grained, white to light grey in color with well rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These deposits, as shown in Figure 3.1.2.5-2, can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward. This process was added by formation of the St. Bernard delta of the Mississippi River that enclosed the western end of the Sound. The western-most island in the chain, Cat Island, is a product of the historic St. Bernard delta lobe. What remains today is a beach front face of the island where waves have sorted the material leaving the sand and deltaic deposits behind the beach.



Figure 3.1.2.5-2. Peat-like organic soils outcropping on the south beach of East Ship Island. These deposits are the remains of sediments and organic matter that settle in the bottom of the marshes and lakes that occur on the barrier islands. The deposits are exposed as the islands migrate northward.

East and West Ship Island, Horn Island and Petit Bois Island are migrating over Pleistocene formations that created a relatively stable platform for the constantly moving islands. Other Holocene deposits provide a relatively thin cover on the bottom of the Mississippi Sound and some areas south of the Islands and consist of a muddy mixture of sand and clay along with shell fragments or buried oyster shell beds.

After the islands formed, the Sound became a brackish estuary and deposits of mostly fine grained, muddy sediments began forming in the Sound. Other than Cat Island, the other islands such as they exist today, are migrating along the littoral drift and are mostly composed of sand. Local layers of peat-like organic soil that are forming in the inter-island lakes and marshes and can become exposed on the beaches as the sand migrates.

If increasing the land mass of the islands, it would be desirable to maintain the same quality sand that now makes up the existing islands. Sources of sand in the quantity that would be required for this option are extremely large, especially when considering the quality standard that must be met. Potential sources for sand were investigated both inland and offshore. Of concern is matching the sand to the sand on the beaches of the National Seashore. Samples taken from Dauphin and Pelican Island in Alabama are in the same island chain and have been tested for color, grain size and particle shape. These results, included in this section as Table 3.1.2.5-2 and Figures 3.1.2.5-3 and 3.1.2.5-4, can be used to match potential sand sources.

Table 3.1.2.5-2.
Munsell Soil Color Evaluation of Sand Samples Taken from the Barrier Islands of Alabama that is within the Littoral Drift Zone of the Mississippi Barrier Islands

Sample ID	Hue	Value	Chroma	Color
Composite 1	5YR	6	3	Pale Olive
Composite 2	10YR	8	1	White
Composite 3	10YR	8	2	White
Composite 4	2.5 YR	7	2	Light Grey

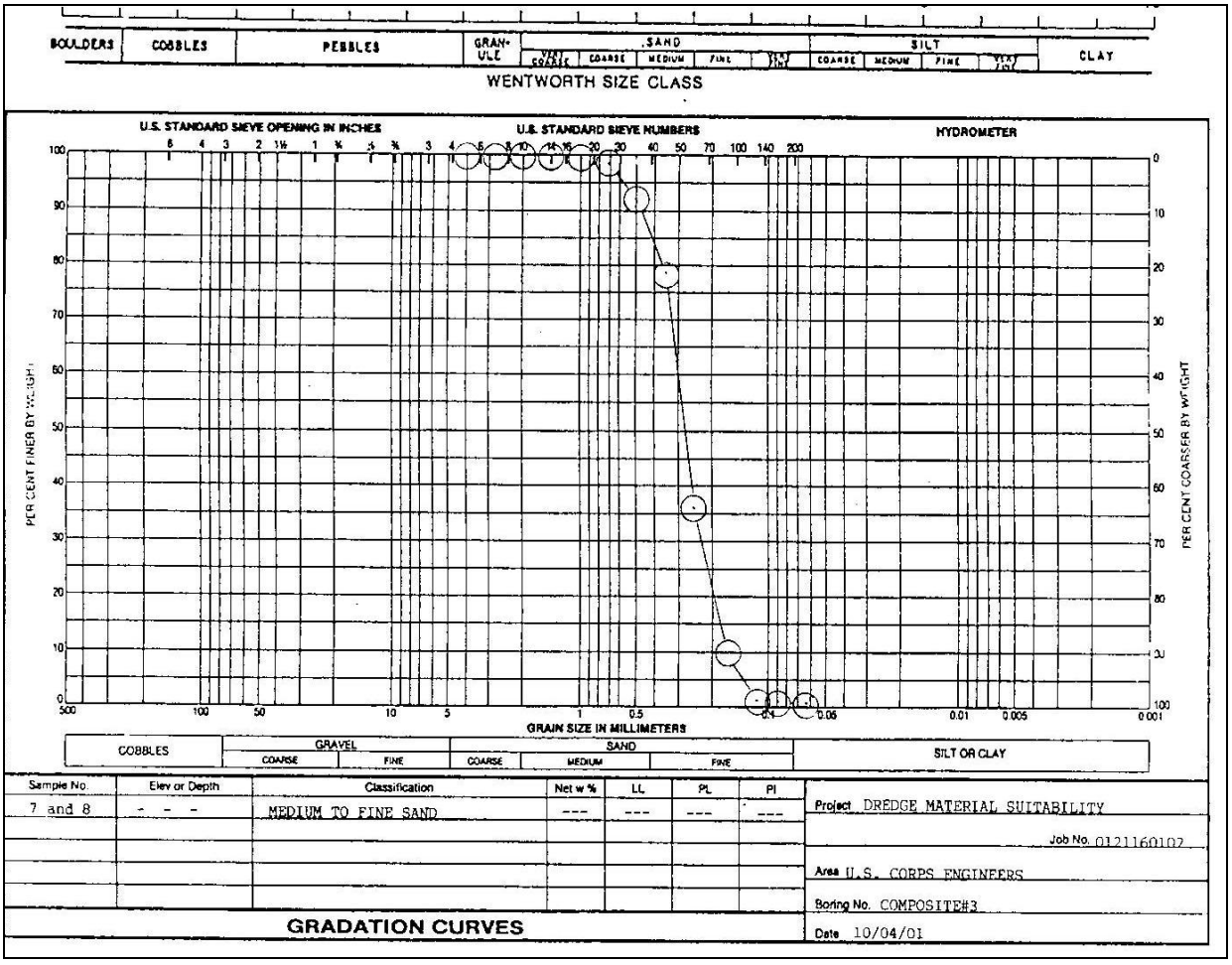


Figure 3.1.2.5-3. Composite gradation from sieve analysis of sand taken from the barrier islands of Alabama that is within the littoral drift zone of the Mississippi barrier islands.

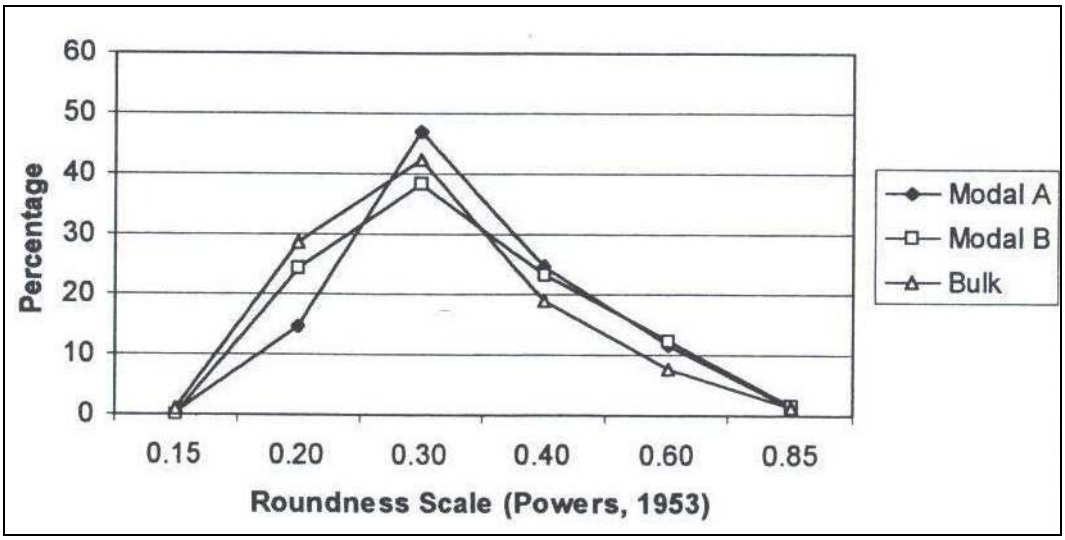


Figure 3.1.2.5-4. Grain Sphericity of composite sand sample taken the barrier islands of Alabama that are within the littoral drift zone of the Mississippi barrier islands Values for sphericity (roundness) are .15 - very angular, .20 - angular, .30 - sub-angular, .40 - sub-rounded, .60 – rounded, and .85 – well rounded.

These beaches are used for nesting by endangered sea turtles where grain size, particle shape and color of the sand are very important. The sand from inland river sources is not a perfect match to any of these criteria and its use was discounted for direct application on the islands. Using sand from the littoral drift zone around and between the islands would certainly be a good match, but it was generally felt that removing the quantity of sand required would be harmful to the future natural accretion of the islands in the future. Discussions with the USGS revealed that previous work by there agency has potentially identified a large source of high quality sand south of the existing islands. This source is a submerged chain of islands named St. Bernard Shoals, created when the sea level was lower in an interglacial period (see Figure 3.1.2.5-5). These islands are believed to have a sand of quality similar to what is found in the present day Mississippi islands and sufficient quantity to meet the needs of this option. Presently, limited geophysical profiling and samples have been completed, but additional work is being conducted by the USGS under a grant to the State of Mississippi by the Minerals Management Agency. This source is located approximately 45 miles south of the barrier islands and lies in about 60 feet of water.

3.1.2.5.3 Structural, Mechanical and Electrical

This option will have no structural, mechanical or electrical components.

3.1.2.5.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

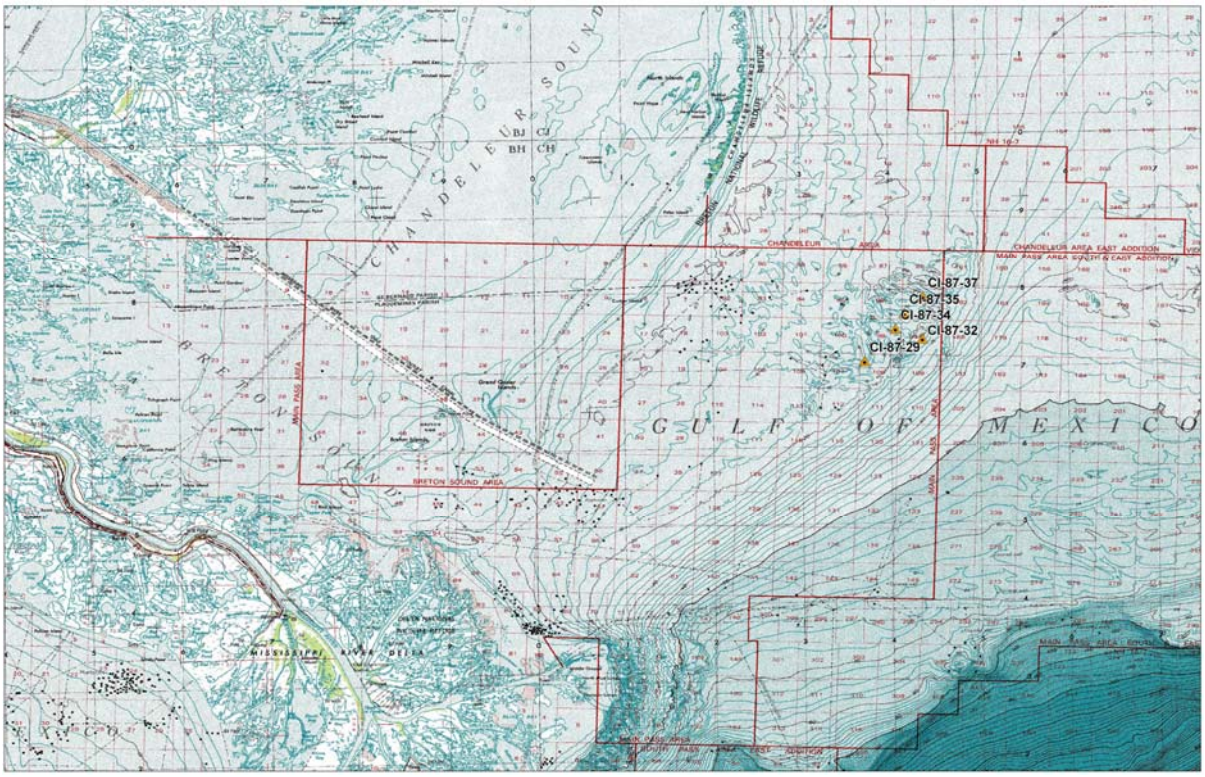


Figure 3.1.2.5-5. St. Bernard Shoals is shown as the area in the center right of the map with the numbered borings that were taken in the past to sample the sand sediments located there. Note the southern end of the Chandeleur Islands northwest of the Shoals.

3.1.2.5.5 Construction Procedures and Water Control Plan

To increase the size of the footprint of each island and restore them back to a pre-Camille footprint will involve several different operations, some of which can take place concurrently. The source of sand that has been designated as the potential borrow area will require additional investigation using both geophysical techniques and physical sampling. The sand is expected to be in submerged shoals that will have to be located and mapped prior to any removal of the sand. This will be completed during design and before the construction begins.

Each of the islands will require that a “dump basin” be excavated by dredging before any sand is transported from the borrow areas which is located about 45 miles south of the islands. These basin are required due to the depth of the water which is too shallow for the dredges to approach the islands. The basins will typically be located about one mile from the beach of the respective island where sand is being added to surrounding waters. These basins will be of sufficient size to allow a large quantity of sand to be stored after being bottom dumped from a hopper dredge. The material dredged from these basins is anticipated to be unsuitable for placement on the islands and is expected to be transported to permitted disposal areas. As each basin is completed, a hopper dredge can begin to remove sand from the borrow area and transport it to the basin where it can be quickly dumped, allowing the dredge to have minimal delays between trips. When the sand in a basin reaches a set capacity, a cutterhead, suction dredge will move the sand from the basin to the area where the sand is needed. Where needed, booster pumps will be utilized. The discharge from the suction dredge will be moved over the areas where the size of the island is being increased. As an area is filled to the desired grade, the sand will be shaped into dunes, basins and beaches. As this earthwork is completed for a given area, planting can begin. The suction dredge will be moved

as needed to accommodate the excavation of the basins and the transfer of the sand from the basins to the islands. It is anticipated that the suction dredge will be moved, then remobilized several times during the entire process for completing an islands enlargement.

3.1.2.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.5.7 Operations and Maintenance

The placement of sand to increase the land mass of each of the islands will be a one-time event. Per an agreement with the National Park Service, no additional beach maintenance will be performed in the future. This project will provide a one-time supplement of the sand supply of the islands and the littoral system, after which, natural processes will be allowed to maintain and shape the islands in accordance with 2006 NPS Management Policies. Therefore, there will be no costs associated with operations and maintenance for this option.

3.1.2.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.11, Cost Summary. Total project costs for the various options are included in Table 3.1.2.11-1. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.5.9 Schedule for Design and Construction

This option will require extensive coordination with both state and Federal agencies to acquire the necessary permits that allow construction of this option. It is also anticipated that during the design process additional modeling will be required to assist in determining the most appropriate configuration of the additional land mass. Once the design is complete, construction may require several years due to the large quantity of sand that would be required and the distance from the borrow site to the island. Planting of vegetation can be concurrent with sand placement and shaping.

3.1.2.6 Option B – Replenish Sand in Littoral Zone, Inland Source

Another consideration to help restore the islands is to supplement the sand in the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system. Potential locations for sand placement are shown in Figure 3.1.2.6-1. NPS support for this option would be dependent on additional research, data collection, analysis and modeling, particularly with respect to sand compatibility and littoral zone placement.

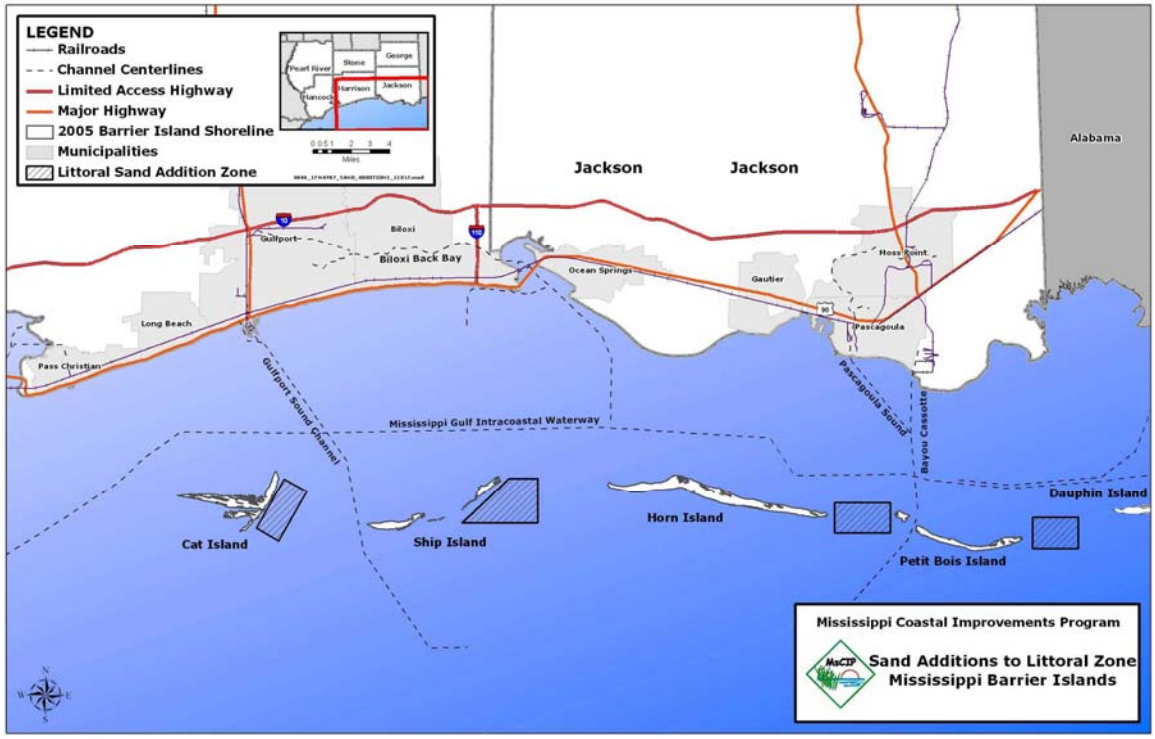


Figure 3.1.2.6-1. Potential areas for sand addition to the littoral drift zone at the Mississippi Barrier Islands. Actual locations would be based on sediment transport modeling.

As discussed in Part 1, the construction of inland waterways in Alabama and Mississippi has resulted in continuing maintenance dredging to maintain the channel depths and alignments. This dredged material is now accumulated in disposal areas along the banks of the river. Dredging of some of the areas along the river has produced large quantities of sand that have potential use for replenishment of littoral zones such as are found along the Mississippi Barrier Islands. An inventory of current disposal sites indicates that approximately 30,000,000 cubic yards of sand is available. Only disposal sites that contain a minimum of 100,000 cubic yards of sand were included in the inventory. Of interest to this study are disposal sites that are located along the Black Warrior – Tombigbee River system and the Tennessee – Tombigbee Waterway. Figure 1.5-6 showed the relationship of these disposal areas to the project sites along the Mississippi coast. Material from these sites could easily be transported by barge down the river system for use among the islands littoral zone. The cost to store this type of dredged material is high and it has recently been estimated that removing the sand from the existing disposal areas would save the Government over

$100,000,000 at today's cost. This cost is based on a recent cost estimate for all costs, real estate, construction and mitigation, required to construct additional disposal areas.

Because of the shortage of additional disposal areas, the Corps of Engineers' Operations Division has contracted for several studies on the beneficial use of the sand. Some of these studies have been targeted at using the sand for beach nourishment, (Thompson Engineering, 2001). Using sand samples from some of the inland disposal areas along the Black Warrior – Tombigbee River, a series of analyses were conducted on the samples. For comparison purposes, several samples of actual beach sand and from the littoral drift zone from coastal Alabama were taken and subjected to the same tests. These tests included grain size distribution (gradation), color and roundness. The results of the tests indicated that some of the samples may be suitable for beach nourishment. The sand from the river was typically a finer grain size than the beach sand with the predominant river size being a fine sand while the beach sand was mostly medium sand. It was also noted that the beach sand was more rounded than the river sand. The roundness of two typical samples of the river sand was described in the analyses shown in Figures 3.1.2.6-2 and 3.1.2.6-3. The majority of the sample is angular to sub-angular in particle shape.

One factor that warranted further analysis was the color difference of the river sand as compared to the beach sand. All of the river sand had a brown tint described as "very pale brown" or "light yellow brown" (see Table 3.1.2.6-1). This compared to the beach sand samples which were described as "pale olive, white or light grey". These colors were assigned along with evaluations for hue, value and chroma from a Munsell Soil Color chart which provides a standard method of assigning color to soils. The report also noted that beach sand came from a higher energy environment where any staining due the depositional environment may have been removed by abrasion due to wave action. It also noted that the sand might undergo bleaching from the ultraviolet radiation from the sun if the color was caused by a mineral staining. To test these conditions that may change the color of the sand, a series of tests were conducted on samples from the same areas that were used during the initial analyses, (Thompson, 2002). The samples were subjected to two tests. The first involved actual bleaching of the samples using a chemical oxidizer, hydrogen peroxide, for different periods of time. These tests did indicate that the bleaching process was detectable after 72 hours. Other tests were conducted to simulate the process of wave action causing an agitation of the particles which may remove any mineral coating or staining along with exposure to ultraviolet light. This process was conducted for 144 hours without a notable difference in color.

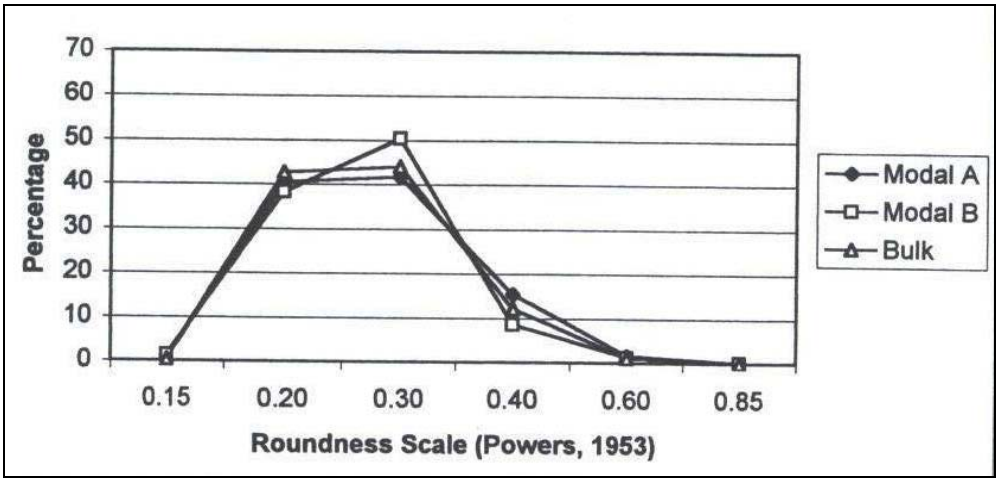


Figure 3.1.2.6-2. Grain Sphericity of composite sand sample taken from Baldbar disposal area on the Black Warrior – Tombigbee River system in Alabama. Values for sphericity (roundness) are .15 - very angular, .20 - angular, .30 - sub-angular, .40 - sub-rounded, .60 – rounded, and .85 – well rounded.

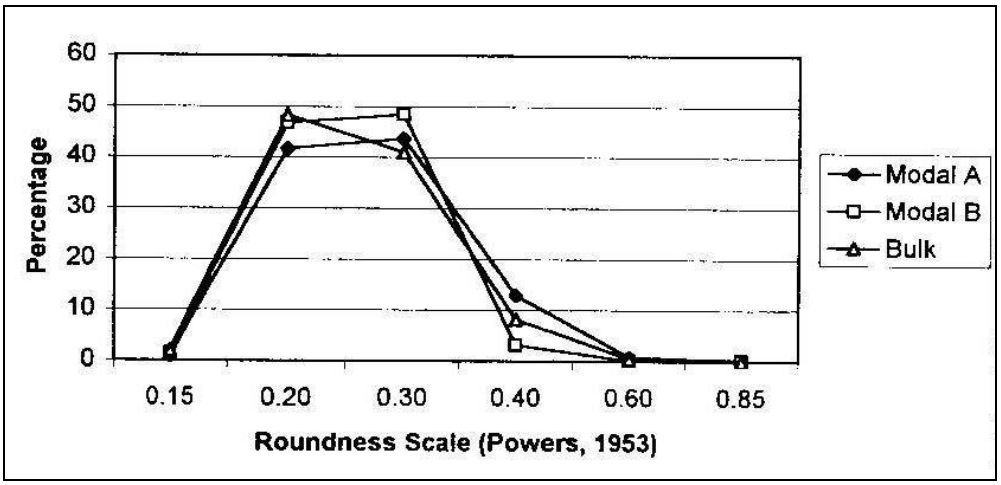


Figure 3.1.2.6-3. Grain Sphericity of composite sand sample taken from Buena disposal area on the Black Warrior – Tombigbee River system in Alabama. Values for sphericity (roundness) are .15 - very angular, .20 - angular, .30 - sub-angular, .40 - sub-rounded, .60 – rounded, and .85 – well rounded.

Table 3.1.2.6-1.
Munsell Soil Color Evaluation of Sand Samples Taken from the Alabama, Black Warrior and Tombigbee River Systems in Alabama

Sample ID	Hue	Value	Chroma	Color
Buena Vista 2 (surface)	10YR	7	3	Very Pale Brown
Buena Vista 2 (1.5" depth)	10YR	7	3	Very Pale Brown
Bald Bar/Big Sand	10YR	6	4	Light Yellow Brown
North Star Wreck	10 YR	7	4	Very Pale Brown

As discussed in Section 2.1, recent testing with a different type of abrasion process has concluded that the color of the sand is a grain surface staining should be removed as the sand abrades during littoral transport, (Baehr, 2007). The resulting sand should then be similar in color to the existing beaches. This process will be verified through additional controlled laboratory research and testing based on multiagency work group recommendations prior to any sand placement.

By spreading the sand over large areas to a small thickness, approximately one foot, the natural sediment transport process would blend the two sands together. The transport process may also tend to remove any staining from the sand grains and could help to round the individual particles through abrasion. Based on having 30,000,000 cubic yards of sand available, each of the islands was assigned a percentage of that quantity. This percentage was based on the amount of land loss (percentage of total loss) for each of the islands from pre-Camille to post-Katrina. The volumes of sand to be placed near each island are as follows:

Cat – 4,200,000 cubic yards

Ship – 9,600,000 cubic yards

Horn – 9,600,000 cubic yards

Petit Bois – 6,600,000 cubic yards

The entire process would consist of loading the sand onto river barges at the various disposal areas, moving the barges downriver and into the Mississippi Sound via tugboat tows, unloading the barges with a “hydraulic unloader”, and spreading the sand with a “spreader barge”. The process would require a continuous supply of loaded barges as the unloader only needs about an hour to remove the sand from a typical river barge. Staging this process from within the Mississippi Sound would also help with down time due to weather that would be more affected on the south side of the islands.

3.1.2.6.1 Interior Drainage

The type of work anticipated for adding sand into the littoral drift zone will not require any type of drainage system. The addition of sand under this operation will be with dredge pipe discharge into open water.

3.1.2.6.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. When the sea level returned to present condition, sediments filled the river channels and started to cover the area that would become the Mississippi Sound. Sandy deposits that had been transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with these deposits.

The actual Sound formed as an estuary after littoral drift of sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand is typically medium grained, white to light grey in color with a sub-angular to rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These deposits can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward. The estuary forming process was added by formation of the St. Bernard delta of the Mississippi River that enclosed the western end of the Sound. The western-most island in the chain, Cat Island, is a product of the historic St. Bernard delta lobe. What remains as Cat Island today is a beach front face of the island where waves have sorted the material leaving the sand and deltaic deposits behind the beach.

East and West Ship Island, Horn Island and Petit Bois Island are migrating within a littoral zone over Pleistocene formations that created a relatively stable platform for the constantly moving islands. By increasing the sand within the littoral zone, it would allow it to become subject to the same coastal processes that move the sand already in the system.

The beaches of the Mississippi Barrier Islands are used for nesting by endangered sea turtles where grain size, particle shape and color of the sand are very important. The sand from inland river sources is not a perfect match to these criteria, but if added into the existing system, it would be subject to the same forces that abrade the sand grains to a rounder particle shape. Using sand from the same littoral drift zone where the Mississippi Islands are located would certainly be a good match, but it was generally felt that removing the quantity of sand required would be harmful to natural accretion of the islands in the future.

3.1.2.6.3 Structural, Mechanical and Electrical

This option will have no structural, mechanical or electrical components.

3.1.2.6.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.6.5 Construction Procedures

To add off-site sand into the littoral system under this option, material from inland dredged material disposal sites would be transported by barge down the river system for use among the islands littoral zones.

Each of the areas designated for adding sand will require that a staging area where barges could be unloaded and the sand spread over the selected area. The sand would be transported from each of numerous disposal sites located up the river systems. The size of the locks on the river systems and the depth of associated channels will dictate the size of barges that can be used. As the barges are unloaded at each site, the sand would be pumped to spreader barges that would be able to cover an area sufficient to control the depth of sand placement.

3.1.2.6.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.6.7 Operations and Maintenance

The placement of sand into the littoral zone of each of the islands will be a one-time event. No additional beach maintenance is anticipated in the future, therefore, there will be no costs associated with operations and maintenance for this option.

3.1.2.6.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12, Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering

design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Project Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.6.9 Schedule for Design and Construction

This option will require extensive coordination with both state and Federal agencies to acquire the necessary permits that allow implementation of this option. It is also anticipated that during the design process additional sediment transport modeling will be required to assist in determining the most appropriate locations for the addition of sand into the littoral system. Once the design is complete, construction may require several years due to the large quantity of sand that would be required and the distance from the inland borrow sites to the island.

3.1.2.7 Option C – Replenish Sand in Select Littoral Zones, Offshore and Inland River Sources

Another consideration to help restore the islands is to supplement the sand in select littoral system zones with sand obtained from both inland river and offshore borrow areas. Like Option B, this could be accomplished by adding sand in specific locations based on sediment transport modeling. Potential areas where the sand may be added was shown in Figure 3.1.2.6-1, but for this option would be limited to the areas east of Ship Island and Petit Bois Island. These two areas were selected based on cooperation between the National Park Service (NPS, 2007) and the Corps of Engineers and is based on restoration policy of natural resources with the NPS. Both of these islands are affected by the presence of navigation channels that limit westward migration. Placement of sand into these two areas would add sediment into the system and would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. The sand that could be used in this option may come from the same offshore borrow area as Option A, the St. Bernard Shoals located about 45 miles south of the barrier islands and the lower inland river sand described in Option B. A hydrographic map showing the location of St. Bernard Shoals in relationship to the southern end of the Chandeleur Islands was shown in Figure 3.1.2.5-5. The sand from the inland river sources would be from the lower-most areas shown in Figure 1.5.6. NPS support for this option would be dependent on additional research, data collection, analysis and modeling, particularly with respect to sand compatibility and littoral zone placement.

The volume of sand that could be added into the littoral zone under this option could vary based on additional modeling, but for the volumes of sand to be placed near each island are as follows:

Ship – 5,000,000 cubic yards

Petit Bois – 4,000,000 cubic yards

These volumes were computed based on records from maintenance dredging for the Pascagoula Navigation Channel and represent that total volume less the sand that would be used to fill the breach between East and west Ship Island. The higher volume of sand for the littoral zone placement at the east end of East Ship Island was based on the professional judgement of a Multiagency group (including the NPS) that is working on the barrier island measures. These volumes could change based on additional sediment transport modeling that will assist in the exact placement locations.

3.1.2.7.1 Interior Drainage

The type of work anticipated for adding sand into the littoral drift zone will not require any type of drainage system. The addition of sand under this operation will be with dredge pipe discharge into open water.

3.1.2.7.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. Sandy deposits that were transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with deposits.

The actual Sound formed as an estuary after littoral drift of sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand is typically medium grained, white to light grey in color with well rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These deposits can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward. The estuary forming process was added by formation of the St. Bernard delta of the Mississippi River that enclosed the western end of the Sound. The western-most island in the chain, Cat Island, is a product of the historic St. Bernard delta lobe migrating across the historic littoral zone. What remains of Cat Island today is a T-shaped island with an east facing beach front face of the island where waves have reshaped the island and sorted the material leaving the east-west elongated sand ridges and deposits behind the beach.

East and West Ship Island, Horn Island and Petit Bois Island are migrating over Pleistocene formations that created a relatively stable platform for the constantly moving islands. Other Holocene deposits provide a relatively thin cover on the bottom of the Mississippi Sound and some areas south of the islands and consist of a muddy mixture of sand and clay along with shell fragments or buried oyster shell beds.

If increasing the sand within the littoral zone, it is desirable to maintain the same quality sand that now makes up the existing islands. Sources of sand in the quantity that would be required for this option are large, especially when considering the quality standard that must be met. Potential sources for this sand have potentially identified both offshore and from inland river sources. These are the same borrow areas that is being considered for Option A and B. Of concern is matching the sand being added to the littoral system to the physical characteristics of the sand on the beaches of the National Seashore. As discussed in Option A for the barrier islands, sand from the St. Bernard Shoals should be of similar quality to that presently on the islands. Discussions with the USGS revealed that this source is a submerged chain of islands created when the sea level was lower in an interglacial period. These islands are believed to have a sand of quality similar to what is found in the present day Mississippi islands and sufficient quantity to meet the needs of this option. This source is located approximately 45 miles south of the barrier islands and lies in about 60 feet of water. The sand from Option B may also be suitable for this option following further testing for compatibility.

3.1.2.7.3 Structural, Mechanical and Electrical

This option will have no structural, mechanical or electrical components.

3.1.2.7.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.7.5 Construction Procedures and Water Control Plan

To increase sand within the littoral zone from inshore and off-shore sources will involve several different operations, some of which can take place concurrently. The source of sand that has been designated as the potential borrow area will require additional investigation using both geophysical techniques and physical sampling. The offshore sand is expected to be dredged from submerged shoals that will have to be located and mapped prior to any removal of the sand. This will be completed during design and before the construction begins. The inland river sand will be loaded and brought down the river on barges for transportation to the area where it will be spread.

3.1.2.7.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.7.7 Operations and Maintenance

The placement of sand into the littoral zone of each of the islands will be a one-time event. No additional direct beach maintenance is anticipated in the future, therefore, there will be no costs associated with operations and maintenance for this option.

3.1.2.7.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12, Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.7.9 Schedule for Design and Construction

This option will require extensive coordination with both state and Federal agencies to acquire the necessary permits that allow implementation of this option. It is also anticipated that during the design process additional sediment transport modeling will be required to assist in determining the most appropriate locations for the addition of sand into the littoral system. Once the design is complete, construction may require several years due to the large quantity of sand that would be required and the distance from the inland borrow sites to the island.

3.1.2.8 Option D – Environmental Restoration w/ 2-foot Dune

This option would involve environmental restoration of the islands consisting of shaping existing sand into dunes on the beaches with planted vegetation and planting of maritime forests on the existing islands where they were mostly destroyed by Hurricane Katrina. Despite continual changes that occur, the barrier islands remain to buffer the mainland from storms and provide habitat for the rich, diverse wildlife residing within the area. On the southern portion of the islands, sea oats primarily, which are tolerant of high salt levels, thrive on the dune system which is located behind the beach area. Behind the primary dunes, trees and shrubs, such as short-leaf and long-leaf pines, can be found in the maritime forest. In the island interiors, emergent marshes collect fresh rainwater to help support its inhabitants. NPS support for this option is unlikely due to conflicts with that agency's 2006 Management Policies and statutory responsibilities.

Gulf Coast barrier islands and barrier spits can support stunted oak and yaupon shrublands. These scrub-scrub habitats are most often located on rises surrounded by black needlerush (*Juncus roemarianus*) salt marshes and have been reported from the Gulf Islands National Seashore (Natureserve Explorer 2002). Stunted slash pine may be present in the overstory, but most cover will be in a shrub layer dominated by yaupon, live oak, sand live oak, wax myrtle, saw palmetto, and salt bush (*Baccharis halimifolia*).

Immediately following Hurricane Katrina, most of the effort was spent protecting human life and securing structures throughout the impacted areas; therefore, few assessments of the vegetation impacts exist. For the barrier island system, most all of the vegetation recovered several months following Hurricane Katrina. The predominant vegetation that has long-term impacts consists of those pines found in the maritime forests. It is estimated that about 75% of these pine species were killed following the hurricane season of 2005, with most that attributable to Hurricane Katrina. The sea oats are still found in small patches due to the reduced dune system. Figure 3.1.2.8-1 is a photo of the south beach of Horn Island showing the lack of dunes and the damaged pine forest. An exception to the loss of vegetation is the emergent marsh habitat. It is thriving so well it actually looks as though hurricanes never past through the barrier island system.

One restoration option for the barrier islands would be to re-establish the vegetation that was destroyed by Hurricane Katrina. This option could involve restoration of the existing islands through adding sand dunes on the beaches along with planted vegetation (i.e. *Uniola paniculata*), planting of marshes (i.e. *Spartina alterniflora*, *Juncus roemerianus*, and Spartina patens) and maritime forests (i.e. *Pinus elliottii Engelm*, *Serenoa repens*, *Sabal minor*, etc.), and planting seagrasses (i.e. *Diplanthera wrightii*, *Cymodocea manatorum*, *Thalassia testudinum*, and *Ruppia maritime*) in the near-shore areas of the islands. Foremost, the vegetation would restore the island's natural setting, which allows for the diverse array of flora and fauna to persist. This plan would not involve adding any land mass to the islands other than the possibility of adding to the dune system. Vegetation would aid in reducing erosion from wind; thus helping in maintaining the stability of the islands. The vegetation would also aid in preventing erosion in the event that the islands gets overtopped by storm surge in a large hurricane.



Figure 3.1.2.8-1. Photo across the beach from the water on the south side of Horn Island. The wide, flat beach is now typical of the Mississippi Barrier Islands. The pine trees in the background are mostly dead, destroyed by the affects of Hurricane Katrina.

An environmental impact of the islands continuing to diminish in size is the increase in Mississippi Sound's salinity. Under current conditions, the islands provide a boundary between the sea water salinity [~33 parts per thousand (ppt)] of the open Gulf of Mexico and the brackish water found in the Sound. Salinity in the Sound during low flow periods range from 10 to 30 ppt. Highest salinities occur just south of Pascagoula and Gulfport and the lowest salinities in the Lake Borgne-Pearl River area. Loss of the islands would allow the salinity to greatly increase changing the ecological habitats that exist now. Mississippi Sound is one of the most productive systems on the Gulf coast. Changes in its salinity would impact not only fisheries but also the estuarine marshes, and the saltwedge in the area's rivers. This would impact shellfish and many other forms of marine life. Oysters currently found in concentrated Mississippi Sound areas would possibly cease to exist. At the Chandeleur Islands, loss in the island mass allows us to anticipate those potential environmental changes. Initial assessments are showing seagrasses diminishing, marsh erosion ongoing, and wave energy having no natural barrier.

The dune would be shaped from sand that would be removed from the surface between the constructed dune and the edge of the vegetation north of the dune. The dune would have a height of 2-feet, 1v to 3h slopes and a crest width of 6 feet. The dune would be continuous for the length of the gulf-side, south beach. While not designed as a structural defense against storms, the dune would be used as a platform to establish a line of sea oats that in turn would help in the natural process of creating larger and more pronounced sand dunes. The dunes would build with time as wind driven deposits of sand become trapped by the vegetation.

As previously discussed, the marsh grasses were not adversely affected by Hurricane Katrina. Island vegetation that was affected and would benefit the ecological community by a re-planting program is pine trees in the interior of the islands and sea oats on the beaches. The pines could be planted without any preparation, but the sea oats would benefit from a constructed dune to help

become established. The quantities of vegetation for each island with a 2-foot constructed dune on the southern beach are shown in Table 3.1.2.8-1.

Table 3.1.2.8-1.
Quantities of Plantings for each Barrier Island

Island	2006 Acres	Pre-Katrina Acres Maritime Pine Forest	Replanting 75 Percent of Pine Forest Acres	Sea Oats - Planted 2-foot Dune Acres
Cat	1957	1% of Island	15 acres	6.3 acres
Ship (East & West)	631	3.7% of Island	18 acres	8.4 acres
Horn	3077	23% of Island	531 acres	23.4 acres
Petit Bois	1098	23%of Island	190 acres	13.2 acres

3.1.2.8.1 Interior Drainage

Interior drainage features are not applicable to the option.

3.1.2.8.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. When the sea level returned to present condition, sediments filled the river channels and started to cover the area that would become the Mississippi Sound. Sandy deposits that had been transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with these deposits.

The Mississippi Sound north of the islands formed as an estuary after littoral drift of the sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand that composes the islands is typically medium grained, white to light grey in color with well rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These deposits, as shown in Figure 3.1.2.5-2, can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward. This process was added by formation of the St. Bernard delta of the Mississippi River that enclosed the western end of the Sound. The western-most island in the chain, Cat Island, is a product of the historic St. Bernard delta lobe. What remains today is a beach front face of the island where waves have sorted the material leaving the sand and deltaic deposits behind the beach. The islands, such as they exist today, are migrating along the littoral drift and are mostly composed of sand with local layers of peat-like organic soil that are forming in the inter-island lakes and marshes.

3.1.2.8.3 Structural, Mechanical and Electrical

Structural, Mechanical and Electrical is not applicable to this option.

3.1.2.8.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final selection of any sites associated with this option. The

construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.8.5 Construction Procedures

This option will involve the planting of various types of vegetation in selected areas on the islands. Actual construction activities will take place only during the shaping of the small dunes on the beaches from existing the sand berm. Although the dune is of limited size, the total length of the dune construction will be approximately 30 miles for all the islands.

3.1.2.8.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.8.7 Operations and Maintenance

The initial planting of the various types of vegetation will have a warranty that will insure an approved survival rate. There will be no additional maintenance of the established plants under this option.

3.1.2.8.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12, Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.8.9 Schedule for Design and Construction

This option will require extensive coordination with both state and Federal agencies to acquire the necessary permits that allow implementation of this option. The actual design will be straight-forward with designated areas for the different types of planting vegetation and general guidance for the dune construction. The actual construction will require coordination with suppliers to furnish the large number of plants that are required for this option.

3.1.2.9 Option E – Environmental Restoration w/ 6-foot Dune

This option would involve environmental restoration of the islands consisting of shaping existing sand into dunes on the beaches with planted vegetation and planting of maritime forests on the existing islands where they were mostly destroyed by Hurricane Katrina. The sand required to construct a dune of this size would be more than could be removed from the existing beach berm and would come from the same offshore borrow area as the sand used in Option A. Placement of the sand would require moving the sand from a hopper dredge to a staging area on the beach, then moving the sand to the area of placement along the beach.

Despite continual changes that occur, the barrier islands remain to buffer the mainland from storms and provide habitat for the rich, diverse wildlife residing within the area. On the southern portion of the islands, sea oats primarily, which are tolerant of high salt levels, thrive on the dune system which is located behind the beach area. Behind the primary dunes, trees and shrubs, such as short-leaf and long-leaf pines, can be found in the maritime forest. In the island interiors, emergent marshes collect fresh rainwater to help support its inhabitants. NPS support for This option is unlikely due to conflicts with agency natural resources management policies.

Gulf Coast barrier islands and barrier spits can support stunted oak and yaupon shrublands. These scrub-scrub habitats are most often located on rises surrounded by black needlerush (*Juncus roemarianus*) salt marshes and have been reported from the Gulf Islands National Seashore (Natureserve Explorer 2002). Stunted slash pine may be present in the overstory, but most cover will be in a shrub layer dominated by yaupon, live oak, sand live oak, wax myrtle, saw palmetto, and salt bush (*Baccharis halimifolia*).

Immediately following Hurricane Katrina, most of the effort was spent protecting human life and securing structures throughout the impacted areas; therefore, few assessments of the vegetation impacts exist. For the barrier island system, most all of the vegetation recovered several months following Hurricane Katrina. The predominant vegetation that has long-term impacts consists of those pines found in the maritime forests. It is estimated that about 75% of these pine species were killed following the hurricane season of 2005, with most that attributable to Hurricane Katrina. The sea oats are still found in small patches due to the reduced dune system. An exception to the loss of vegetation is the emergent marsh habitat. It is thriving so well it actually looks as though hurricanes never past through the barrier island system.

One restoration option for the barrier islands with be to re-establish the vegetation that was destroyed by Hurricane Katrina. This option could involve restoration of the existing islands through adding sand dunes on the beaches along with planted vegetation (i.e. *Uniola paniculata*), planting of marshes (i.e. *Spartina alterniflora, Juncus roemerianus*, and *Spartina patens*) and maritime forests (i.e. *Pinus elliottii Engelm, Serenoa repens, Sabal minor*, etc.), and planting seagrasses (i.e. *Diplanthera wrightii, Cymodocea manatorum, Thalassia testudinum,* and *Ruppia maritime*) in the near-shore areas of the islands. Foremost, the vegetation would restore the island's natural setting, which allows for the diverse array of flora and fauna to persist. This plan would not involve adding any land mass to the islands other than the possibility of adding to the dune system. Vegetation would aid in reducing erosion from wind; thus helping in maintaining the stability of the islands. The vegetation would also aid in preventing erosion in the event that the islands gets overtopped by storm surge in a large hurricane.

An environmental impact of the islands continuing to diminish in size is the increase in Mississippi Sound's salinity. Under current conditions, the islands provide a boundary between the sea water salinity [~33 parts per thousand (ppt)] of the open Gulf of Mexico and the brackish water found in the Sound. Salinity in the Sound during low flow periods range from 10 to 30 ppt. Highest salinities occur just south of Pascagoula and Gulfport and the lowest salinities in the Lake Borgne-Pearl River area.

Loss of the islands would allow the salinity to greatly increase changing the ecological habitats that exist now. Mississippi Sound is one of the most productive systems on the Gulf coast. Changes in its salinity would impact not only fisheries but also the estuarine marshes, and the saltwedge in the area's rivers. This would impact shellfish and many other forms of marine life. Oysters currently found in concentrated Mississippi Sound areas would possibly cease to exist. At the Chandeleur Islands, loss in the island mass allows us to anticipate those potential environmental changes. Initial assessments are showing seagrasses diminishing, marsh erosion ongoing, and wave energy having no natural barrier.

The dune would be shaped from sand that would be removed from the surface between the constructed dune and the edge of the vegetation north of the dune. The dune would have a height of 6-feet, 1v to 3h slopes and a crest width of 6 feet. The dune would be continuous for the length of the gulf-side, south beach. While not designed as a structural defense against storms, the dune would be used as a platform to establish a line of sea oats that in turn would help in the natural process of creating larger and more pronounced sand dunes. The dunes would build with time as wind driven deposits of sand become trapped by the vegetation.

As previously discussed, the marsh grasses were not adversely affected by Hurricane Katrina. Island vegetation that was affected and would benefit the ecological community by a re-planting program is pine trees in the interior of the islands and sea oats on the beaches. The pines could be planted without any preparation, but the sea oats would benefit from a constructed dune to help become established. The quantities of vegetation for each island with a 6-foot high constructed dune on the southern beach are shown in Table 3.1.2.9-1.

Table 3.1.2.9-1.
Quantities of Plantings for each Barrier Island

Island	2006 Acres	Pre-Katrina Acres Maritime Pine Forest	Replanting 75 Percent of Pine Forest Acres	Sea Oats - Planted 6-foot Dune Acres
Cat	1957	1% of Island	15 acres	14.9 acres
Ship (East & West)	631	3.7% of Island	18 acres	19.9 acres
Horn	3077	23% of Island	531 acres	55.3 acres
Petit Bois	1098	23%of Island	190 acres	31.2 acres

3.1.2.9.1 Interior Drainage

Interior drainage features are not applicable to the option.

3.1.2.9.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. When the sea level returned to present condition, sediments filled the river channels and started to cover the area that would become the Mississippi Sound. Sandy deposits that had been transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with these deposits.

The Mississippi Sound north of the islands formed as an estuary after littoral drift of the sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals

became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand that composes the islands is typically medium grained, white to light grey in color with well rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These deposits can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward. This process was added by formation of the St. Bernard delta of the Mississippi River that enclosed the western end of the Sound. The western-most island in the chain, Cat Island, is a product of the historic St. Bernard delta lobe. What remains today is a beach front face of the island where waves have sorted the material leaving the sand and deltaic deposits behind the beach. The islands, such as they exist today, are migrating along the littoral drift and are mostly composed of sand with local layers of peat-like organic soil that are forming in the inter-island lakes and marshes.

3.1.2.9.3 Structural, Mechanical and Electrical

Structural, Mechanical and Electrical is not applicable to this option.

3.1.2.9.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final selection of sites associated with this option. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.9.5 Construction Procedures

This option will involve placement of dredged material onto the existing beaches and shaping the sand into low dunes as described. Other activities will involve the planting of various types of vegetation in selected areas on the islands.

3.1.2.9.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.9.7 Operations and Maintenance

The initial planting of the various types of vegetation will have a warranty that will insure an approved survival rate. There will be no additional maintenance of the established plants under this option.

3.1.2.9.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12, Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are

comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.9.9 Schedule for Design and Construction

This option will require extensive coordination with both state and Federal agencies to acquire the necessary permits that allow implementation of this option. The actual design will be straight-forward with designated areas for the different types of planting vegetation and general guidance for the dune construction. The actual construction will require coordination with suppliers to furnish the large number of plants that are required for this option. The quantity of sand required for this project, while not extremely large will require an off-shore source and could take considerable time to dredge, transport and place.

3.1.2.10 Option F – Environmental Restoration of Sea Grass Beds

This option would involve environmental restoration of the sea grass beds that have historically existed on the north side of the islands in the Mississippi Sound as shown in Figure 3.1.2.10-1. Despite continual changes that occur, the barrier islands remain to buffer the mainland from storms and provide habitat for the rich, diverse wildlife residing within the area. Knowledge of submerged aquatic vegetation (SAVs) is limited to reports by Humm (1956) and Humm and Caylor (1957) before the Gulf of Mexico Estuarine Inventory (GMEI) Study (1973). They reported the occurrence of five flowering species known as “seagrasses” and 77 algal species all along the Mississippi barrier islands. Studies carried out by the GMEI personnel revealed that there were about 17,000 acres of SAVs in Mississippi Sound.

High turbidity and lack of suitable substrate have limited distribution of SAVs in Mississippi. SAVs have been restricted to relatively quiet waters along the mainland and barrier island shores. Isolated patches occur only several hundred acres in size along mostly the northern portions of the barrier islands. In turbid waters of the Sound, seagrass beds are typically found in shallow water less than six feet in depth, most in two or less. With the exception of shoal grass (*Halodule wrightii*), which grows on hard sandy bottoms, the species characteristic of Mississippi Sound area prefer soft muddy substrates. A study of the Mississippi portion of Mississippi Sound by Eleuterius in 1969 indicated that about 17,000 acres of SAVs were present including turtle grass (*Thalassia testudinum*), manatee grass (*Cymodocea manatorum*), shoal grass, *Halophilia engelmanni* (no common name), and widgeon grass (*Ruppia maritima*). In 1969, Hurricane Camille destroyed the majority of SAVs along the Mississippi Gulf coast (Eleuterius 1973). Moncreiff (1998) identified the northern shorelines of Ship, Horn, and Petit Bois Islands as potential habitat for seagrass beds. These areas have historically supported populations of shoal grass, *Halophila engelmannii*, manatee grass, and turtle grass. Currently, these locations only appear to support beds of shoal grass. In areas where SAVs are present, significant quantities of benthic and epibenthic macroalgae are found, such as red, brown, and green species.

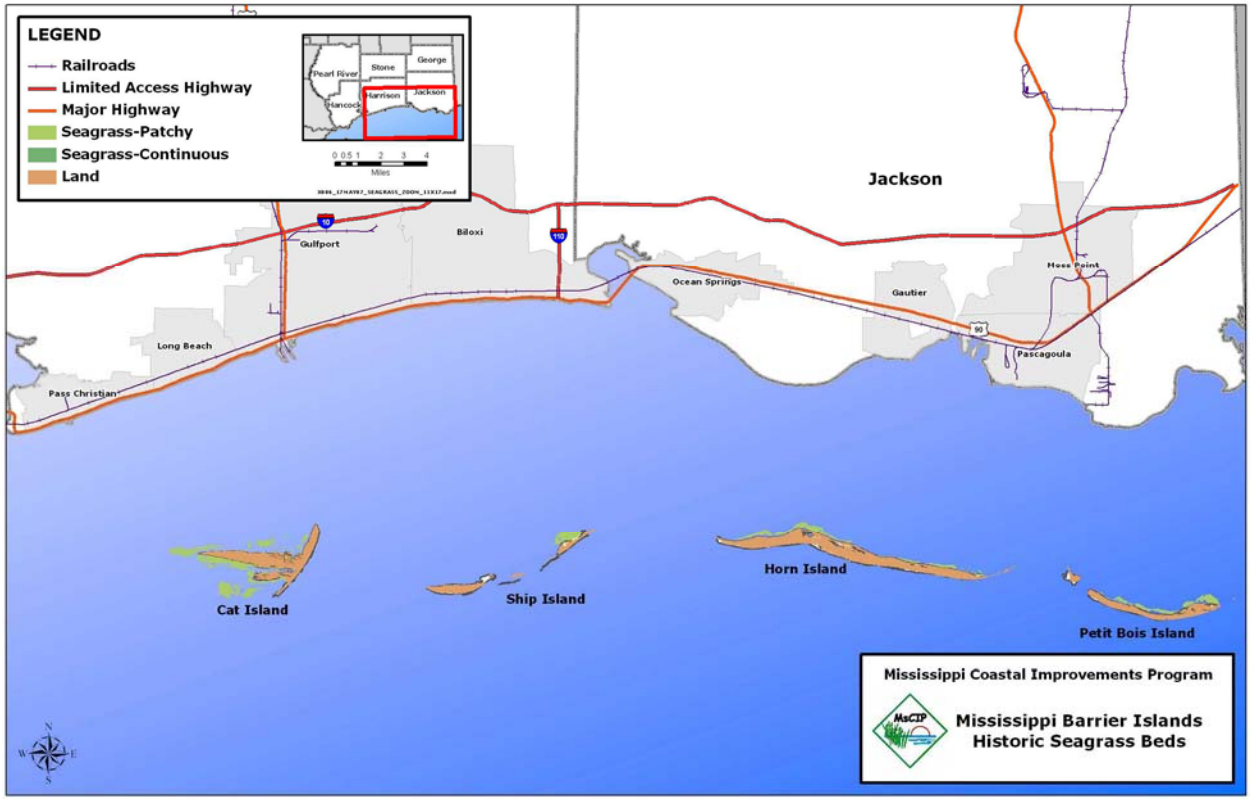


Figure 3.1.2.10-1. Location of Historical Sea Grass Beds near the Mississippi Barrier Islands

The Mississippi Department of Marine Resources (DMR) has provided the estimated pre-Camille acreage of the grass beds and the current amount of beds that exist today. The types of grass that would be planted include Diplanthera wrightii (i.e Shoal Grass), Cymodocea manatorum (i.e. Manatee Grass), Thalassia testudinum (i.e. Turtle Grass) and Ruppia maritima (i.e. widgeon grass). The planting would occur at selected locations in coordination with DMR and would cover 50 percent of the historical acreage. Due to the large number of plants required for this option, the supply of available stock would have to be matched to the planting schedule. The amount of acres of sea grasses to be planted at each island, based on 50 percent of pre-Camille acreage, is as follows:

Cat – 210 acres

Ship – 760 acres

Horn – 2,650 acres

Petit Bois – 780 acres

3.1.2.10.1 Interior Drainage

Interior drainage is not applicable to this option.

3.1.2.10.2 Geotechnical Data

The actual Sound formed as an estuary after littoral drift of sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. East and West Ship Island, Horn Island and Petit Bois Island are migrating over Pleistocene formations that created a relatively stable platform for the constantly moving islands. Other Holocene deposits provide a relatively thin cover

on the bottom of the Mississippi Sound and some areas south of the Islands and consist of a muddy mixture of sand and clay along with shell fragments or buried oyster shell beds.

3.1.2.10.3 Structural, Mechanical and Electrical

Structural, Mechanical and Electrical is not applicable to this option.

3.1.2.10.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste at the sites. These studies, if deemed necessary, will be conducted during the next phase of work after the final selection of sites. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.10.5 Construction Procedures

This option will only involve the planting of various types of marine aquatic vegetation in selected areas around the islands. No actual construction activities will take place. The extremely large quantity of plants required for this type of project would require that the project would have to have an extended project life to allow the procurement of the vegetation that would not be readily available in today's market.

3.1.2.10.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.10.7 Operations and Maintenance

The initial planting of the various types of sea grass will have a warranty that will insure an approved survival rate. There will be no additional maintenance of the established plants under this option.

3.1.2.10.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12, Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate,

preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.11 Option G – Restore Ship Island Breach

The most predominate affect of Hurricane Katrina on the Mississippi Barrier Islands was the large increase in size of the breach in Ship Island commonly known as the Camille Cut, (see Figure 3.1.2.11-1). This photo was taken after Hurricane Katrina, but, would be similar to conditions after Hurricane Camille.

The pre-Camille footprint of Ship Island was obtained from historical records and this data shows the area that was breached during Hurricane Camille now forming two separate islands, West and East Ship Island. Two major historic sites, one on each island, are in danger from the continuing erosion of the barrier islands. Current studies by the Corps indicate that restoring the two islands to a single island, pre-Camille condition may prevent the rapid erosion of the beaches that is now occurring as well as potentially helping to provide wave erosion on the mainland. Estimates indicated that the total restoration of Ship Island to a pre-Camille footprint, single land mass off the Mississippi coast will involve approximately 21 million cubic yards of sand. Other variances of filling only the breach and some areas along the northern shores with lesser quantities of sand may also provide opportunity for a natural healing of the island. This limited sand placement, approximately 13,000,000 cubic yards, has the support of the NPS (NPS, 2007) and will be the basis of this option. This volume is based on computing the the sand needed to fill the breach to a 1,000-foot width and to a elevation of 2.0. The total volume of sediment removed during all historical maintenance dredging for the Pascagoula Navigation Channel was compiled and the balance of that total will be used for littoral zone placements under Option C as previously described. As happened during Hurricane Camille, the breach was opened during Hurricane Katrina leaving two islands with approximately three miles of open water between the remaining portions. This portion of the island has also been breached during other prior hurricanes and while most of the island has reformed to a low bar over time, it never gained enough sand to form dunes and establish vegetation along this center portion. Consequently, even small storms easily washed over and eroded this part of the island and reopened the breach. Natural healing from the littoral drift is hindered by the large amount of sand that must rebuild the bar across the breach from the east. This is further aggravated by the fact that Ship Island is the last island in a littoral system that extends westward from its main source of sand on the panhandle of Florida, a distance of about 250 miles. Numerous opportunities exist along this pathway for the amount of sand in the system to be diminished. An additional consideration is the ebb tidal flushing in the deeper portion of the pass just east of West Ship Island when sand is moved southward thus starving the northern shore of West Ship Island. To mitigate this problem, the breach could be filled as single operation with planted dune vegetation that will become established and promote stable dune growth. With an understanding that all barrier islands are dynamic in nature and change constantly, the object of restoration would be to establish the island with sufficient sand mass and enough vegetation to again have the island as a somewhat stable member in the island chain. Fort Massachusetts located on the northern shore of West Ship Island and the French Warehouse located on the northern shore of East Ship Island would benefit from this option. Both of these sites are endangered by on-going erosion of the shoreline with Mississippi Sound. Another site, known as the Quarantine Station, has already been lost to erosion as shown in comparing Figure 3.1.2.11-1 and Figure 3.1.2.11-2.

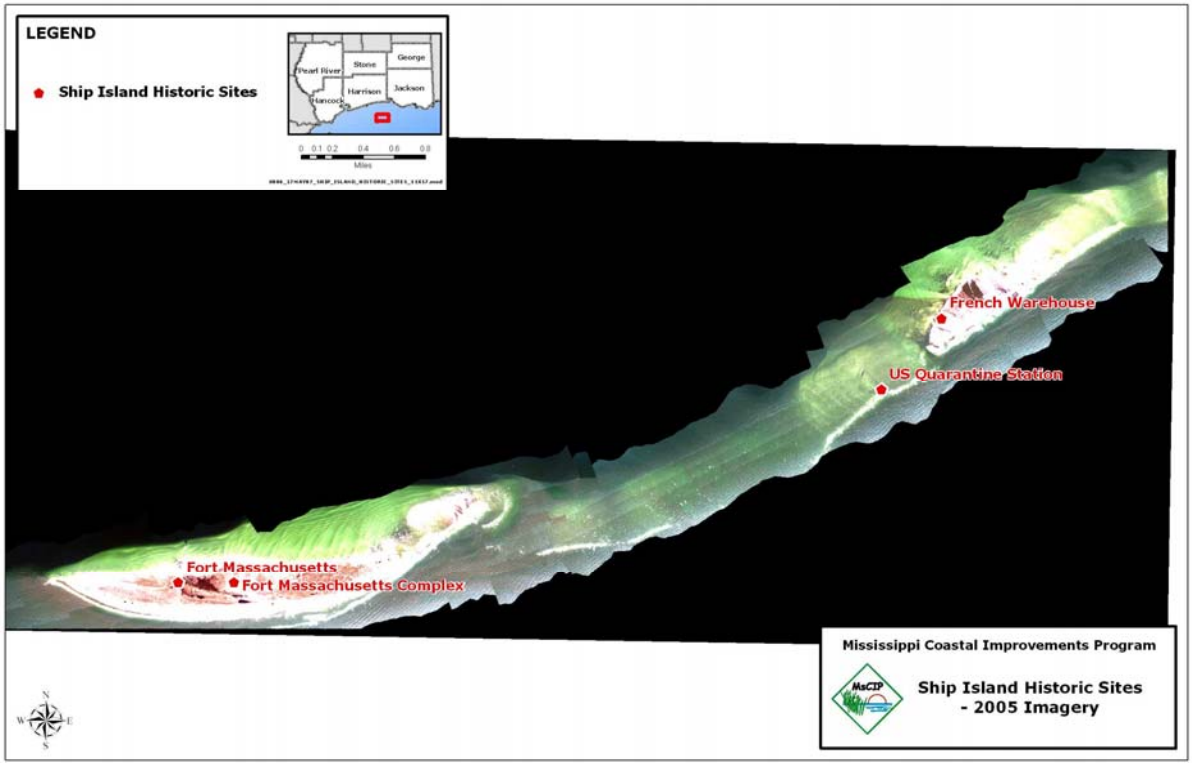


Figure 3.1.2.11-1. Aerial photo of West and East Ship Island taken in 2005 after Hurricane Katrina showing the locations of listed historical sites.

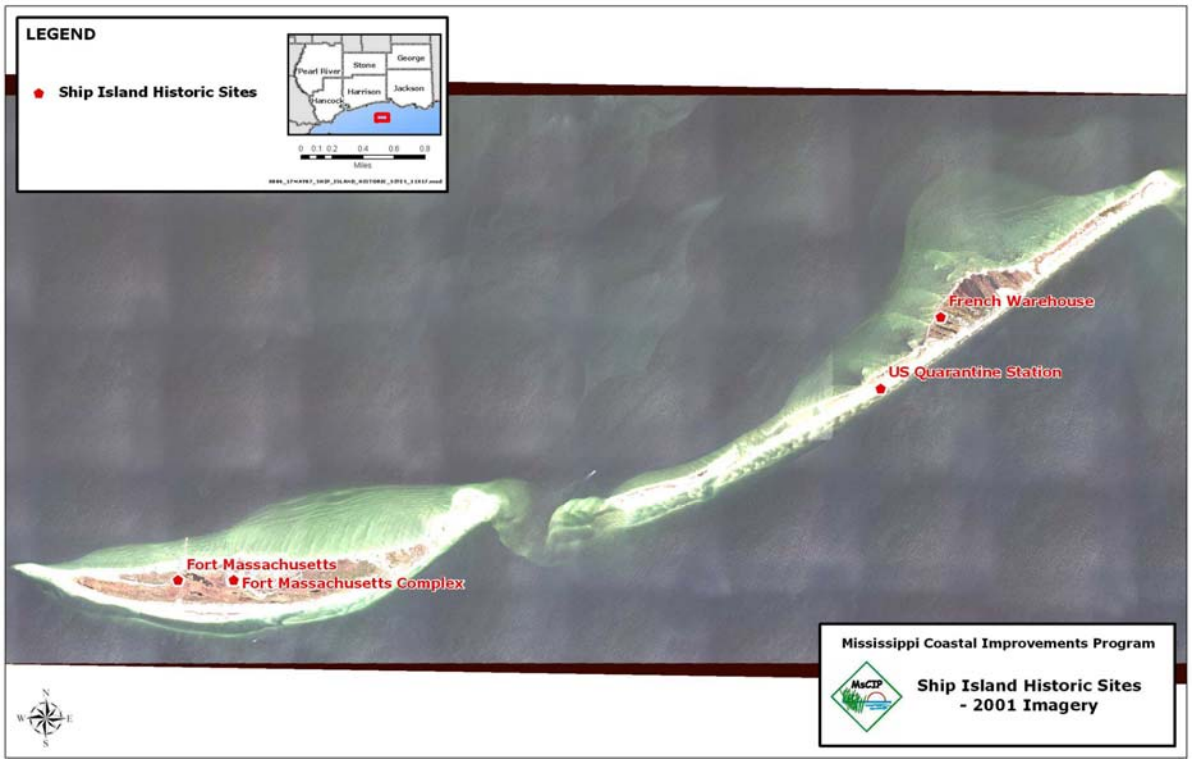


Figure 3.1.2.11-2. Aerial photo of West and East Ship Island taken in 2001. Note the sand spit extending westward from East Ship Island and the pass between the two islands.

Fort Massachusetts was originally built on the western tip of Ship Island. The westward migration of sand along the southern shore and erosion of the northern shore now has put the fort almost a mile from the western tip of the island, but dangerously close to being in the Sound (see Figure 3.1.2.11-3). Several emergency beach re-nourishments have taken place over the last 35 years through use of the beneficial use of dredged material from maintenance of the federally authorized Gulfport Harbor Navigation Project to protect the fort from wave action during winter storms. At present, the NPS is again requesting that the Corps place sand along the shore near the fort in conjunction with dredging operations at the Federal Gulfport Harbor navigation channel. This emergency placement of sand is being repeated about every five to six years. Figure 3.1.2.11-3 shows that in July, 2007, the north side of the fort showing and the relationship of the shore to the structure. Note the small jetty that has created severe scour at the down-current end.



Figure 3.1.2.11-3. Photo of erosion on north side of Fort Massachusetts showing relationship to encroaching waters to the structure. Note the small jetty that has created severe scour at the down-current end.

The French Warehouse site has not had any sand placement on its shoreline in the past. The erosive process is slower at that location, but now there are concerns from the NPS about the integrity of the site. Unlike the location of the fort, the warehouse site is covered by maritime forest which may be contributing to slowing the erosion of the shore due to the vegetation and the higher surface elevation.

The filling of the Camille Cut to provide a longer term solution to the erosion on the northern shores will require modeling to better understand the benefits that are believed to be associated with this plan. The costs will be substantial due to the large quantities of high quality sand that will be required to fill the breach. Initial estimates for sand requirements are approximately 8 million cubic yards. The fill would be expected to prevent the continuing loss of sand to West Ship Island, but it is also understood that the islands are a dynamic system, ever changing to nature's forces. As well as the sand placement, this plan would include planting sea oats or other dune grasses to restore dune

habitat on the newly created land. The volume of sand estimated for this project is based on an assumed average water depth of 5-feet in the existing breach.

There are many characteristics for the sand that must be considered during the design of the projects. Ideally, any sand used for beach construction or re-nourishment would come from the same littoral system so it would have the same gradation, particle shape and color. Ship Island is but one of many barrier islands that extend westward toward Louisiana that is located within a continuous littoral drift zone originating in Florida. The sand that migrates along this drift zone could be envisioned as moving from one island to another over very long periods of time. With this in mind, any sand of similar quality that is added into the drift zone would become part of the migration and be mixed with existing material. This added sand would also be available to the islands as a source for their beaches during the natural process of aggradations.

Sand of sufficient quality in the quantities required for this type of project is not known to occur in close proximity to the islands. Proposed geophysical studies may locate sources near the western end of West Ship Island, but this source has not yet been confirmed. Review of literature indicates that suitable sand can be obtained from St. Bernard Shoals which is a chain of submerged barrier islands that are located about 45 miles south of Ship Island. This sand should be very high quality material and could be used in the island reconstruction Prior studies of the St. Bernard Shoals (Oral Communication, USGS, 2006) are probably the best source of the sand. Additional studies and sampling will be required to ensure the source. As previously described, St. Bernard Shoals are a series of submerged barrier islands. The average water depth over the shoals is 60 feet which puts the sand within reach of a hopper type dredge, however the water depth near the islands is shallow for the draft of hopper dredge that would be used in this type of operation. In order to accomplish this, the dredge will have to pump-off from an offshore location.

Another source of sand could be sand from inland river systems. This sand could be considered as a source for direct placement, but the material stored on the lower Tombigbee River would require additional testing of physical characteristics to assure it meets the required quality standards. As discussed under Option B, dredging of the inland rivers produces large quantities of well sorted sand that may have potential use for sand replacement as described above. An inventory of current disposal sites on the Mobile River system indicates that approximately 30,000,000 cubic yards of sand is available. Only disposal sites that contain a minimum of 100,000 cubic yards of sand were included in the inventory. Of interest to this study are disposal sites that are located along the lower Tombigbee River which contain over 8,000,000 cubic yards of sand. Material from these sites could easily be transported by barge down the river system for use.

The sand selected for use, regardless of the source, would have a quality control program to ensure that it meets any established criteria prior to placement. The existing breach on Ship Island is approximately three miles in length. With an average water depth of five feet, an island width of approximately 1,000 feet the project will take 8,000,000 cubic yards of sand including a typical 30% loss of material during placement. Some of this material would also be placed along the north shore on either side of Camille Cut to repair existing erosion. Planting of the newly created land surface would be initiated when placement progress allowed. The planting would include dune grasses in two strips, one on each shoreline. The planting would consist of plants on 30-inch centers with the width of the planted strips set at 60-feet. The planted strips would extend along all shorelines where new beach is being created. With time, the dunes grasses will trap wind-blown sand and create dunes. The newly formed land mass will transform itself into a more natural state as wind shifts the sand and the planted vegetation establishes dunes similar to the beach scene shown in Figure 3.1.2.11-4.



Figure 3.1.2.11-4. Typical Mature Dands Funes on Gulf Coast Barrier Island

This potential option as a stand-alone measure will not provide any appreciable storm surge benefits based on modeling of the islands, but will provide benefits from storm induced wave damage on the shoreline. In addition, the role of the islands in maintaining the ecology of the Mississippi Sound has been realized and this alone may well be justification for additional study of filling Camille Cut. With this area under the control of the NPS, their endorsement is valuable to continued study.

3.1.2.11.1 Interior Drainage

The type of work anticipated for adding sand to increase the land mass of the islands will not require any type of drainage system. The addition of sand under this operation will be with dredge pipe discharge and all water will be allowed to run back to the sea.

3.1.2.11.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. When the sea level returned to present condition, sediments filled the river channels and started to cover the area that would become the Mississippi Sound. Sandy deposits that had been transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with these deposits.

The actual Sound formed as an estuary after littoral drift of sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand is typically medium grained, white to light grey in color with well rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These

deposits, as shown in Figure 3.1.2.11-5, can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward.



Figure 3.1.2.11-5. Peat-like organic soils outcropping on the south beach of East Ship Island. These deposits are the remains of sediments and organic matter that settle in the bottom of the marshes and lakes that occur on the barrier islands. The deposits are exposed as the islands migrate northward.

East and West Ship Island are migrating over Pleistocene formations that created a relatively stable platform for the constantly moving islands. Other Holocene deposits provide a relatively thin cover on the bottom of the Mississippi Sound and some areas south of the Islands and consist of a muddy mixture of sand and clay along with shell fragments or buried oyster shell beds.

If increasing the land mass of the islands, it would be desirable to maintain the same quality sand that now makes up the existing islands. Sources of sand in the quantity that would be required for this option are extremely large, especially when considering the quality standard that must be met. Potential sources for sand were investigated both inland and offshore. Of concern is matching the sand to the sand on the beaches of the National Seashore. Samples taken from Dauphin and Pelican Island in Alabama are in the same island chain and have been tested for color, grain size and particle shape. These results, included in this section, can be used to match potential sand sources.

3.1.2.11.3 Structural, Mechanical and Electrical

This option will have no structural, mechanical or electrical components.

3.1.2.11.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted

during the next phase of work after the final siting of the various structures. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.11.5 Construction Procedures and Water Control Plan

Prior to any additional detailed design, this project will require extensive modeling to predict the effects of partially or completely filling the breach. The modeling will be conducted to assist in location of sand placement, quantities of sand that may be required for a partial filling, and to help predict the amount of sand that would be required for future re-nourishment of the island's north shore.

To fill the breach and associated shorelines will involve several different operations, some of which can take place concurrently. The source of sand that has been designated as the potential borrow area will require additional investigation using both geophysical techniques and physical sampling. The sand is expected to be in submerged shoals that will have to be located and mapped prior to any removal of the sand. This will be completed during design and before the construction begins.

3.1.2.11.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.11.7 Operations and Maintenance

The direct placement of sand to fill Camille Cut and will be a one-time event. Per an agreement with the National Park Service, no additional beach maintenance will be performed in the future. This project will provide a boost in the existing sand within the littoral system, then in accordance with the 2006 NPS Management Policies, nature will take it course. Therefore, there will be no costs associated with operations and maintenance for this option. Changes in future maintenance dredging practices at both Gulfport and Pascagoula Navigation Channels will ensure that more sand in the littoral zone will be available for natural beach building. This option will not preclude the NPS from performing sand additions at Fort Massachusetts or the French Warehouse to protect these structures from erosion of beaches that endangers these historic sites.

3.1.2.11.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12 Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering

design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.11.9 Schedule for Design and Construction

This project will require additional study and investigation to verify borrow areas. These can be accomplished within a one-year time frame after funding at which time placement of sand can be initiated pending all required permits.

3.1.2.12 Cost Estimate Summary

The total project costs for all options are shown in Table 3.1.2.12-1. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.1.2.12-1.
Summary of Total Project Costs

Option	Total Project Costs
Option A – Restoration of Island Footprints	$942,200,000
Option B – Replenish Littoral Zone w/ Inland River Sand	$1,013,800,000
Option C – Replenish Littoral Zone w/ Off-shore Sand	$147,400,000
Option D – Environmental Restoration w/ 2-foot Dune	$14,200,000
Option E – Environmental Restoration w/ 6-foot Dune	$39,200,000
Option F – Environmental Restoration of Sea Grass Beds	$264,500,000
Option G – Restore Ship Island Breach	$181,400,000

Note: There are no Operational and Maintenance costs for the barrier island options.

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3.2 Line of Defense 2 – Beach/Dune Construction

3.2.1 General

The Mississippi Mainland shoreline extends approximately 68 miles, and is divided into three coastal counties: Jackson, Harrison, and Hancock Counties, Figure 3.2.1-1. The Mississippi coast beaches are a valuable asset and provide vital environmental, cultural, recreational, and economic resources; they assist in maintaining the health and productivity of adjacent waters and provide for diverse cultural and recreational activities. They are also important in limiting infrastructure damage and providing protection to the seawalls along the coast (Schmid 2002). This study evaluated berm and dune options for approximately 35 miles of shoreline along the three Mississippi coastal counties as outlined in Figure 3.2.1-1. The coastal processes modeling analysis to evaluate the future without and with project berm and dune systems were conducted through application of the engineering-economic model Beach-fx. The purpose of the analysis was to evaluate the physical performance of the beach and dune system for anticipated future without-project and with project conditions. The development of the coastal processes input data and physical performance results of the Beach-fx analysis are provided in detail in Section 2.3 of this report. For this study, the exploration of the costal processes and economic inventorying was conducted. Further study would be required to combine the observed data and to evaluate the eleven alternatives previously mentioned. More detail on the further study can be found in the MsCIP Comprehensive Plan Main Report.

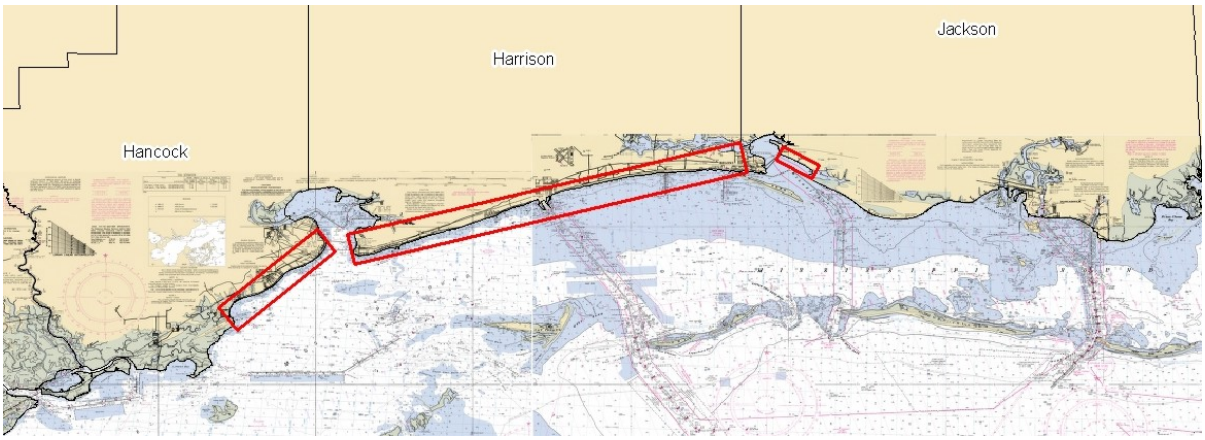


Figure 3.2.1-1. Project Location, Mississippi Coast Beach Evaluations

3.2.2 Hancock County Beaches

3.2.2.1 General

The purpose of this section is to provide engineering information and data for the planning and design of shore protection and restoration to the shoreline along Hancock County, MS following impacts from Hurricane Katrina, 29 August 2005. Hurricane Katrina severely damaged approximately six miles of public beaches along the shoreline from the US 90 bridge extending southwest to Beach Road.

3.2.2.2 Location

The Mississippi mainland shoreline is divided into three coastal counties: Jackson, Harrison, and Hancock Counties. Hancock County, Figure 3.2.2-1, is the western-most coastal county in Mississippi and is located approximately 95 miles west of Mobile, Alabama and approximately 40-miles east of New Orleans, Louisiana. Hancock County is bordered to the east by Harrison County, MS, and to the west by the Mississippi-Louisiana state line. The County consists of two municipalities: Bay St. Louis and Waveland. The beaches along the Hancock County shoreline, Figure 3.2.2-1, are separated in two sections: the reach extending approximately 6-miles from Grand Bayou in Waveland to the US 90 bridge in Bay St Louis, and the reach extending northeastward approximately 1-mile from Cadet Bayou.

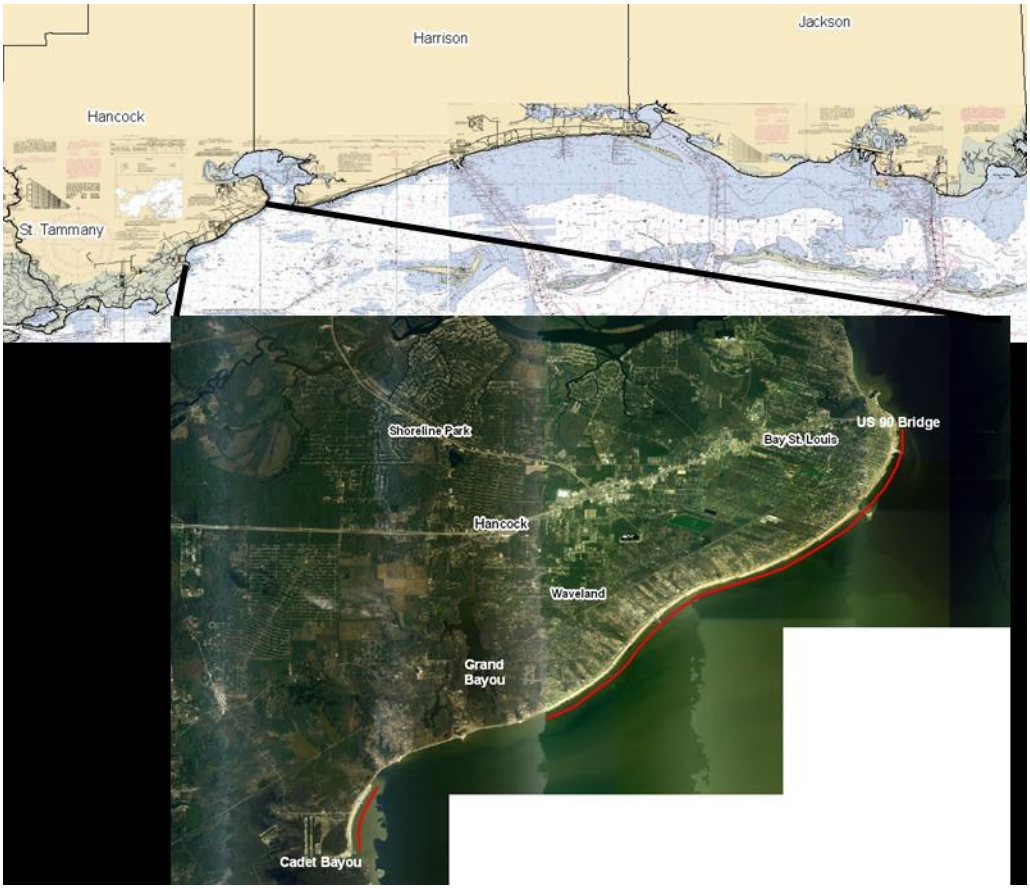


Figure 3.2.2-1. Project Location, Hancock County Beaches

3.2.2.3 Existing Conditions

The Hancock County shoreline south of the US 90 bridge is protected by an 8 mile long, approximately+ 5 ft elevation seawall extending from the US 90 bridge to Cadet Bayou. The Hancock County beaches were constructed for shore protection; however, the area provides added outdoor recreation and environmental benefits. The area experienced wave and wind erosion and is therefore periodically maintained or renourished with sand. The elevation of the seawall ranges between +3.8 and +5.0 feet National Geodetic Vertical Datum (NGVD). The seawall fronting the downtown Bay St Louis beaches is significantly higher. A sand beach was constructed along approximately 6 miles of the seawall in 1967 as part of the emergency repair and protection

following Hurricane Betsy (September 1965). The approximate 1 mile section of beach fronting the downtown Bay St Louis area was constructed during the construction of the US 90 bridge. The 1 mile section extending from Bayou Cadet was constructed in 2005.

The Hancock County beaches were renourished in 1994 with material from a borrow area located approximately 1000 feet offshore. The beaches fronting downtown Bay St Louis, the northeast section of the beaches, were again renourished in 1996 with material from a borrow area located on the north side of the US 90 bridge. After renourishment, beach width was maintained by scraping upper portions of the beach and moving sediment to widen the beach (Schmidt 2002).

The existing Hancock County beach profile consists of a berm only feature which extends approximately 150 ft from the seawall to the Mississippi Sound. The berm elevation varies from approximately 5.0 ft at the seawall to 3.5 ft at the slope break to the Mississippi Sound. The downtown Bay St Louis area beaches include a bluff with an elevation of about +12 feet. Access ramps and pavements are located along the beach, and storm water culverts pass beneath the roadway adjacent to the beach to the shoreline to drain sections of Hancock County. A typical cross section for the existing condition is shown in Figure 3.2.2-2.

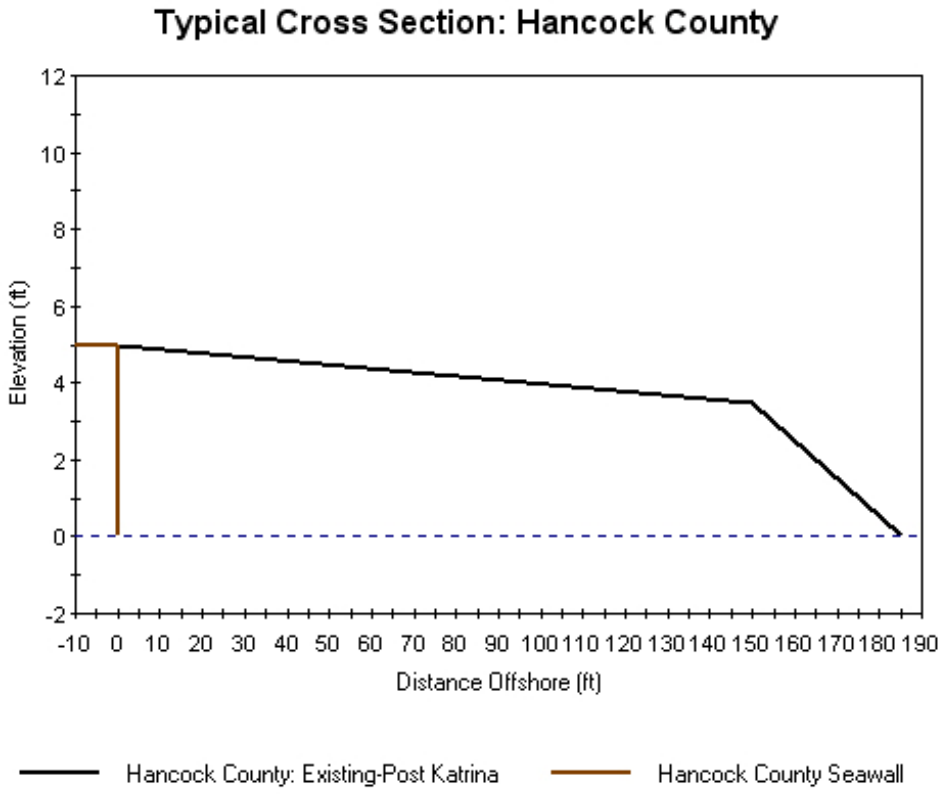


Figure 3.2.2-2. Typical Cross Section, Hancock County Existing Conditions

3.2.2.4 Coastal and Hydraulic Data

The climate in the project area is subtropical, characterized by warm summers and short, mild winters. Average temperatures are 82 degrees Fahrenheit for the summer months and 53 degrees Fahrenheit for the winter months. The average annual rainfall is about 60 inches, and is fairly evenly distributed throughout the year. Precipitation records also indicate July as the wettest month, while October is the driest.

Mississippi Sound is a shallow coastal lagoon extending 80 miles along the coast of the Gulf of Mexico from Mobile Bay, Alabama westward to Lake Borgne, Louisiana. The average depth in the sound is 10 feet, and 99 percent of the sound is less than 29 feet deep.

Circulation patterns within the vicinity of the study area are controlled by astronomical tides, winds, and freshwater discharges. The mean diurnal tide range in St. Louis Bay is 1.6 feet, and the extreme (except during storms) is about 3.5 feet. The velocity of normal tidal currents ranges from 0.5 to 1.0 ft per second (fps) and their direction is generally east to west. Predominant winds average eight miles per hour (mph) from the south during the summer and from the northeast during the winter. Though the tides produced by astronomical forces are relatively small in magnitude, the wind can produce larger variations. Strong winds from the north can evacuate the sound causing current velocities of several knots in the passes to the gulf. Winds from the southeast can produce high tides, piling water up against the shoreline. The study area has been impacted by several tropical storms and hurricanes, most recently from Hurricane Katrina in 2005. Post-Hurricane Katrina high water mark measurements in the area suggest storm surges on the order of 20 to 25 feet or more.

Transport is generally from northeast to southwest, although there are areas with reversals. From 1994 and 2000, 60 percent of the shoreline eroded at least -5.0 feet/year (ft/yr) which corresponds to volumetric losses of approximately -12,000 CY/yr. A portion of this erosion was likely due to adjustment of the renourished beaches in 1993-1994 and 1996. From 1997 to 2001, a period without post-nourishment adjustment, only 30 percent of the beach retreated at rates higher than -5.0 ft/yr. Schmidt estimated that renourishment would be required in 2012 if present retreat rates continued. For the Bay St Louis Downtown beach, more than 2/3 was retreating at rates greater than -5.0 ft/yr /yr, and Schmidt estimated that renourishment would be required earlier than 2012.

3.2.2.5 Future Without-Project Conditions

The future without-project conditions assumed continuation of the present maintenance activities in Hancock County; maintenance occurs on an annual basis by truck haul placement. Two cross sections or scenarios were considered as future without project conditions. The first scenario examined continued maintenance of the existing post-Katrina cross section which included a berm only feature, Figure 3.2.2-2 and Figure 3.2.2-3. Scenario 1, continued maintenance of the post-Katrina berm only feature, consists of a berm which extends approximately 150 ft from the seawall to the Mississippi Sound. The berm elevation varies from approximately 5.0 ft at the seawall to 3.5 ft at the slope break to the Mississippi Sound. The downtown Bay St Louis area beaches include a bluff with an elevation of about +12 feet. A typical cross section for the post-Katrina existing condition is shown in Figure 3.2.2-3.

The second scenario included a dune feature and was identified as an interim project to this study with funding appropriated for construction. Therefore both scenarios were considered in the evaluation of future without-project conditions. Scenario 2 consists of a 7 ft (NAVD 88) dune elevation with a 10 ft wide dune crest comprised of approximately 1.6 CY/ft of sand. The dune would be constructed approximately 50 ft seaward of the existing seawall. To provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms, the dunes will be vegetated and protected with sand fencing. A typical cross section for Scenario 2 is shown in Figure 3.2.2-3.

3.2.2.5.1 Results-Future Without-Project Conditions

The coastal processes modeling analysis to evaluate the future without project berm and dune systems were conducted through application of the engineering-economic model Beach-*fx*. The purpose of the analysis was to evaluate the physical performance of the beach and dune system for anticipated future without-project project conditions. The development of the coastal processes input

data for the Beach-*fx* analysis are provided in Section 2.3 of this report. The economic results of the Beach-*fx* analysis are documented in the Economic Appendices of this report.

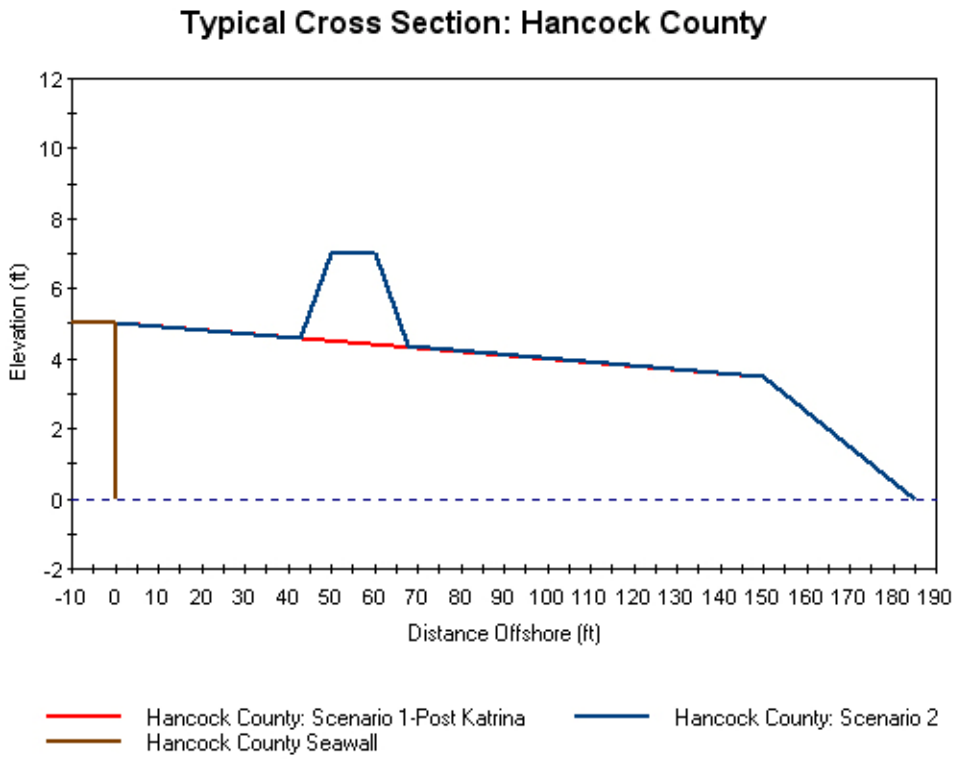


Figure 3.2.2-3. Typical Cross Sections, Hancock County Scenarios 1 and 2

Table 3.2.2-1 summarizes the results of the Hancock County without-project Beach-*fx* simulations. The data in Table 3.2.2-1 indicate that existing beach maintenance practices will require approximately 304 CY/ft of beach over a 100 year project life assuming the existing rate of sea level rise persists into the future. If the future rate of sea level rise increases, the simulations indicate that the potential moderate rate of future sea level rise will result in about a 51 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about a 69 percent increase in project volume requirements.

Table 3.2.2-1.
Hancock County Without-Project Summary

Scenario Name[1]	Number of Nourishments				Nourishment Volume (CY/ft)			
	mean	sd	max	min	mean	sd	max	min
Scenario 1 ESLR	100	0	100	100	297.7	28.1	379.7	250
Scenario 2 ESLR	100	0	100	100	310.3	31.6	396.9	250
Scenario 1 MSLR	100	0	100	100	443.7	47.0	581.7	302.9
Scenario 2 MSLR	100	0	100	100	473.1	53.5	607.0	285.7
Scenario 1 HSLR	100	0	100	100	497.2	53.1	654.8	351.9
Scenario 2 HSLR	100	0	100	100	531.5	32.1	619.7	452.1

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

As a result of the difference in maintenance cycles in Harrison and Hancock counties the project volume requirements in Hancock County exceed those in Harrison County by approximately 225 percent for without project conditions under existing sea level rise conditions. For the potential future sea level rise scenarios the increase in volume requirement is about 180 percent.

3.2.2.6 Future With-Project Options

The future with-project evaluations for Hancock County included 11 options which were evaluated for environmental restoration and enhancement of environmental habitat. Options A through D include four design cross-sections with varying dune and berm configurations. The berm and dune options would be constructed adjacent to the seawall along the length of the beach. For environmental and economic purposes, Options E through H further evaluated the four design cross-sections to include sand fencing and plantings on the dune to provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms. The wider dune features would provide for a larger spatial extent with which to create environmental habitat. Options A through H were evaluated in conjunction with the Line of Defense 3 seawall.

Option A consists of a 10 ft dune elevation, 40 ft dune crest width, with a dune slope of 1:3, and a berm with an 80 ft width, an upper berm elevation of 5.5 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option B consists of an 8 ft dune elevation, 50 ft dune crest width, with a dune slope of 1:3, and a berm with an 80 ft width, an upper berm elevation of 5.5 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option C consists of a 10 ft dune elevation, 20 ft dune crest width, with a dune slope of 1:3, and a berm with a 100 ft width, an upper berm elevation of 5.5 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option D consists of an 8 ft dune elevation, 30 ft dune crest width, with a dune slope of 1:3, and a berm with a 100 ft width, an upper berm elevation of 5.5 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Dune volumes for the Hancock County design options are 10.7 CY/ft, 7.3 CY/ft, 6.6 CY/ft, and 4.7 CY/ft, for Options A, B, C, and D, respectively. Typical cross sections for Options A through D are shown in Figure 3.2.2-4. The same cross sections were used for Options E through H. For Options E through H, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.

Options I and J are comparative with-project options, for future evaluation, consisting of a design cross-section which includes a dune and berm constructed as a stand alone project which does not incorporate the Line of Defense 3 seawall. Option I consists of a dune feature constructed approximately 50 ft seaward of the seawall at an elevation of 10 ft (NAVD 88), with a crest width of 55 ft, and a dune slope of 1:3. The berm width would be extended to accommodate the placement of the dune feature. Sand fencing would be placed on the dunes to reduce sand transport due to the strong winds which frequently occur during storms. The cross section for Option J is the same as Option I; however the dune would be planted to provide for additional environmental habitat. For Option J, sea oats would be planted on both the landward and seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the landward and seaward toes of the dune. The dunes will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Options I and J is shown in Figure 3.2.2-5.

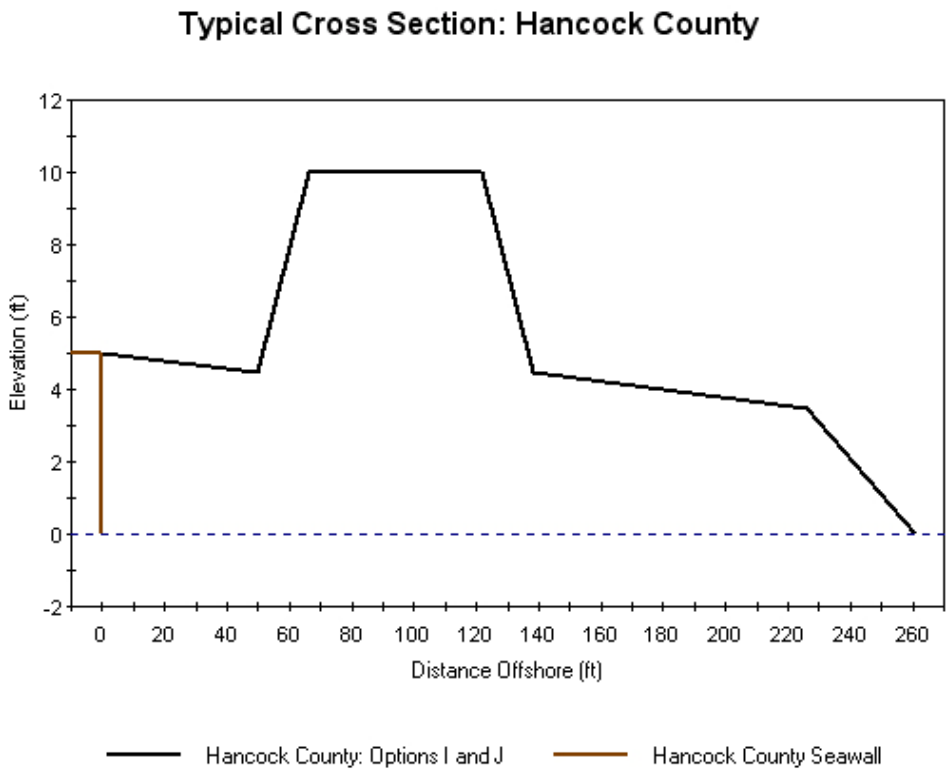


Figure 3.2.2-4. Typical Cross Sections, Hancock County Options A-D and E-H

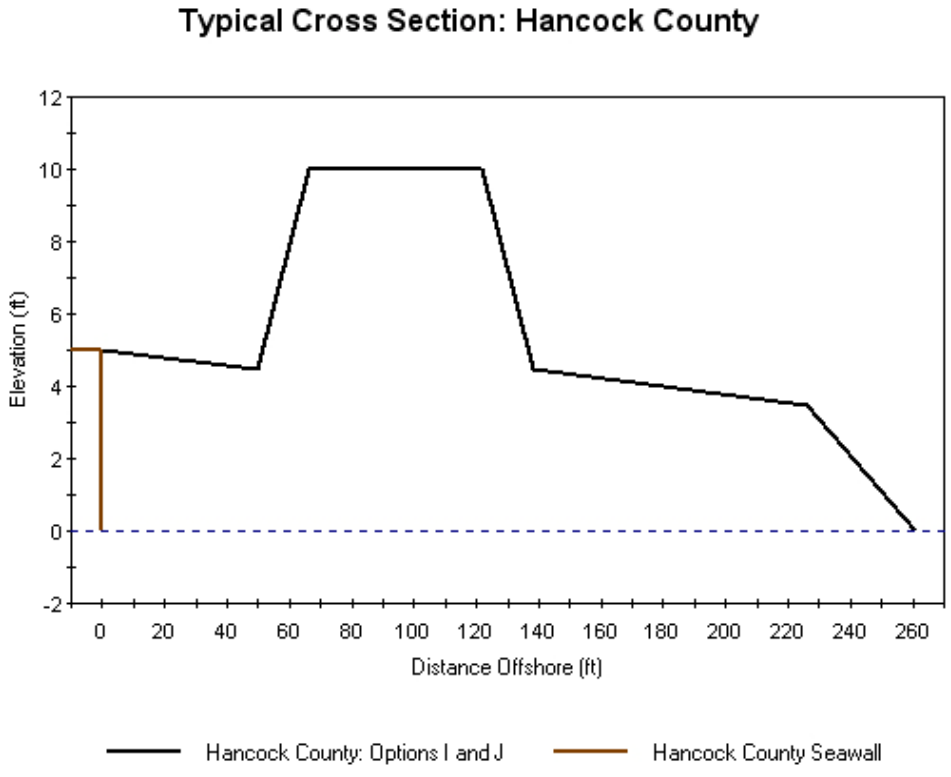


Figure 3.2.2-5. Typical Cross Section, Hancock County Comparative Dune Options I and J

Option K is also an option for future evaluation which consists of an elevated berm section constructed primarily for the creation of environmental habitat. Option K would be constructed as a stand alone option which does not incorporate the Line of Defense 3 seawall. The elevated berm section would be constructed approximately 50 ft seaward of the existing seawall to an elevation 2 ft above the existing berm with a width of approximately 60 ft. The berm width would not be extended to accommodate the placement of the elevated berm feature. The new feature would be vegetated and sand fencing would be placed to create environmental habitat and to reduce sand transport due to the strong winds which frequently occur during storms. For Option K, sea oats would be planted in a 30 by 30 inch grid pattern over the entire elevated berm area. The new feature will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Option K is shown in Figure 3.2.2-6.

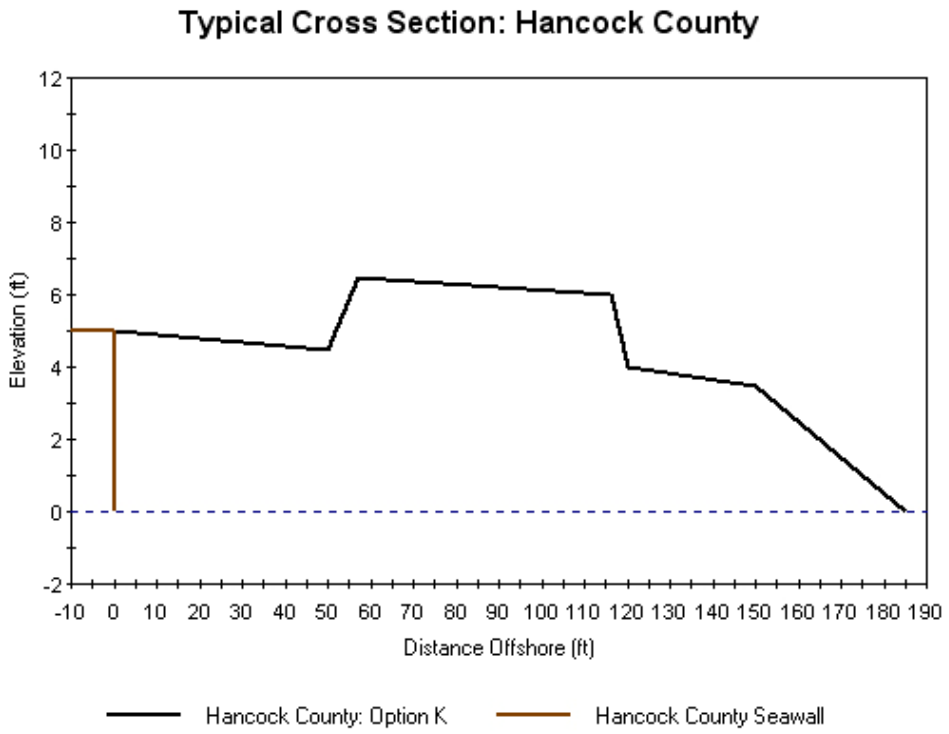


Figure 3.2.2-6. Typical Cross Section, Hancock County Option K

3.2.2.6.1 Results-Future With-Project Options

The coastal processes modeling analysis to evaluate the future with project berm and dune systems, Options A through D, were conducted through application of the engineering-economic model Beach-*fx*. The purpose of the analysis was to evaluate the physical performance of the beach and dune system for anticipated future with-project conditions and to estimate the economic costs and benefits of each. The development of the coastal processes input data for the Beach-*fx* analysis are provided in Section 2.3 of this report. The economic results of the Beach-*fx* analysis are documented in the Economic Appendices of this report. The environmental benefits of Line of Defense 2 are documented in the Environmental Appendices of this report.

Table 3.2.2-2 summarizes the Hancock County with-project Beach-*fx* simulations. The data in Table 3.2.2-2 indicate that with-project nourishment volumes for the existing rate of sea level rise are approximately 369 CY/ft of beach over a 100-year project life. If the future rate of sea level rise increases, the simulations indicate that the potential moderate rate of future sea level rise will result in about a 75 percent increase in volume requirements. A high rate of future sea level rise will result in about a 102 percent increase in project volume requirements.

Table 3.2.2-2.
Hancock County With-Project Summary

Option Name[1]	Number of Nourishments				Nourishment Volume (CY/ft)			
	mean	sd	max	min	mean	sd	max	min
Option AESLR	100	0	100	100	384.1	68.3	829.8	283.6
Option B ESLR	100	0	100	100	380.6	65.8	748.8	294.7
Option C ESLR	100	0	100	100	352.9	61.8	758.5	272.0
Option D ESLR	100	0	100	100	358.1	75.7	1,117.7	279.3
Option A MSLR	100	0	100	100	690.1	121.9	1,034.5	445.8
Option B MSLR	100	0	100	100	674.1	136.3	1,059.4	410.3
Option C MSLR	100	0	100	100	587.5	93.0	877.4	404.7
Option D MSLR	100	0	100	100	587.4	100.1	887.6	371.6
Option AHSLR	100	0	100	100	835.8	107.6	1,252.4	624.3
Option B HSLR	100	0	100	100	704.0	80.5	1,012.8	549.6
Option C HSLR	100	0	100	100	682.1	77.3	883.9	490.9
Option D HSLR	100	0	100	100	599.9	63.7	853.2	449.3

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

3.2.2.6.2 Summary-Future With-Project Options

The coastal processes analysis conducted as a part of this study has provided a number of useful insights with respect to morphology change, coastal evolution, and the primary drivers for storm-induced damages along the Mississippi Sound shoreline. First, the Mississippi Sound shoreline is primarily a stable, low energy coast that is dramatically impacted by tropical storm events. In the absence of tropical storm events the shoreline is expected to be only slightly erosive with shoreline change rates on the order of -1 ft/year. In general, moderate storm events produce more coastal erosion and volumetric beach change along the Mississippi Sound shoreline than do major hurricanes. This is because the large storm surge associated with the very intense storms completely inundates the beach system and protects it from the high energy dissipation associated with wave breaking, which results in less overall shoreline change and volumetric erosion of the beach. Damages to upland infrastructure are largely driven by inundation and direct wave attack as opposed to erosion, partly because most of the infrastructure is located landward of the sea wall that runs along Highway 90 in Harrison County and Beach Boulevard in Hancock County.

For with project conditions, the volume requirements in Hancock County exceed those in Harrison County by approximately 190 percent. Because the beach is restored to design conditions every year, if needed, in Hancock County the volume requirements are much larger than the volume requirements in Harrison County. In Harrison County, the beach is restored to design conditions once every 12 years. If the beach in Harrison County is damaged by a major storm in the year following reconstruction of the design template the beach remains vulnerable for the remainder of the 11 year nourishment cycle. Essentially, the present analysis indicates that the nourishment cycle in Harrison County should be shortened or augmented with a provision for emergency dune reconstruction after the occurrence of a major storm event.

3.2.2.6.3 Interior Drainage

This section is not applicable.

3.2.2.6.4 Geotechnical Data

Geology. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical. The Line 2 defense provides for the installation of dunes on the Mississippi Sound side of the existing seawalls. These dunes are intended to provide toe protection for the seawall when subjected to storm surges in the range of 3 to 5 ft. The dune slopes will be constructed to one vertical to three horizontal side slopes with a ten ft crest. The dunes for Options E through H and J thorough K will be reinforced with plantings of native sea grasses and fencing. The sand used for the dune construction would come from upland sources within 10 miles of the work area. The sands will be compatible with the existing sand with respect to grain size and color.

3.2.2.6.5 Structural, Mechanical and Electrical

This section is not applicable.

3.2.2.6.6 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.2.2.6.7 Construction Procedures and Water Control Plan

Respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, etc. and the foundation prepared for the new work. Access ramps shall be created and temporary haul routes shall be established. All temporary haul routes shall be regraded upon completion of the work.

3.2.2.6.8 Project Security

Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.2.2.6.9 Operations and Maintenance

The features that require periodic operations will be the regrading of the dune materials within the beach system and the replacement of any appreciable loss of the sea grasses and the replacement of any damaged fence sections.

3.2.2.6.10 Cost Estimate

The costs for the various options are presented in Section 3.2.2.7 Cost Estimate Summary. Total project costs for the various options are included in Table 3.2.2-3 and costs for the annualized Operation and Maintenance of the options are included in Table 3.2.2-4. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost. The project costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25 percent to cover the Cost Growth of the project.

3.2.2.6.11 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months to complete comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require approximately one year.

3.2.2.7 Cost Estimate Summary

Construction costs for the various options are included in Table 3.2.2-3 and costs for the annualized Operation and Maintenance (O&M) of the options are included in Table 3.2.2-4. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost.

3.2.2.8 References

Schmidt, K. 2002. Biennial report of sand beaches, Hancock County, 2001. Mississippi Department of Environmental Quality, Office of Geology, Open-File Report 110B, April, 53 p.

Table 3.2.2-3.
Hancock County LOD2 - Project Cost

Option	Description						Project Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	10	40	1:3	80			$8,070,000
B*	8	50	1:3	80			$6,100,000
C*	10	20	1:3	100			$4,960,000
D*	8	30	1:3	80			$4,030,000
E*	10	40	1:3	80	X	X	$8,400,000
F*	8	50	1:3	80	X	X	$6,440,000
G*	10	20	1:3	100	X	X	$5,300,000
H*	8	30	1:3	100	X	X	$4,360,000
I**	10	55	1:3	Extend to accommodate		X	$19,100,000
J**	10	55	1:3	Extend to accommodate	X	X	$19,450,000
K**				Add 2ft, 60 ft width	X	X	$4,640,000

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

Table 3.2.2-4.
Hancock County LOD2 – Operation and Maintenance Cost

Option	Description						O&M Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	10	40	1:3	80			$2,167,694
B*	8	50	1:3	80			$1,638,530
C*	10	20	1:3	100			$1,332,313
D*	8	30	1:3	80			$1,082,504
E*	10	40	1:3	80	X	X	$2,256,336
F*	8	50	1:3	80	X	X	$1,729,857
G*	10	20	1:3	100	X	X	$1,423,640
H*	8	30	1:3	100	X	X	$1,171,146
I**	10	55	1:3	Extend to accommodate		X	$5,130,478
J**	10	55	1:3	Extend to accommodate	X	X	$5,224,492
K**				Add 2ft, 60 ft width	X	X	N/A

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

3.2.3 Harrison County Beaches

3.2.3.1 General

The purpose of this section is to provide engineering information and data for the planning and design of shore protection and restoration to the shoreline along Harrison County, MS following impacts from Hurricane Katrina, 29 August 2005. Hurricane Katrina severely damaged

approximately 26 miles of public beaches along the shoreline across the entire coastline of the county's shoreline.

3.2.3.2 Location

The Mississippi mainland shoreline is divided into three coastal counties: Jackson, Harrison, and Hancock Counties. Harrison County, Figure 3.2.3-1, extends approximately 27-miles, has the largest population, and the greatest number of municipalities. It is bordered on the east by industrialized Jackson County, on the west by Hancock County and the John C. Stennis Space Center and to the north by primarily rural Stone County. The County consists of five municipalities: Biloxi, D'Iberville, Gulfport, Long Beach, and Pass Christian. The Harrison County Federal Shore Protection Project, Figure 3.2.3-1, extends approximately 26-miles from Biloxi on the east to Henderson Point on the west.

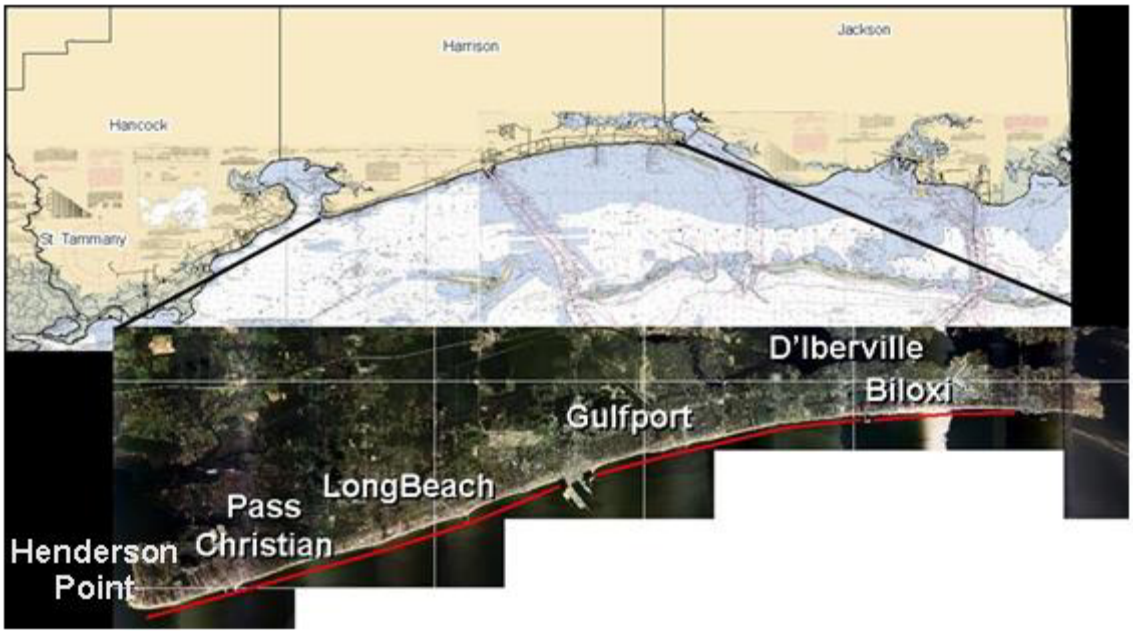


Figure 3.2.3-1. Project Location, Harrison County Beaches

3.2.3.3 Existing Conditions

As a result of the 1915 hurricane which destroyed half of U.S. 90, a seawall was constructed to protect the roadway and beach front property. After the hurricane in 1947 and due to ongoing loss of sediment, the Harrison County, Mississippi Federal Beach Erosion Control Project was constructed in 1952 under the Section 2 authority of the River and Harbor Act approved July 3, 1930. The project was constructed to protect the seawall and US 90, which provides an evacuation route for residents. Broken concrete groins were constructed to compartmentalize the beach, and a total of 6 million CY of fill was hydraulically pumped from borrow areas offshore of Gulfport Harbor.

The authorized Harrison County project provides for a beach profile consisting of a berm only feature which extends approximately 265 ft from the seawall to mean sea level (MSL). The berm elevation varies from an elevation of approximately 7.2 ft (NAVD 88) at the seawall to 3.5 ft at the slope break to the Mississippi Sound. An approximately 10 ft wide boardwalk, located adjacent to the seawall, extends along most of the Harrison County seawall. Access ramps and pavements are located along the beach, and storm water culverts pass beneath US 90 to the shoreline to drain sections of Biloxi,

Long Beach, and Pass Christian. A typical cross section for the existing condition is shown in Figure 3.2.3-2.

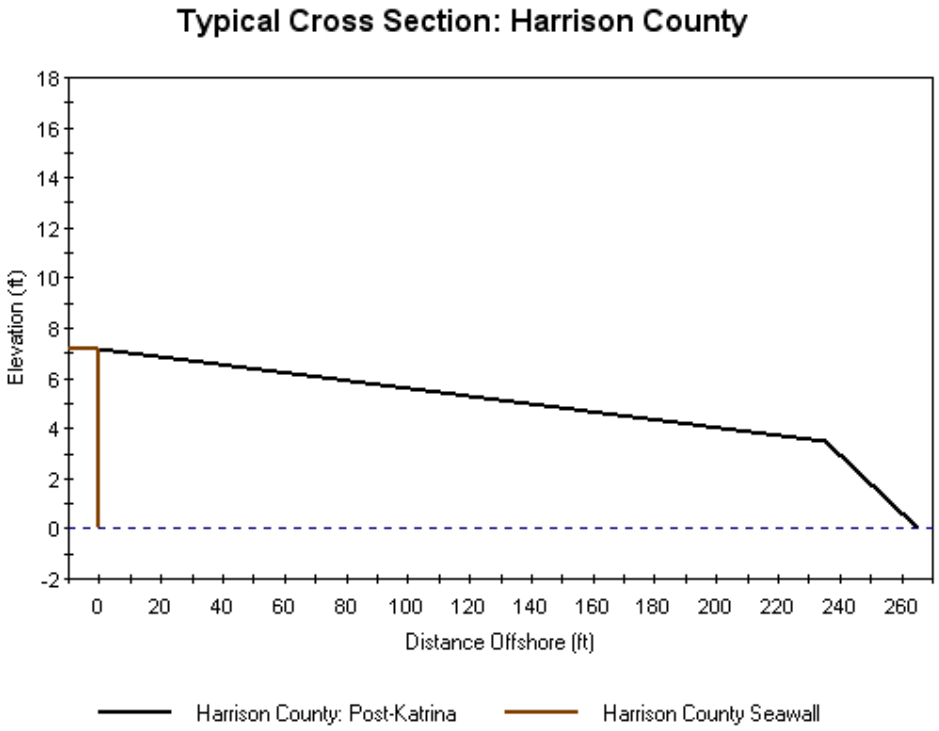


Figure 3.2.3-2. Typical Cross Section, Harrison County Existing Conditions

The Harrison County beaches were last renourished in 2001, which placed approximately 1.1 million CY of beach quality sand obtained from borrows sites located about 1,500 ft offshore of the Harrison County shoreline.

During Hurricane Katrina on 29 August 2005, the project experienced erosional damage due to wind driven waves, debris scour, storm surge and subsequent return flow after the hurricane.

3.2.3.4 Coastal and Hydraulic Data

The climate in the project area is subtropical, characterized by warm summers and short, mild winters. Average temperatures are 82 degrees Fahrenheit for the summer months and 53 degrees Fahrenheit for the winter months. The average annual rainfall is about 60 inches, and is fairly evenly distributed throughout the year. Precipitation records also indicate July as the wettest month, while October is the driest.

Mississippi Sound is a shallow coastal lagoon extending 80 miles along the coast of the Gulf of Mexico from Mobile Bay, Alabama westward to Lake Borgne, Louisiana. The average depth in the sound is 10 ft, with the majority of the sound less than 30 ft deep. The offshore slope of the Sound is relatively flat with the 6 ft contour located a few hundred yards offshore to as far as 1.5 miles offshore. Bed materials are primarily fine grained sands and silt, with some areas of clay content and others, particularly offshore of Bay St. Louis, occupied by expansive oyster beds.

Circulation patterns within the vicinity of the study area are controlled by astronomical tides and winds. The mean diurnal tide range is 1.6 ft, and the extreme (except during storms) is about 3.5 ft.

The velocity of normal tidal currents ranges from 0.5 to 1.0 ft per second (fps) and their direction is generally east to west. Predominant winds average eight miles per hour (mph) from the south during the summer and from the northeast during the winter. Though the tides produced by astronomical forces are relatively small in magnitude, the wind can produce larger variations. Strong winds from the north can evacuate the sound causing current velocities of several knots in the passes to the gulf. Winds from the southeast can produce high tides, piling water up against the shoreline. The study area has been impacted by several tropical storms and hurricanes, most recently from Hurricane Katrina in 2005. Post-Hurricane Katrina high water mark measurements in the area suggest storm surges on the order of 20 to 25 ft or more.

In General, longshore sediment transport is low in magnitude and directed from east to east, although seasonal reversals can occur. Areas dominated by marsh vegetation have minimal or no longshore transport. In some sections groins or drainage structures reduce or block sediment transport.

Sand accumulated to the east of each groin indicating a weak net transport direction to the west, and a series of five profiles taken within each groin compartment indicated losses from the beach extending from Henderson Point to the Biloxi lighthouse from 1951 to 1953 were approximately 32, 500 CY/year.

Byrnes et al. (1993a, 1993b) evaluated shoreline position change rates for the mainland beach in Harrison County from 1851/52 to 1986, and found that long-term beach change has been minor (0.7 ft/yr), with change from 1951-1986 erosive at -1.6 ft/year. The greatest shoreline change has been associated with beach nourishment projects and impoundment or erosion at recently-constructed littoral barriers. The coastal highway was protected by construction of a seawall in 1928, and thus shoreline retreat has been limited by the structure. Seven geomorphic zones defined by coastal structures and harbor complexes essentially block littoral transport from the east to the west across each structure. The analysis showed impoundment of sand on the east side and erosion west of each complex or structure, indicating littoral transport from east-to-west. More than 100 smaller structures (e.g., water drainage pipes and canals that block littoral transport) and periodic beach scraping resulted in variability in shoreline position within each geomorphic zone.

3.2.3.5 Future Without-Project Conditions

The future without-project conditions assumed continuation of the present maintenance activities in Harrison County; maintenance occurs on a 12 year interval at which time the without project template is restored by hydraulic placement of fill material obtained from offshore sand sources. Two cross sections or scenarios were considered as future without project conditions. The first scenario examined continued maintenance of the existing post-Katrina cross section which included a berm only feature, Figure 3.2.3-2 and Figure 3.2.3-3. Scenario 1, continued maintenance of the post-Katrina berm only feature, consists of a berm which extends approximately 230 ft from the seawall to the Mississippi Sound. The berm elevation varies from approximately 7.2 ft (NAVD 88) at the seawall to 3.5 ft at the slope break to the Mississippi Sound. A typical cross section for the post-Katrina existing condition is shown in Figure 3.2.3-3.

The second scenario included a dune feature and was identified as an interim project to this study with funding appropriated for construction. Therefore both scenarios were considered in the evaluation of future without-project conditions. Scenario 2 consists of a 10 ft (NAVD 88) dune elevation with a 10 ft wide dune crest comprised of approximately 2.9 CY/ft of sand. The dune would be constructed approximately 50 ft seaward of the existing seawall. To provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms, the dunes will be vegetated and protected with sand fencing. A typical cross section for Scenario 2 is shown in Figure 3.2.3-3.

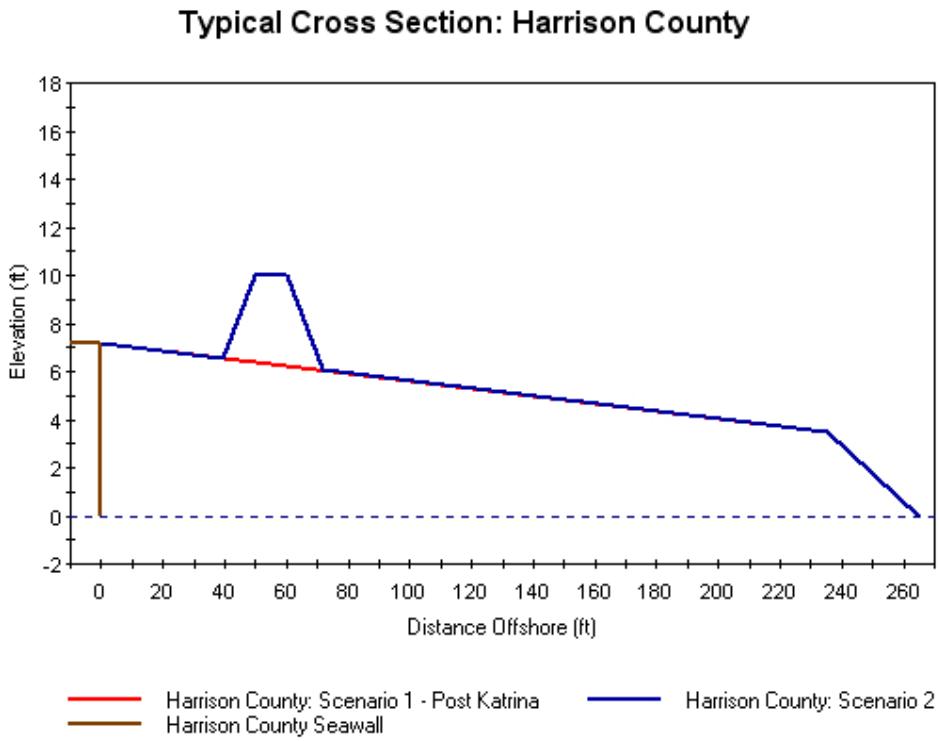


Figure 3.2.3-3. Typical Cross Sections, Harrison County Scenarios 1 and 2

3.2.3.5.1 Results-Future Without-Project Conditions

Table 3.2.3-1 summarizes the results of the Harrison County without-project Beach-*fx* simulations. The data in Table 3.2.3-1 indicate that existing beach maintenance practices will require approximately 130 CY/ft of beach over a 100 year project life assuming the existing rate of sea level rise persists into the future. If the future rate of sea level rise increases, the simulations indicate that the potential moderate rate of future sea level rise will result in about a 90 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about a 115 percent increase in project volume requirements.

Table 3.2.3-1.
Harrison County Without-Project Summary

Scenario Name[1]	Number of Nourishments				Nourishment Volume (CY/ft)			
	mean	sd	max	min	mean	sd	max	min
Scenario 1 ESLR	6	1	8	4	142.3	22.0	214.7	85.6
Scenario 2 ESLR	7	1	8	5	124.9	22.1	208.6	72.5
Scenario 1 MSLR	8	1	8	5	278.1	36.6	385.3	179.6
Scenario 2 MSLR	8	0	8	7	229.2	26.1	310.4	169.4
Scenario 1 HSLR	8	0	8	6	324.4	39.2	437.7	211.3
Scenario 1 HSLR	8	0	8	7	248.9	28.5	338.9	192.1

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

As a result of the difference in maintenance cycles in Harrison and Hancock counties the project volume requirements in Hancock County exceed those in Harrison County by approximately 225 percent for without project conditions under existing sea level rise conditions. For the potential future sea level rise scenarios the increase in volume requirement is about 180 percent.

3.2.3.6 Future With-Project Options

The future with-project evaluations for Harrison County included 11 options which were evaluated for environmental restoration and enhancement of environmental habitat. Options A through D included four design cross-sections with varying dune and berm configurations. The berm and dune options would be constructed adjacent to the seawall along the length of the beach. For environmental and economic purposes, Options E through H further evaluated the four design cross-sections to include sand fencing and plantings on the dune to provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms. The wider dune features would provide for a larger spatial extent with which to create environmental habitat. Options A through H were evaluated in conjunction with the Line of Defense 3 seawall.

Option A consists of a 15 ft dune elevation, 35 ft dune crest width, with a dune slope of 1:3, and a berm with a 160 ft width, an upper berm elevation of 7.2 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option B consists of a 13 ft dune elevation, 45 ft dune crest width, with a dune slope of 1:3, and a berm with a 160 ft width, an upper berm elevation of 7.2 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option C consists of a 15 ft dune elevation, 25 ft dune crest width, with a dune slope of 1:3, and berm with a 170 ft width, an upper berm elevation of 7.2 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option D consists of a 13 ft dune elevation, 15 ft dune crest width, with a dune slope of 1:3, and a berm with a 160 ft width, an upper berm elevation of 7.2 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Dune volumes for the Hancock County design options are 10.7 CY/ft, 7.3 CY/ft, 6.6 CY/ft, and 4.7 CY/ft, for Options A, B, C, and D, respectively. The dunes will be constructed to accommodate the approximately 10 ft wide boardwalk which extends along most of the Harrison County seawall. Typical cross sections for Options A through D are shown in Figure 3.2.3-4. The same cross sections were used for Options E through H. For Options E through H, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.

Options I and J are comparative with-project options, for future evaluation, consisting of a design cross-section which includes a dune and berm constructed as a stand alone project which does not incorporate the Line of Defense 3 seawall. Option I consists of a dune feature constructed approximately 50 ft seaward of the seawall at an elevation of 15 ft (NAVD 88), with a crest width of 55 ft, and a dune slope of 1:3. The berm width would be extended to accommodate the placement of the dune feature. Sand fencing would be placed on the dunes to reduce sand transport due to the strong winds which frequently occur during storms. The cross section for Option J is the same as Option I; however the dune would be planted to provide for additional environmental habitat. For Option J, sea oats would be planted on both the landward and seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the landward and seaward toes of the dune. The dunes will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Options I and J is shown in Figure 3.2.3-5.

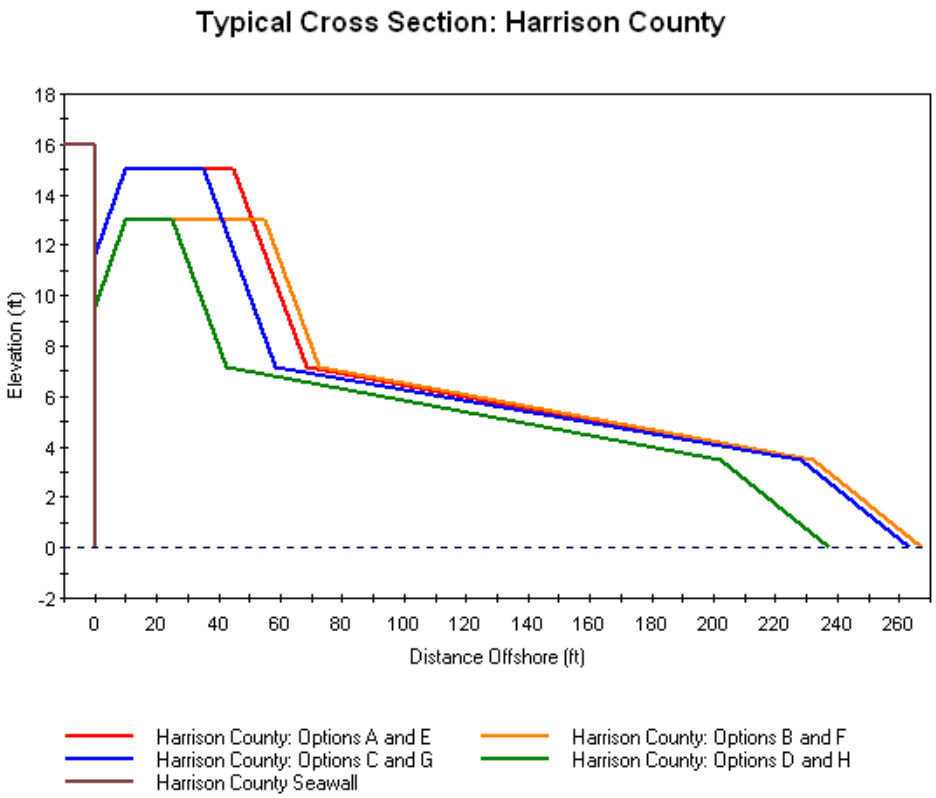


Figure 3.2.3-4. Typical Cross Sections, Harrison County Options A-D and E- H

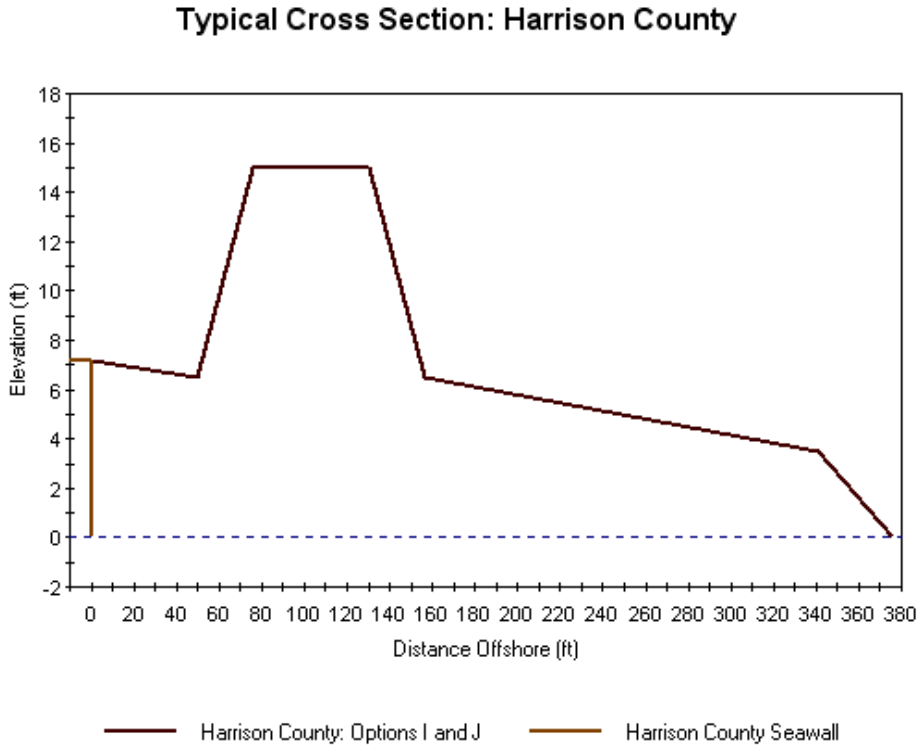


Figure 3.2.3-5. Typical Cross Section, Harrison County Comparative Dune Options I and J

Option K is also an option for future evaluation which consists of an elevated berm section constructed primarily for the creation of environmental habitat. Option K would be constructed as a stand alone option which does not incorporate the Line of Defense 3 seawall. The elevated berm section would be constructed approximately 50 ft seaward of the existing seawall to an elevation 2 ft above the existing berm with a width of approximately 60 ft. The berm width would not be extended to accommodate the placement of the elevated berm feature. The new feature would be vegetated and sand fencing would be placed to create environmental habitat and to reduce sand transport due to the strong winds which frequently occur during storms. For Option K, sea oats would be planted in a 30 by 30 inch grid pattern over the entire elevated berm area. The new feature will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Option K is shown in Figure 3.2.3-6.

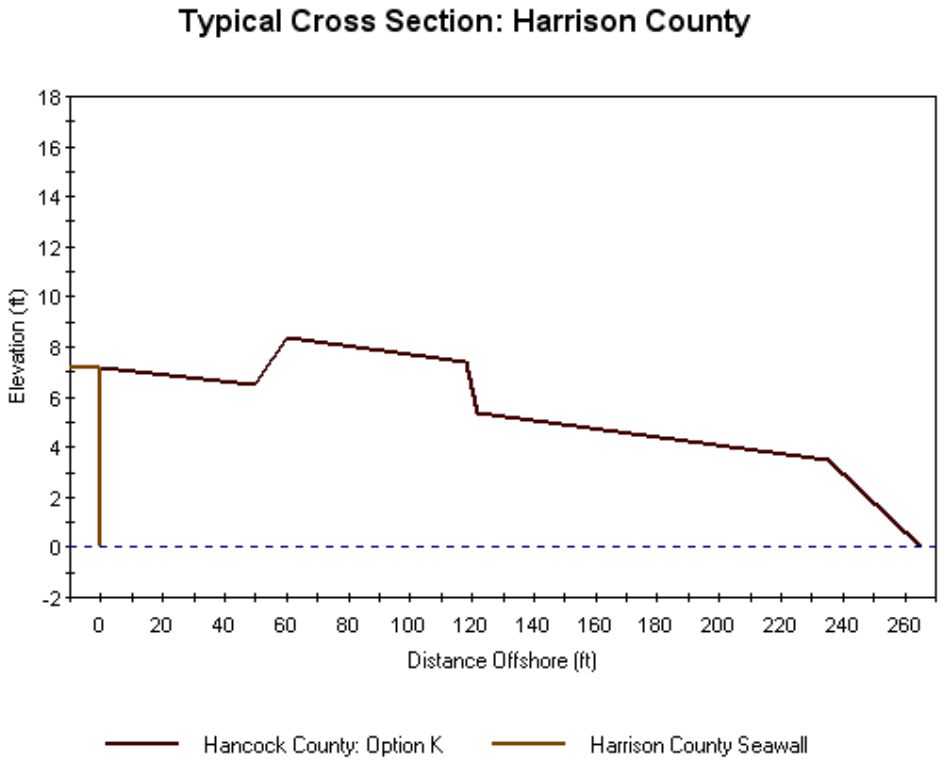


Figure 3.2.3-6. Typical Cross Section, Harrison County Option K

3.2.3.6.1 Results-Future With-Project Options

The coastal processes modeling analysis to evaluate the future with project berm and dune systems, Options A through D, were conducted through application of the engineering-economic model Beach-*fx*. The purpose of the analysis was to evaluate the physical performance of the beach and dune system for anticipated future with-project conditions and to estimate the economic costs and benefits of each. The development of the coastal processes input data for the Beach-*fx* analysis are provided in Section 2.3 of this report. The economic results of the Beach-*fx* analysis are documented in the Economic Appendices of this report. The environmental benefits of Line of Defense 2 are documented in the Environmental Appendices of this report.

Table 3.2.3-2 summarizes the Harrison County with-project Beach-*fx* simulations. The data in Table 3.2.3-2 indicate that, in general, nourishment is required at the end of every nourishment cycle (the maximum number nourishments is 9) for the moderate and high potential future sea level rise rate.

However, for the existing rate of sea level rise, on average, 2 nourishment cycles can be skipped for Option A and one nourishment cycle can be skipped for Options C and D. Nourishment volume requirements over the 100-year project life are approximately 197 CY/ft of beach assuming the existing rate of sea level rise persists into the future. If the future rate of sea level rise increases, the simulations indicate that the potential moderate rate of future sea level rise will result in about a 65 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about an 86 percent increase in project volume requirements.

Table 3.2.3-2.
Harrison County With-Project Summary

Option Name[1]	Number of Nourishments				Nourishment Volume (CY/ft)			
	mean	sd	Max	min	mean	sd	max	min
Option A ESLR	7	1	9	4	201.3	37.3	328.0	116.6
Option B ESLR	8	1	9	4	203.7	38.0	351.9	122.8
Option C ESLR	7	1	9	4	198.7	37.2	360.1	99.4
Option D ESLR	8	1	9	4	180.7	35.5	321.3	82.8
Option A MSLR	9	1	9	7	365.7	48.9	506.2	239.9
Option B MSLR	9	1	9	7	351.5	46.7	483.7	235.0
Option C MSLR	9	0	9	7	359.1	47.6	488.2	242.8
Option D MSLR	9	0	9	7	296.9	40.1	396.2	203.8
Option A HSLR	9	0	9	7	420.8	49.4	538.3	311.9
Option B HSLR	9	0	9	7	418.0	44.7	540.8	294.9
Option C HSLR	9	0	9	7	409.5	49.0	539.7	277.9
Option D HSLR	9	0	9	7	335.5	36.8	437.1	247.8

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

3.2.3.6.2 Summary-Future With-Project Options

The coastal processes analysis conducted as a part of this study has provided a number of useful insights with respect to morphology change, coastal evolution, and the primary drivers for storm-induced damages along the Mississippi Sound shoreline. First, the Mississippi Sound shoreline is primarily a stable, low energy coast that is dramatically impacted by tropical storm events. In the absence of tropical storm events the shoreline is expected to be only slightly erosive with shoreline change rates on the order of -1 ft/year. In general, moderate storm events produce more coastal erosion and volumetric beach change along the Mississippi Sound shoreline than do major hurricanes. This is because the large storm surge associated with the very intense storms completely inundates the beach system and protects it from the high energy dissipation associated with wave breaking, which results in less overall shoreline change and volumetric erosion of the beach. Damages to upland infrastructure are largely driven by inundation and direct wave attack as opposed to erosion, partly because most of the infrastructure is located landward of the sea wall that runs along Highway 90 in Harrison County and Beach Boulevard in Hancock County.

For with project conditions, the volume requirements in Hancock County exceed those in Harrison County by approximately 190 percent. Because the beach is restored to design conditions every year, if needed, in Hancock County the volume requirements are much larger than the volume requirements in Harrison County. In Harrison County, the beach is restored to design conditions once every 12 years. If the beach in Harrison County is damaged by a major storm in the year following reconstruction of the design template the beach remains vulnerable for the remainder of the 11 year nourishment cycle. Essentially, the present analysis indicates that the nourishment cycle

in Harrison County should be shortened or augmented with a provision for emergency dune reconstruction after the occurrence of a major storm event.

3.2.3.6.3 Interior Drainage

This option will not require any interior drainage considerations.

3.2.3.6.4 Geotechnical Data

Geology. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical. The Line 2 defense provides for the installation of dunes on the Mississippi Sound side of the existing seawalls. These dunes are intended to provide toe protection for the seawall when subjected to storm surges in the range of 3 to 5 ft. The dune slopes will be constructed to one vertical to three horizontal side slopes with a ten ft crest. The dunes for Options E through H and J thorough K will be reinforced with plantings of native sea grasses and fencing. The sand used for the dune construction would come from established off shore sources within one mile of the work area. The sands will be compatible with the existing with respect to grain size and color.

3.2.3.6.5 Structural, Mechanical and Electrical

This section is not applicable.

3.2.3.6.6 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.2.3.6.7 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, etc. and the foundation prepared for the new work. Access ramps shall be created and temporary haul routes shall be established. All temporary haul routes shall be regraded upon completion of the work.

3.2.3.6.8 Project Security

Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the

likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.2.3.6.9 Operations and Maintenance

The features that require periodic operations will be the regarding of the dune materials within the beach system and the replacement of any appreciable loss of the sea grasses and the replacement of any damaged fence sections.

3.2.3.6.10 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.2.3.7 Cost Summary. Total project costs for the various options are included in Table 3.2.3-3 and costs for the annualized Operation and Maintenance of the options are included in Table 3.2.3-4. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost. The total project costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25 percent to cover the Cost Growth of the project.

3.2.3.6.11 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months to complete comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in approximately one year.

3.2.3.7 Cost Estimate Summary

Total project costs for the various options are included in Table 3.2.3-3 and costs for the annualized Operation and Maintenance (O&M) of the options are included in Table 3.2.3-4. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost.

Table 3.2.3-3.
Harrison County LOD2 - Project Cost

Option	Description						Project Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	15	35	1:3	160			$21,840,000
B*	13	45	1:3	160			$18,600,000
C*	15	25	1:3	170			$18,100,000
D*	13	15	1:3	160			$10,400,000
E*	15	35	1:3	160	X	X	$22,970,000
F*	13	45	1:3	80	X	X	$19,760,000
G*	15	25	1:3	170	X	X	$19,210,000
H*	13	15	1:3	160	X	X	$11,520,000
I**	15	55	1:3	Extend to accommodate		X	$40,290,000
J**	15	55	1:3	Extend to accommodate	X	X	$41,460,000
K**				Add 2ft, 60 ft width	X	X	$9,680,000

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

Table 3.2.3-4.
Harrison County LOD2 – Operation and Maintenance Cost

Option	Description						O&M Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	15	35	1:3	160			$5,866,473
B*	13	45	1:3	160			$4,996,172
C*	15	25	1:3	170			$4,861,867
D*	13	15	1:3	160			$2,793,559
E*	15	35	1:3	160	X	X	$6,170,004
F*	13	45	1:3	80	X	X	$5,307,761
G*	15	25	1:3	170	X	X	$5,160,025
H*	13	15	1:3	160	X	X	$3,094,403
I**	15	55	1:3	Extend to accommodate		X	$10,822,354
J**	15	55	1:3	Extend to accommodate	X	X	$11,136,629
K**				Add 2ft, 60 ft width	X	X	N/A

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

3.2.3.8 References

Byrnes, M.R., M.W. Hiland, and R.A. McBride. 1993a. Historical shoreline position change for the mainland beach in Harrison County, Mississippi. Proceedings, Coastal Zone ’93, American Shore and Beach Preservation Association, ASCE, July 19-23, 1408-1419.

Byrnes, M.R., M.W. Hiland, and R.A. McBride. 1993b. Harrison County, Mississippi, pilot erosion rate study: phase III. Prepared for Federal Emergency Management Administration, Office of Risk Assessment, Washington, D.C., under Cooperative Agreement No. EMW-90-K-3267, 45 p.

3.2.4 Jackson County Beaches

3.2.4.1 General

The purpose of this section is to provide engineering information and data for the planning and design of shore protection and restoration to the shoreline along Jackson County, MS following impacts from Hurricane Katrina, 29 August 2005. Hurricane Katrina severely damaged approximately 7 miles of public beaches.

3.2.4.2 Location

The Mississippi mainland shoreline is divided into three coastal counties: Jackson, Harrison, and Hancock Counties. Jackson County, Figure 3.2.4-1, is the eastern-most coastal county in Mississippi and is bordered on the east by the Mississippi-Alabama state line and on the west by Harrison County. Jackson County consists of four municipalities: Pascagoula, Moss Point, Gautier, and Ocean Springs. Unlike the beaches of Harrison County, the Ocean Springs beaches are off of US 90 with less traffic and congestion. The beaches along the Ocean Springs shoreline are divided into two reaches: Front Beach extending approximately 1 mile southeastward from US 90 along Front Beach drive to the Ocean Springs Harbor, and East Beach extending approximately 1 mile from the Ocean Springs Harbor to Halstead Road, Figure 3.2.4-1.

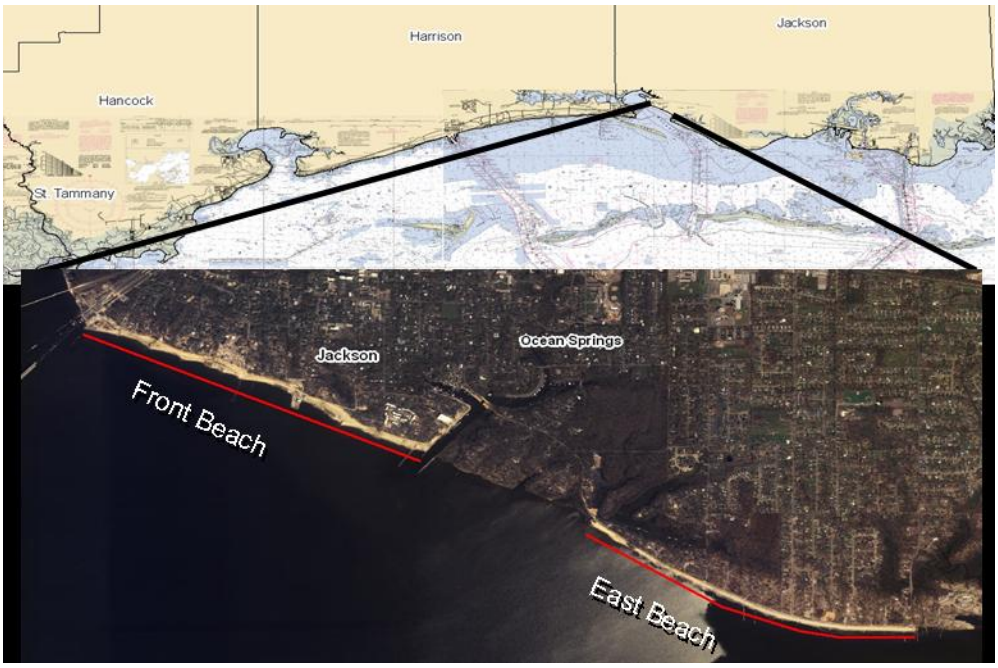


Figure 3.2.4-1. Project Location, Jackson County Beaches

3.2.4.3 Existing Conditions

The shoreline of Ocean Springs, Mississippi has undergone many changes since seaside tourism first became popular in the area a century ago. Discontinuous Pleistocene dune bluffs, interspersed with wetland-fringed bayous, were formerly fronted by muddy tidal flats containing varying amounts of shell material. Seawalls were constructed along the shoreline fronting the developed sections of Ocean Springs in the late 1920s. Two decades later, beach nourishment projects created sand beaches in front of two seawall segments, and the modern shoreline reaches of Front Beach and East Beach became named. Front Beach, more exposed to wave and tidal forces, experienced greater levels of erosion, and renourishment with dredged material was conducted in the 1970s. At wave-sheltered East Beach, marsh vegetation colonized the beachfront intertidal zone and thus assisted in the stabilization of the shoreline. These new wetlands became modified by routine beach maintenance activity in the 1980s, and shoreline retreat appears to have become more pronounced by the early 1990s (Meyer-Arendt, 1992).

Both Front Beach and East Beach systems only consist of a berm with landward elevations ranging from approximately 2.5 to 5 ft and berm widths of about 100 ft. Access ramps and pavements are located along the beach, and storm water culverts pass beneath the roadway adjacent to the beach to the shoreline to drain sections of Jackson County.

3.2.4.4 Coastal and Hydraulic Data

The climate in the project area is subtropical, characterized by warm summers and short, mild winters. The average daily temperature ranges in the summer and winter are 72–89 and 42–63 degrees Fahrenheit, respectively. The average annual rainfall is about 64 inches, and is well distributed throughout the year. Precipitation records indicate July as the wettest month, while October is the driest.

Circulation patterns within the vicinity of the project site are controlled by astronomical tides, winds, and freshwater discharges. The mean diurnal tide range in Mississippi Sound is 1.6 ft, and the extreme (except during storms) is about 3.5 ft. The magnitude of normal tidal currents ranges from 0.5 to 1.0 ft per second (fps) and their direction is generally east to west. Predominant winds average eight miles per hour (mph) from the south during the summer and from the northeast during the winter. Though the tides produced by astronomical forces are relatively small in magnitude, the wind can produce larger variations. Strong winds from the north can evacuate the sound causing current velocities of several knots in the passes to the gulf. Winds from the southeast can produce high tides, piling water up against the shoreline. Freshwater discharge into Mississippi Sound comes primarily from the Pearl River and averages approximately 12,800 cubic ft per second (cfs). Wave heights in Mississippi Sound exceed 5 ft more than 20 percent of the time in winter, but only 5 percent of the time in summer. The project area has been impacted by several tropical storms and hurricanes, most recently from Tropical Storms Arlene and Cindy, and Hurricanes Dennis and Katrina, all in 2005.

3.2.4.5 Future Without-Project Conditions

Evaluation of the Jackson County beaches was based on the analysis of the Hancock and Harrison County beaches, and information was extracted and transferred to this study area. Therefore, the reader is referred to Sections 3.2.2.5 and 3.2.2.5.1 for information regarding future without project conditions for Hancock County.

3.2.4.6 Future With-Project Options

Evaluation of the Jackson County beaches was based on the analysis of the Hancock County beaches, and information was extracted and transferred to this study area. The Jackson County beach options are the same design as the Hancock County beaches; therefore, the reader is referred to Section 3.2.2.6 for information regarding the Hancock County future with-project options.

3.2.4.6.1 Interior Drainage

This option will not require any interior drainage considerations.

3.2.4.6.2 Geotechnical Data

Geology. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical. The Line 2 defense provides for the installation of dunes on the Mississippi Sound side of the existing seawalls. These dunes are intended to provide toe protection for the seawall when subjected to storm surges in the range of 3 to 5 ft. The dune slopes will be constructed to one vertical to three horizontal side slopes with a ten ft crest. The dunes for Options E through H and J thorough K will be reinforced with plantings of native sea grasses and fencing. The sand used for the dune construction would come from upland sources within 10 miles of the work area. The sands will be compatible with the existing sand with respect to grain size and color.

3.2.4.6.3 Structural, Mechanical and Electrical

This section is not applicable.

3.2.4.6.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.2.4.6.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, etc. and the foundation prepared for the new work. Access ramps shall be created and temporary haul routes shall be established. All temporary haul routes shall be regraded upon completion of the work.

3.2.4.6.6 Project Security

Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.2.4.6.7 Operations and Maintenance

The features that require periodic operations will be the regarding of the dune materials within the beach system and the replacement of any appreciable loss of the sea grasses and the replacement of any damaged fence sections.

3.2.4.6.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.2.4.7 Cost Summary. Total project costs for the various options are included in Table 3.2.4-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.2.4-2. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost. The total project costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25 percent to cover the Cost Growth of the project.

3.2.4.6.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months to complete comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in approximately one year.

3.2.4.7 Cost Estimate Summary

Total project costs for the various options are included in Table 3.2.4-1 and costs for the annualized Operation and Maintenance (O&M) of the options are included in Table 3.2.4-2. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost.

Table 3.2.4-1.
Jackson County LOD2 - Project Cost

Option	Description						Project Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	10	40	1:3	80			$1,910,000
B*	8	50	1:3	80			$1,450,000
C*	10	20	1:3	100			$1,180,000
D*	8	30	1:3	80			$960,000
E*	10	40	1:3	80	X	X	$1,990,000
F*	8	50	1:3	80	X	X	$1,530,000
G*	10	20	1:3	100	X	X	$1,260,000
H*	8	30	1:3	100	X	X	$1,040,000
I**	10	55	1:3	Extend to accommodate		X	$4,490,000
J**	10	55	1:3	Extend to accommodate	X	X	$4,570,000
K**				Add 2ft, 60 ft width	X	X	$1,110,000

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

Table 3.2.4-2.
Jackson County LOD2 – Operation and Maintenance Cost

Option	Description						O&M Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	10	40	1:3	80			$513,048
B*	8	50	1:3	80			$389,487
C*	10	20	1:3	100			$316,961
D*	8	30	1:3	80			$257,867
E*	10	40	1:3	80	X	X	$534,537
F*	8	50	1:3	80	X	X	$410,975
G*	10	20	1:3	100	X	X	$338,450
H*	8	30	1:3	100	X	X	$279,356
I**	10	55	1:3	Extend to accommodate		X	$1,206,065
J**	10	55	1:3	Extend to accommodate	X	X	$1,227,554
K**				Add 2ft, 60ft width	X	X	N/A

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

3.2.4.8 References

Meyer-Arendt, K. J., 1992. Shoreline Changes at Ocean Springs, Mississippi, 1900-1992: Journal of the Mississippi Academy of Sciences, v. 37, no. 1, p. 41

Rosati, J.D., Byrnes, M.R., Gravens, M.B., and Griffee, SF (draft). Mississippi Coastal Improvement Project Study: *Regional Sediment Budget for Mississippi Mainland and Barrier, in publication.*

Schmidt, K. 2002. Biennial report of sand beaches, Hancock County, 2001. Mississippi Department of Environmental Quality, Office of Geology, Open-File Report 110B, April, 53 p.

3.3 Line of Defense 3 – Elevated Roadways/Seawalls and Ring Levees

3.3.1 General

As previously mentioned, all of the beaches described as LOD-2 have a roadway landward of the beach. The roads vary from local or county roads to US Highway 90, a major, four-lane, highway that extends across the entire Harrison County coast. The existing roadways vary in elevation from four to five feet in Jackson and Hancock County and up to about 15 feet above sea level in Harrison County. All of these roads are evacuation routes and all have been damaged in past hurricanes. In a damaged or destroyed condition, these roads make re-entry to the area difficult after a hurricane has passed. Raising and using these roadways as barriers or having an associated seawall defines a portion of the 3rd line of defense, LOD-3. This line will be the first hard engineered structure that will not be affected by erosion from a storm such as a dune system.

Initial strategy was to study three elevations for the structure, elevations 12.0, 18.0 and 24.0. It was understood that due to limited heights, it would only provide protection from more frequent, smaller storms, but would be overtopped by some large storms. This coastal barrier will coincide with the beaches where they exist. Raising the beach-front road did present some engineering challenges due to the numerous intersections with other streets and roads. With several feet of elevation, the intersecting roads would require ramps that would be extremely long to have a reasonable grade. Each of these ramps would also create areas where rainfall would collect and have to be removed during a storm. It also soon became apparent that public opinion was against any structure that would block the view of the beaches and water from the roadways or adjoining properties immediately north of the roads. This was voiced in public meetings and also from agencies that were involved in the study. To maintain some level of support for this defense, it was decided to raise the roadways an average of six feet. This allowed reasonable road intersection construction and allowed the aesthetic view of the water to be maintained and would not be perceived as a high seawall along the coast. Review of the typical roadway elevations allowed raising the roadways in Jackson and Hancock County to Elevation 11.0 and Highway 90 in Harrison County to Elevation 16.0. It was decided to study these elevations without other options as the main part of LOD-3 with the understanding that these structures would not provide protection from large storms. As described above, the LOD-2 dunes could also be constructed against the elevated roadway to help protect the toe of the structural wall associated with the road.

This line of defense would be connected to Line 4, described below, at the mouth of Biloxi Bay and St. Louis Bay. It would also extend northward to higher ground or to Line 4 in Jackson County and Hancock County. The bays are an inlet for storm surge that will be controlled by surge gates that are a part of Line 4. It was also recognized that if LOD-3 was constructed without LOD-4, surge gates across the bays would have to be included as part of LOD-3.

As the first structural defense, Line 3 will exclude some areas that may be considered potential areas of retreat or have other non-structural solutions. This may be due to low population density, ecological sensitivity, areas that contain numerous waterway crossings or areas that could not function with a structural barrier in place. In Jackson County, Line 3 will encompass the southern

portion of Ocean Springs, but due to extended marshes and streams, it will extend northeastward from near the eastern end of East Beach Road to higher ground. Areas east of this location contain numerous marshes, streams, and scattered development. Ring levees will be evaluated for housing developments in some areas. Further east in Jackson County are the cities of Gautier, Pascagoula and Moss Point. The presence of numerous streams and inlets will make a continuous barrier very difficult and these areas are also envisioned to have individual ring levees. While alignments were selected that provided the maximum protection for the most developed areas, some portions could be excluded due to cost and technical issues with closing off drainages. Redrawing the alignments would place some areas into a non-structural solution and could be considered as potential options for further study. These alternate alignments were drawn for Pascagoula/Moss Point, Bell Fontaine, and Gulf Park Estates.

At the western end of LOD-3, the barrier will extend down North Beach Boulevard for several miles to near Bayou Caddy and then turn north to tie in with higher ground. By following this path, the existing roadway will provide an alignment and it will encompass much of the developed waterfront from Bay St. Louis to Waveland, MS. Further west, the town of Pearlington will be evaluated for construction of a ring levee.

As with the main portion of LOD-3, the ring levees were initially considered with the same three elevations of 12.0, 18.0 and 24.0. Closer study revealed that in many cases, the elevation 12.0 was too low based on existing ground surfaces and the elevation 24.0 may not be high enough to be certified by FEMA for a 100-year storm event. The elevations to be studied for the ring levees then was changed to 20.0 and 30.0 with the assumption that the 100-year event would fall between these elevations and that the elevation 30.0 design would be sufficiently high for even a 500-year event. A 100-year minimum event is necessary for levee certification by FEMA. Having a conceptual design with cost estimates for these two elevations would allow for a cost curve to help predict the costs for certain storm events once the modeling studies were complete and stage frequency curves developed.

Modeling for storms that could hit the Mississippi Coast will define the predicted return frequency for LOD-3 structures based on the location and type of structure. While many options were reviewed for the type of structure to be used along the roadways, a simple elevated roadway associated with an extension of the existing seawall was chosen for reliability reasons. A structure that did not mainly rely on powered systems or with multiple moving systems was deemed more suitable for the purposes of this line of defense. As previously described, numerous conceptual designs were considered including inflatable barriers, concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall, sliding panel gates within a seawall, and structural concrete seawalls. The ring levees were all designed as earthen structures. It should be understood that all of these LOD-3 structures would provide less protection than would be required for a Camille or Katrina-like storm. LOD-3 storm damage reduction levels are limited and will be determined based on public and local government acceptance and the amount of risk that Mississippi is willing to accept.

As previously mentioned, this line is dependent on having the ability of closure across the two bays to prevent the storm surge from running inside the mouths of the bays. While the plan calls for surge gates to be associated with Line 4, surge gates would also have to be incorporated with Line 3 if Line 4 was not selected as an alternative. The top elevation of surge gates used solely for Line 3 would be of an elevation that would be compatible with the rest of that barrier. To develop a cost curve for the barriers, cost estimates for elevations of 20.0, 30.0 and 40.0 have been completed and will be used in conjunction with both LOD-3 and LOD-4. More detailed discussion of the surge gates is found below under the LOD-4 section.

Interior drainage behind these barriers must be considered. Any large rainfall event would require that the water trapped behind the barrier have a means to drain or even be mechanically pumped.

The amount of storage that a given watershed could provide behind a barrier during surge conditions will vary. The means to block surge but allow drainage as the surge passes may include conduits with flap valves or gated culverts up to surge gates across large bodies of water. The areas where pumping is required are numerous, but necessary to prevent residual damages associated with this blockage of normal drainage.

The pumping stations, where required, must survive any storm damage and continue to operate until the storm event has passed. This will require hardened structures to house the pumps and power systems and be constructed to a height that corresponds to the risk associated with that line of defense.

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that the majority of roadways and all railways crossing the levee alignment would be retained.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required. See Figures 3.3.1-1 and 3.3.1-2 for geometric plan representations of typical types of roadway crossing structures. All gates up to and including 9 feet high would be roller gates. All above 9 feet high would be dual leaf swing gates.

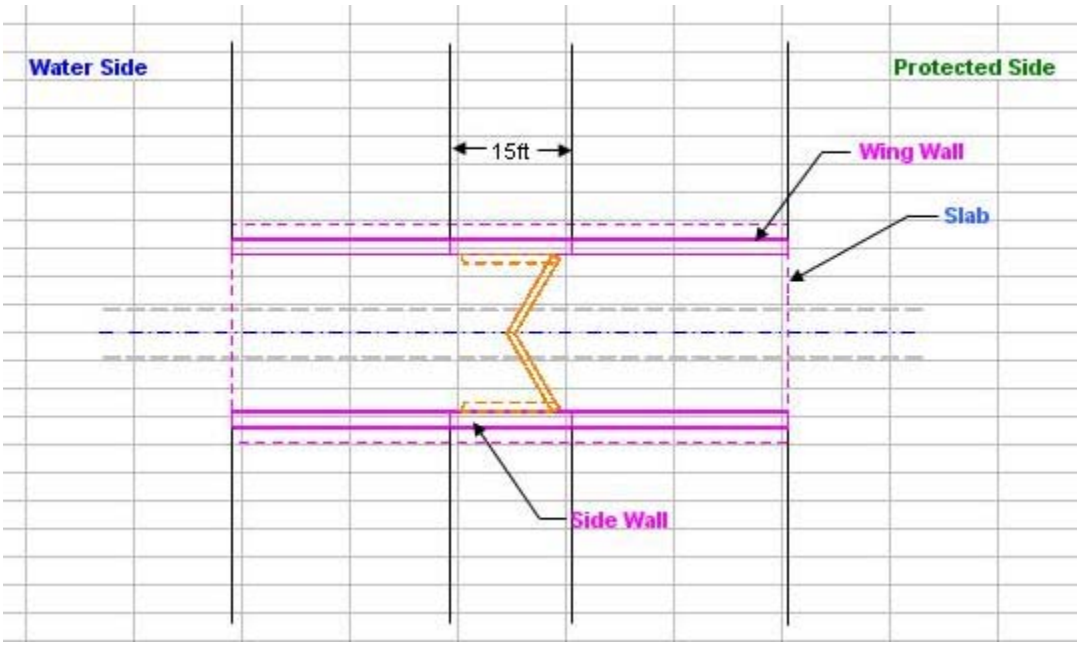


Figure 3.3.1-1. Crossings Under 9ft (two lane gate shown; gate and structure would be mirrored to provide for four-lane highway)

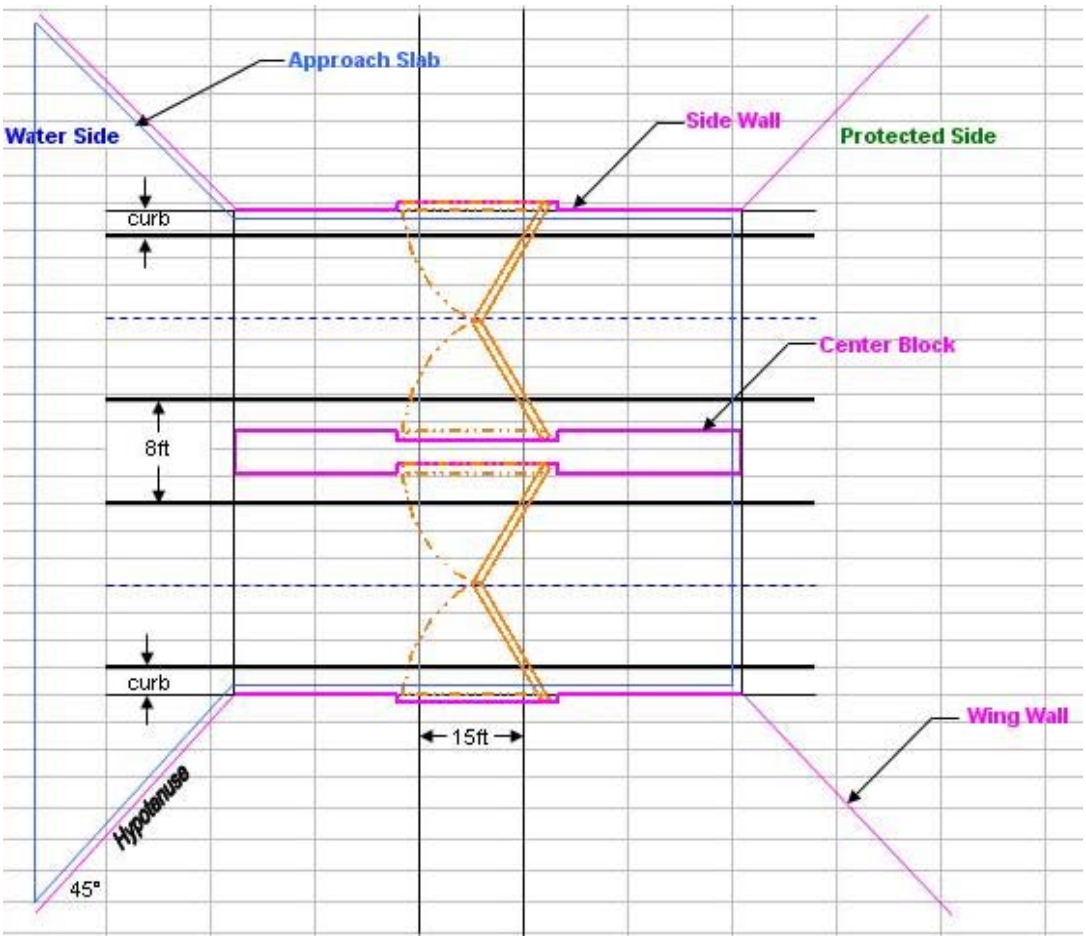


Figure 3.3.1-2. Crossing Over 9ft

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures or much more expensive tunnel structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee. See Figure 3.3.1-3 for geometric plan representation of railroad crossing structures. All railroad gates were assumed to be dual leaf swing gates extending to the full height of levee.

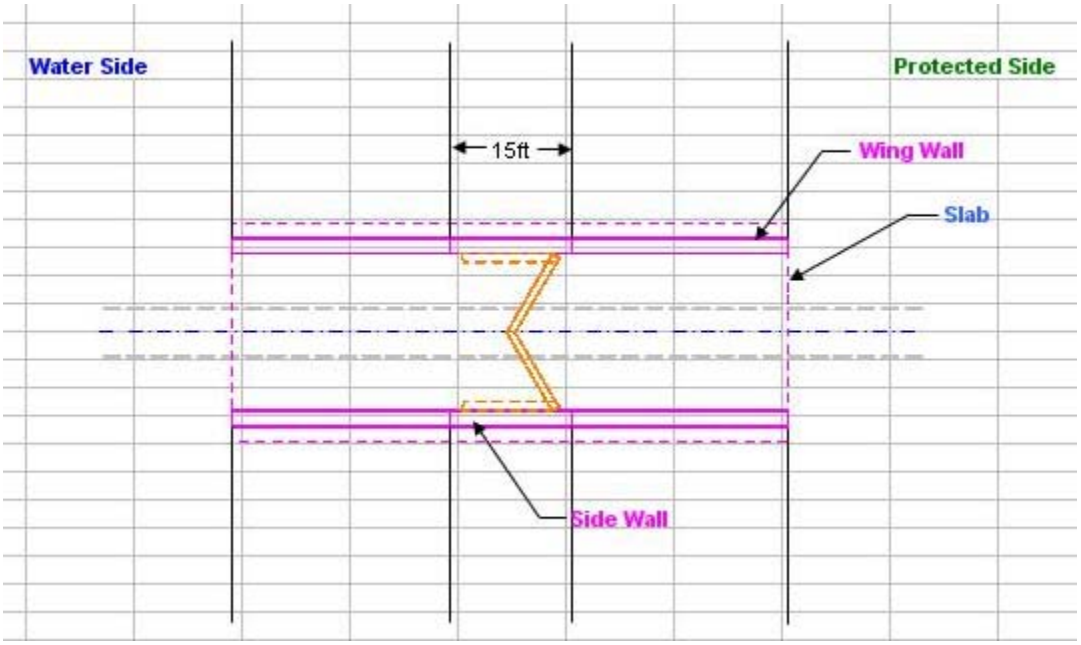


Figure 3.3.1-3. Railroad Crossings

3.3.2 Hancock County Ring Levees, Pearlington

3.3.2.1 General

Pearlington was an extremely hard hit area during the 2005 hurricane season. Water reached a depth of 10-14 ft over the whole community. An earthen ring levee was evaluated for protection of this area. The levee was evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this protection option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.2.2 Locations

The location of the ring levee at Pearlington is shown below in Figure 3.3.2-1 and in Figure 3.3.2-2.



Figure 3.3.2-1. Vicinity Map, Pearlington

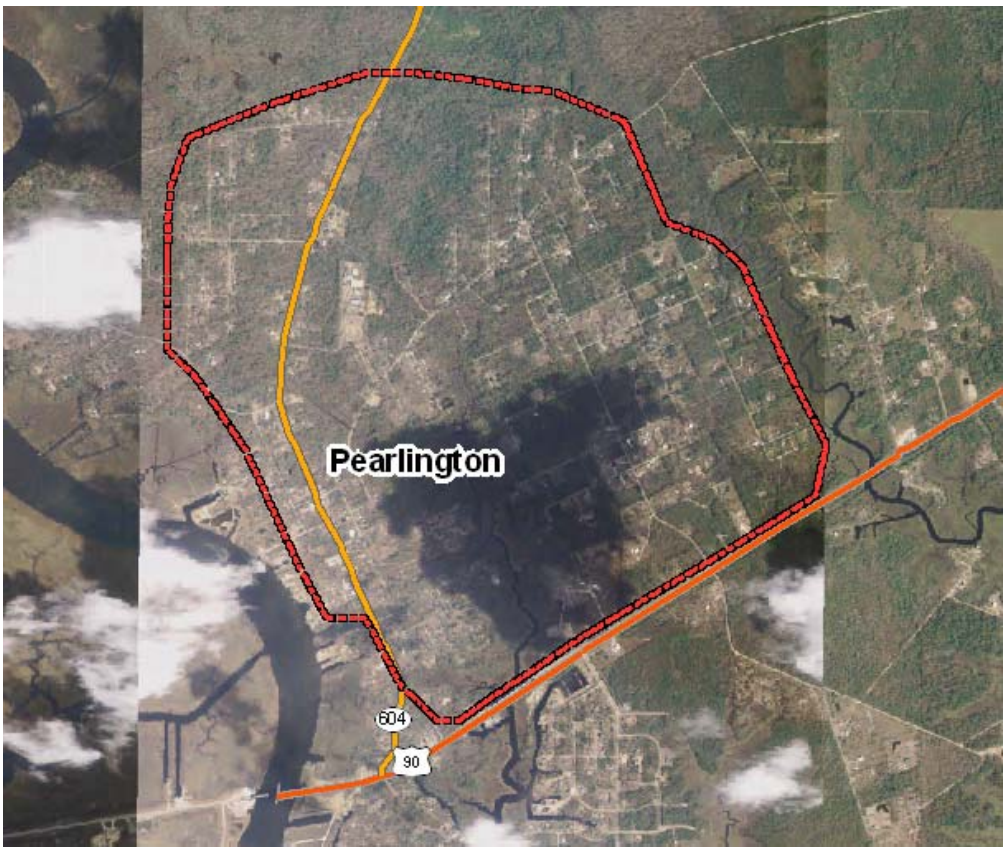


Figure 3.3.2-2. Pearlington Ring Levee

3.3.2.3 Existing Conditions

The town of Pearlington lies on the bank of the Pearl River about 5 miles from the Mississippi Sound. Ground elevations over most of the residential and business areas are very low between elevation 6-10 ft NAVD88. The city limits as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown below in Figure 3.3.2-3.

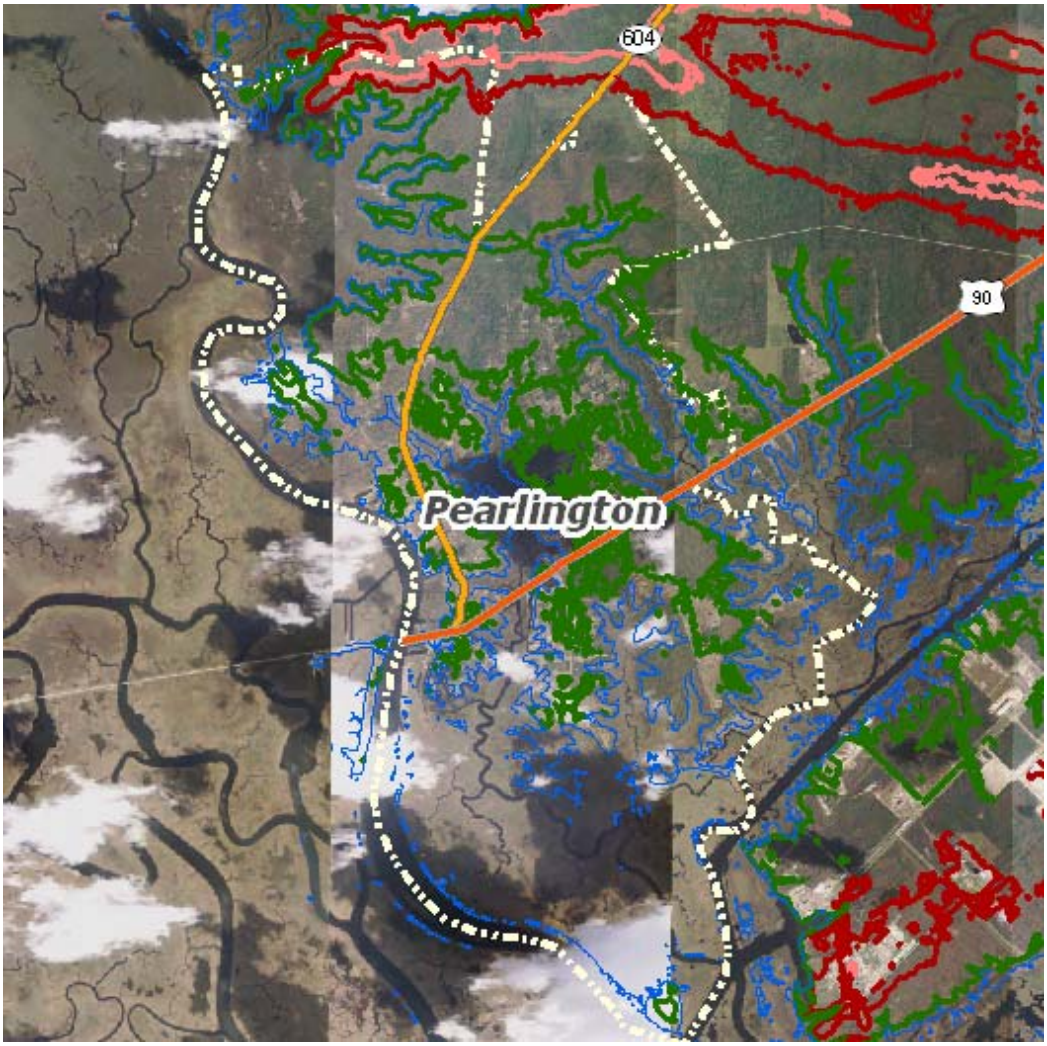


Figure 3.3.2-3. Pearlington Ground Contours and City Limits

Drainage is mostly through natural drainage ways to the Pearl River.

Impacts from hurricanes can be devastating. Damage from Hurricane Katrina in August, 2005 in the Pearlington area are shown below in Figures 3.3.2-4 and 3.3.2-5.



Source: http://ngs.woc.noaa.gov/storms/katrina/24615651.jpg

Figure 3.3.2-4. Hurricane Katrina Damage, Pearlington, MS



Source: wndyfront, http://www.flickr.com/photos/wndyfrost/230684420/

Figure 3.3.2-5. Hurricane Katrina Damage, Pearlington, MS

3.3.2.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.2-6. The data indicates the water was as high as 18-20 ft NAVD88 near the site, totally inundating the entire area.



Figure 3.3.2-6. Ground Contours and Katrina High Water, Pearlington

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Pearlington at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.2-7.

Existing Condition Stage –Frequency data for Save Point 62, at Highway 90 in Pearlington, is shown below in Figure 3.3.2-8. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

It should be noted that the frequency curve shown above reflects only that flooding resulting from storm surge in the gulf. Riverine flooding is not incorporated into this curve.

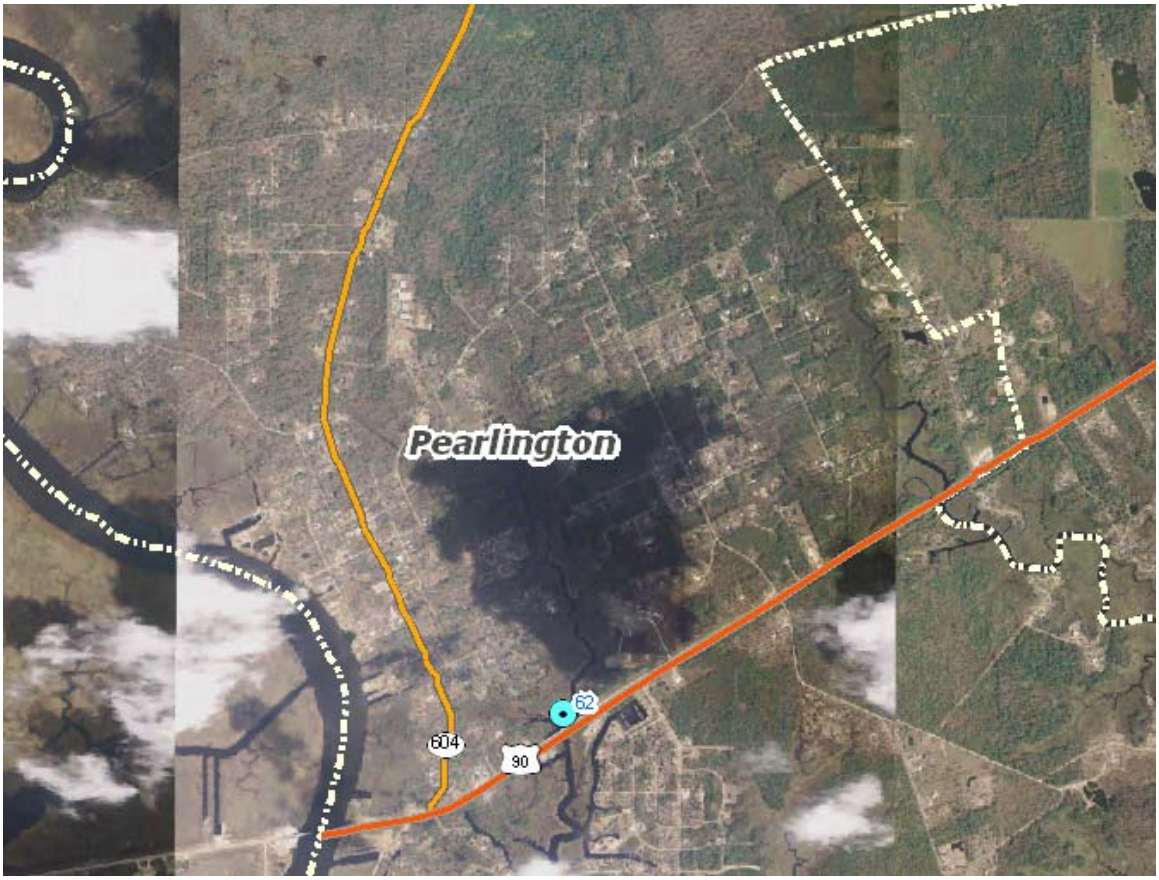


Figure 3.3.2-7. Hydrodynamic Modeling Save Point near Pearlington

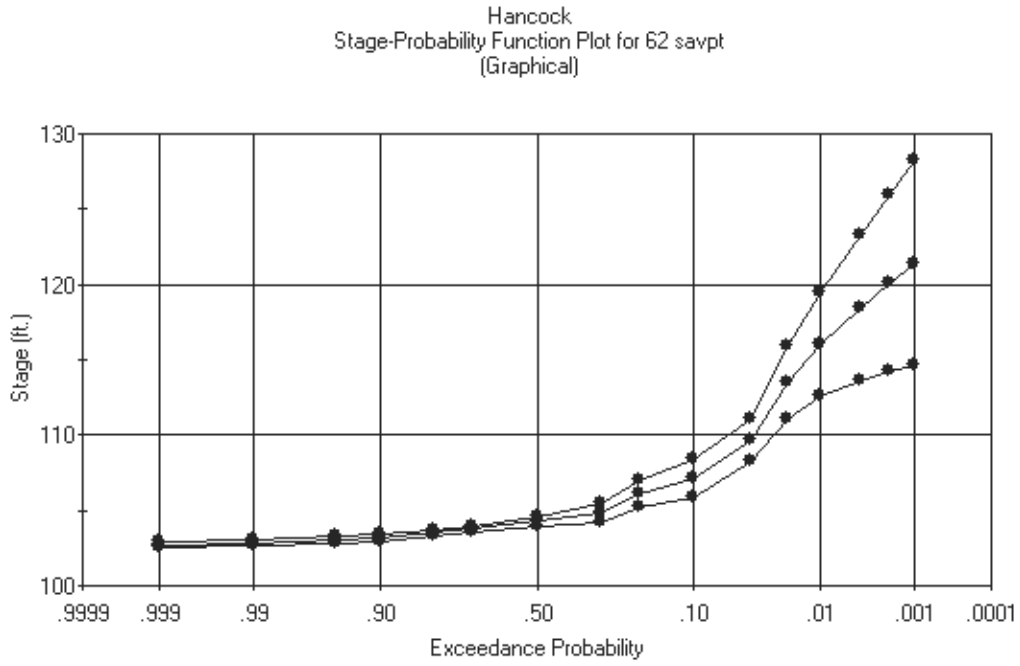


Figure 3.3.2-8. Existing Conditions at Save Point 62, near Pearlington, MS

3.3.2.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 1217 acres around the most densely populated areas of Pearlington as shown on the following Figure 3.3.2-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

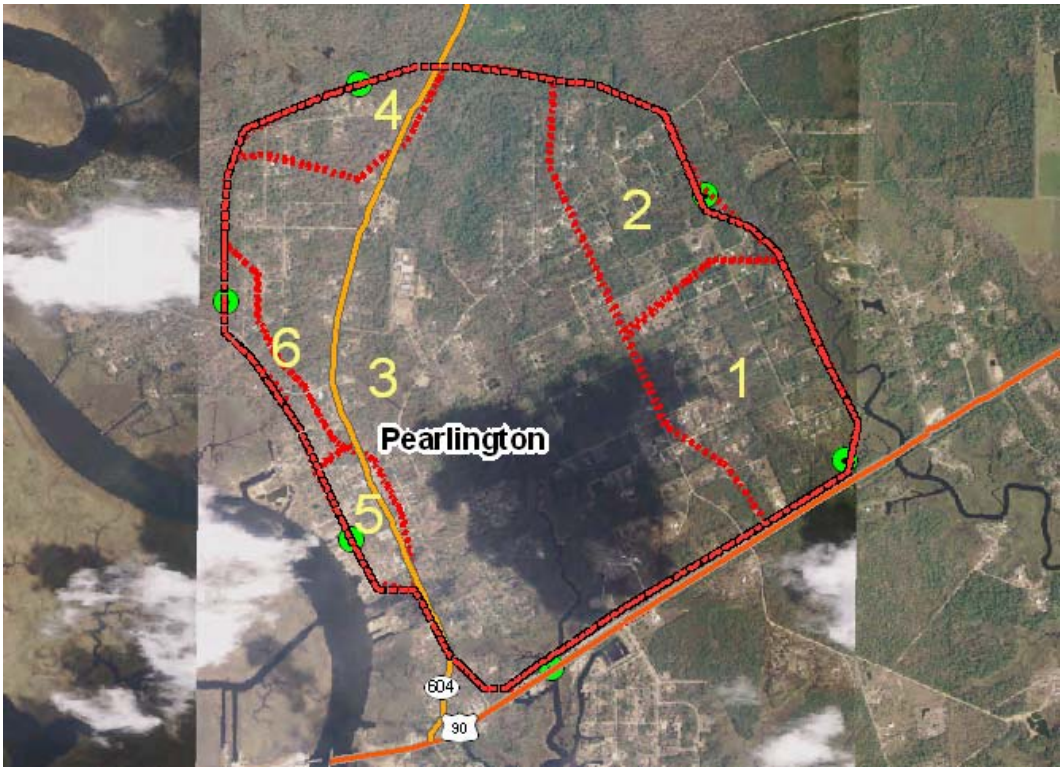


Figure 3.3.2-9. Pump/Culvert/Sub-basin Site Locations

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown below in Figure 3.3.2-10.

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.2-11 was caused by approximately 1-2 ft of overtopping crest depth.

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.2-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.2-10. North Sea, Germany, March 1976



Source: ERDC, Steven Hughes

Figure 3.3.2-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

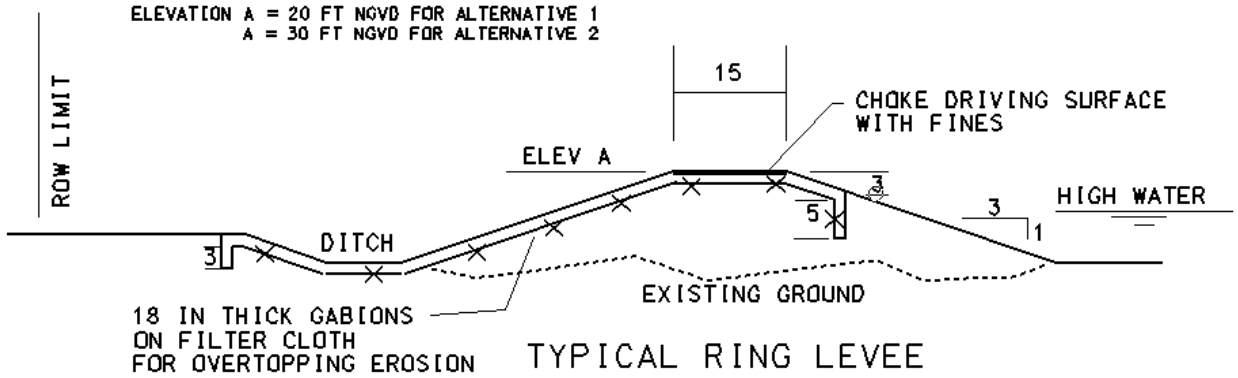


Figure 3.3.2-12. Typical Section at Ring Levee

3.3.2.5.1 Interior Drainage

Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee at the locations shown above. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.2-13.

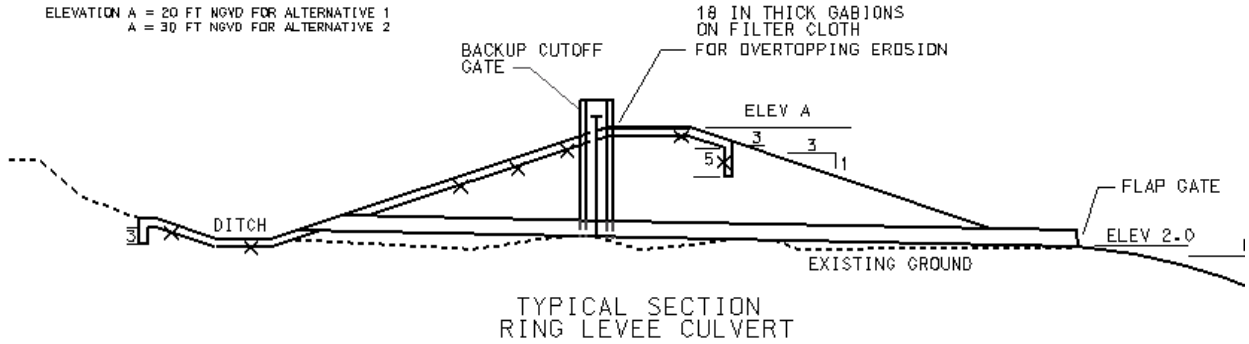


Figure 3.3.2-13. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the ring levee into major sub-basins as shown below in Figure 3.3.2-14 and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number. The variation in soil types, hydrologic soil groups, and major sub-basins are shown below in Figure 3.3.2-14.

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

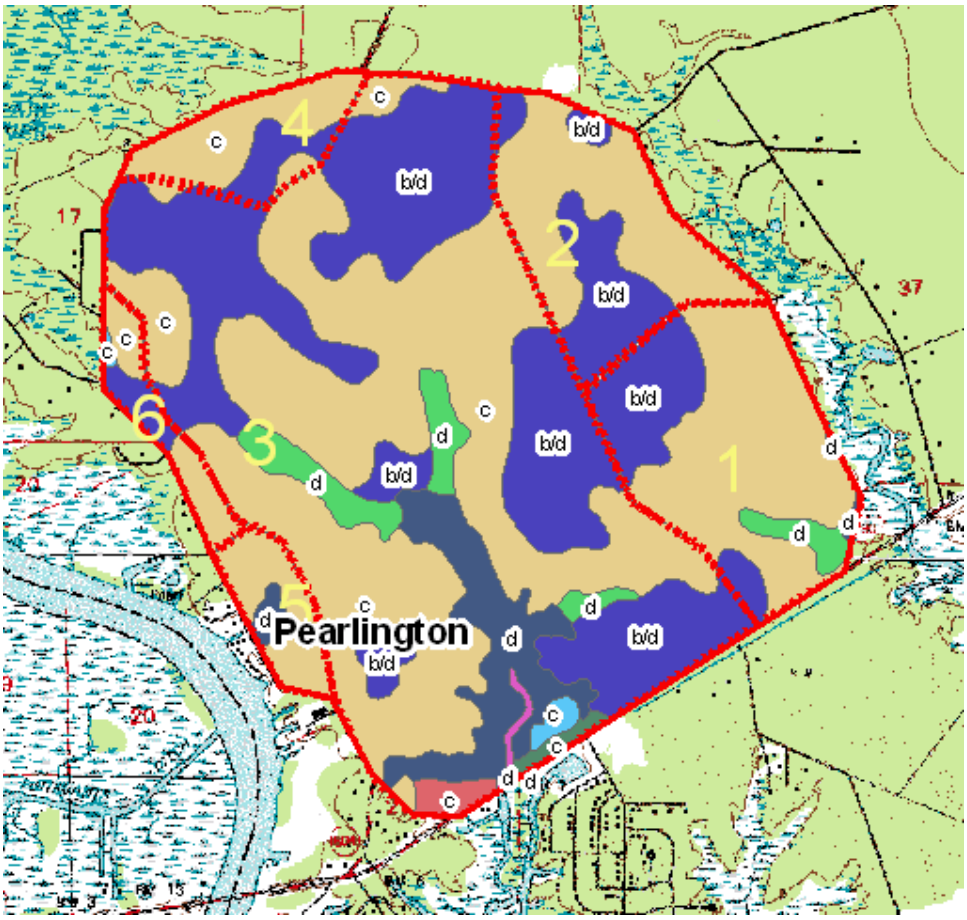


Figure 3.3.2-14. Pearlington Hydrologic Soil Groups

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico" US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is "National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)", R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report, therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.2.5.2 Geotechnical Data

Geology: Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.2.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts and pumping facilities. The sites are shown above.

3.3.2.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the

area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.2.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.2.5.3.3 Pumping Stations Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.2.5.3.4 Pumping Stations Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing

and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.2.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 6 pumping facilities included in the Pearlington Ring Levee system for the elevation 20 protection level were constant at approximately 15 feet and the corresponding flows required varied from 47,127 to 594,701 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 290 horsepower pumps, to one having eight 60-inch diameter pumps each running at 560 horsepower.

3.3.2.5.3.6 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.2.5.3.7 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.2.5.3.8 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Pearlington area to elevation 20, 18 roadway intersections would have to be accommodated. For this study it was estimated that all 18 would require swing gate structures.

3.3.2.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report

therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.2.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.2.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.2.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Maintenance costs are included in this report.

3.3.2.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.2.7, Cost Summary. Construction costs for the various options are included in Table 3.3.2-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.2-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.2.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.2.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Pearlington. The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.2.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.2.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.2.6.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

3.3.2.6.3.1 Pumping Facilities. Flow and Pump Sizes. Option B.

Design hydraulic heads derived for the 6 pumping facilities included in the Pearlington Ring Levee system for the elevation 30 protection level were constant at approximately 25 feet and the corresponding flows required varied from 47,127 to 594,701 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 475 horsepower pumps, to one having eight 60-inch diameter pumps each running at 1000 horsepower.

3.3.2.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.2.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.2.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.2.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.2.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.2.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.2.7 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.2-1 and 3.3.2-2 below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.2-1.
Pearlington Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$104,800,000
Option B – Elevation 30 ft NAVD88	$120,200,000

Table 3.3.2-2.
Pearlington Ring Levee O & M Cost Summary

Option	O&M Cost
Option A – Elevation 20 ft NAVD88	$1,320,000
Option B – Elevation 30 ft NAVD88	$1,526,000

3.3.2.8 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

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USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

National Resource Conservation Service (NRCS). 2003. WinTR5-55 User Guide (Draft). Agricultural Research Service. 7 May 2003.

Environmental Science Services Administration. 1968. “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968.

Weather Bureau and USACE. 1956. National Hurricane Research Project Report No. 3, “Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers.

3.3.3 Hancock County, Bay St. Louis Ring Levee

3.3.3.1 General

Bay St. Louis was an extremely hard hit area during the 2005 hurricane season. Water reached a depth of 10-20 ft over the coastal community. An earthen ring levee was evaluated for protection of this area. The levee was evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this protection option was done by comparing benefits computed by Hydrologic Engineering Center’s (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented elsewhere in this report.

3.3.3.2 Location

The location of the ring levee at Bay St. Louis is shown below in Figures 3.3.3-1 and in Figure 3.3.3-2.



Figure 3.3.3-1. Vicinity Map, Bay St. Louis



Figure 3.3.3-2. Bay St. Louis Ring Levee

3.3.3.3 Existing Conditions

Drainage at Bay St. Louis and Waveland is to the Mississippi Sound to the south and to tributaries of St. Louis Bay to the north. The Shoreline Park subdivision area to the north of Bay St. Louis is very low at elevations of 4-6 ft NAVD88 and subject to frequent flooding from storm surge. The 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), 20-ft(peach), and 24-ft(dark pink) ground contour lines are shown below in Figure 3.3.3-3.

Impacts from hurricanes can be devastating. Damage from Hurricane Katrina in August, 2005 in the Bay St. Louis area are shown below in Figure 3.3.3-4 and 3.3.3-5.

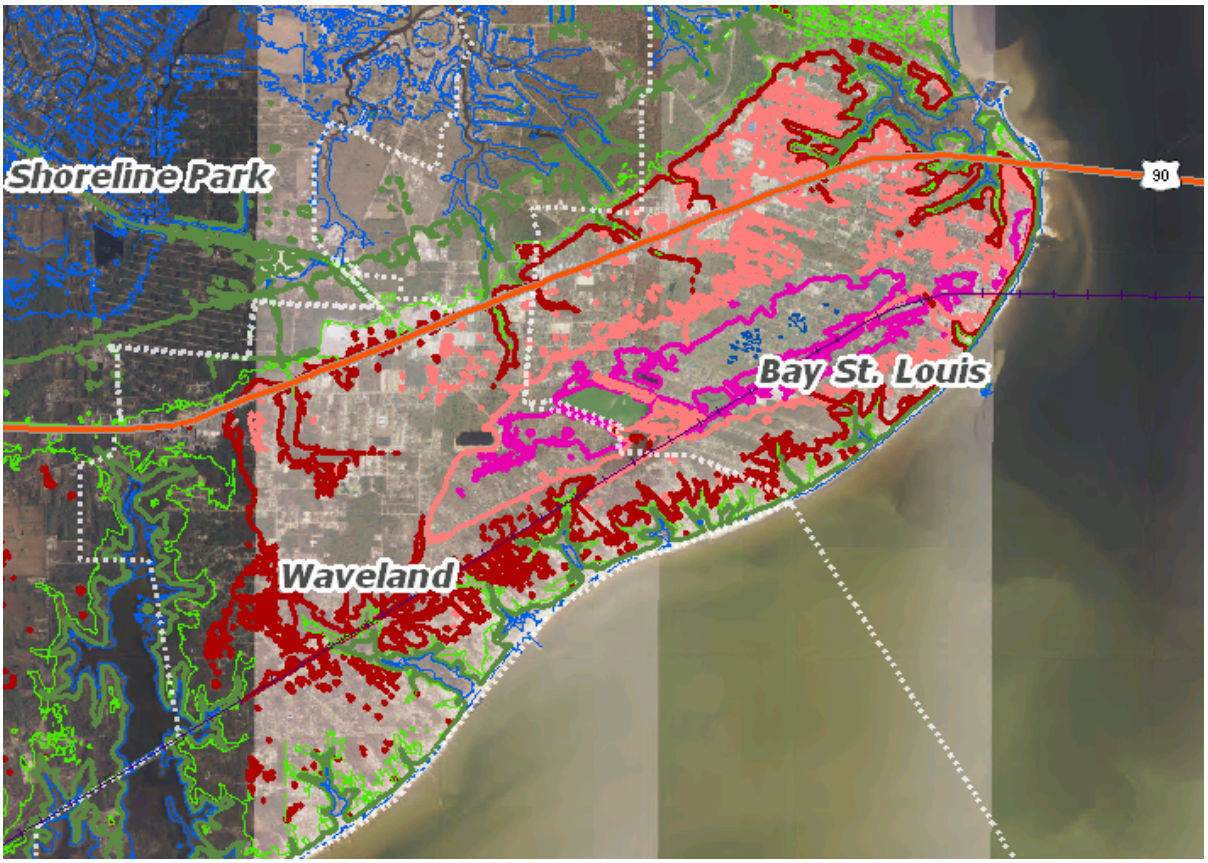


Figure 3.3.3-3. Bay St. Louis Ground Contours and City Limits



Source: http://ngs.woc.noaa.gov/storms/katrina/24614515.jpg

Figure 3.3.3-4. Hurricane Katrina Damage, Bay St. Louis, MS



Source: http://www.pbase.com/dbphotos/image/48766824

Figure 3.3.3-5. Hurricane Katrina Damage, Bay St. Louis, MS

3.3.3.4 Coastal and Hydraulic Data

Historic coastal data are shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), 20-ft(peach), and 24-ft(dark pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.3-6. The data indicates the water was as high as 22-28 ft NAVD88 near the site, totally inundating most of the area.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown elsewhere in this report. Points near Bay St. Louis at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.3-7.

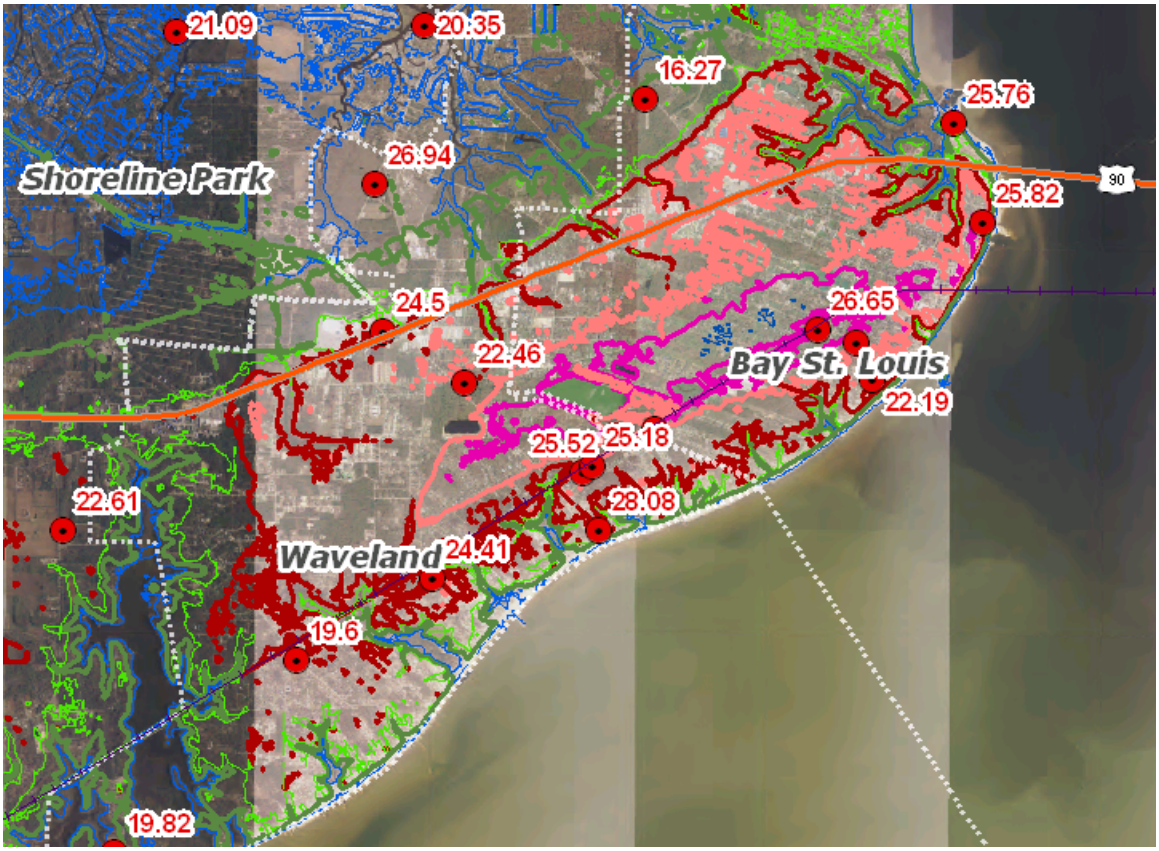


Figure 3.3.3-6. Ground Contours and Katrina High Water, Bay St. Louis



Figure 3.3.3-7. Hydrodynamic Modeling Save Point near Bay St. Louis

Existing Condition Stage –Frequency data for Save Point 62, at Highway 90 in Bay St. Louis, is shown below in Figure 3.3.3-8. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

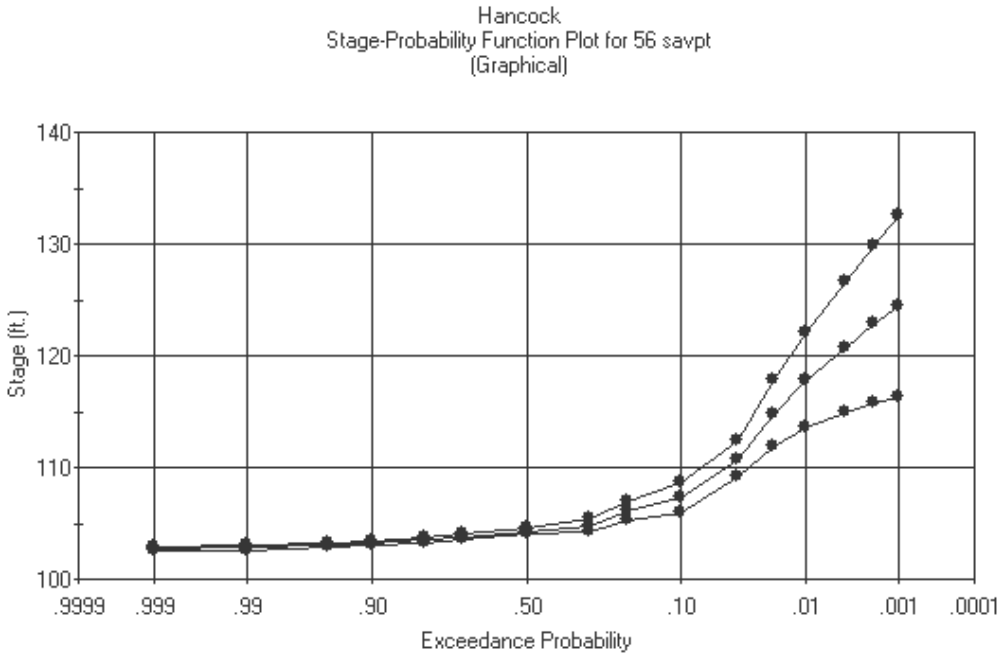


Figure 3.3.3-8. Existing Conditions at Save Point 56, near Bay St. Louis, MS

It should be noted that the frequency curve shown above reflects only that flooding resulting from storm surge in the gulf. Riverine flooding is not incorporated into this curve.

3.3.3.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 3591 acres around the most densely populated areas of Bay St. Louis as shown on the following Figure 3.3.3-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal.



Figure 3.3.3-9. Pump/Culvert/Sub-basin Site Locations

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in Figure 3.3.3-10.

Overtopping failures are caused by the high velocity of flow on the back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.3-11 was caused by approximately 1-2 ft of overtopping crest depth.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.3-10. North Sea, Germany, March 1976



Source: ERDC, Steven Hughes

Figure 3.3.3-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.3-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

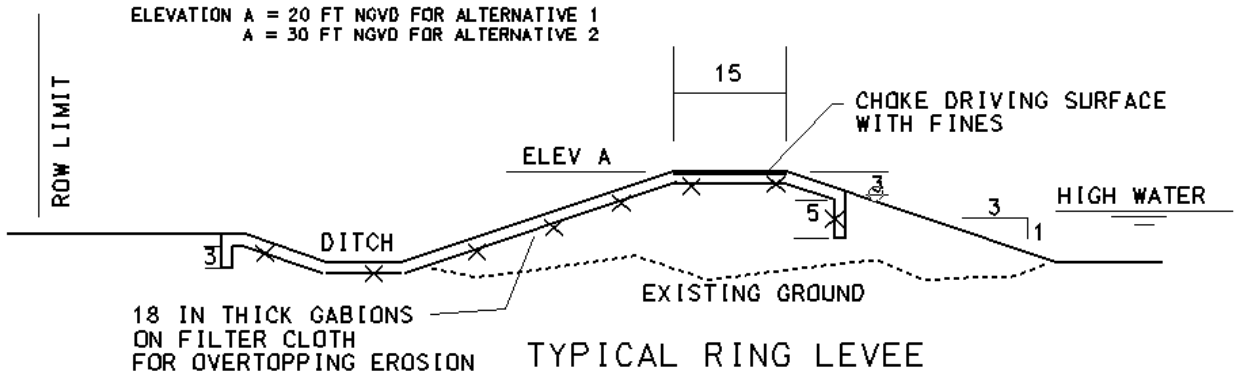


Figure 3.3.3-12. Typical Section at Ring Levee

3.3.3.5.1 Interior Drainage

Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee at the locations shown above. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.3-13.

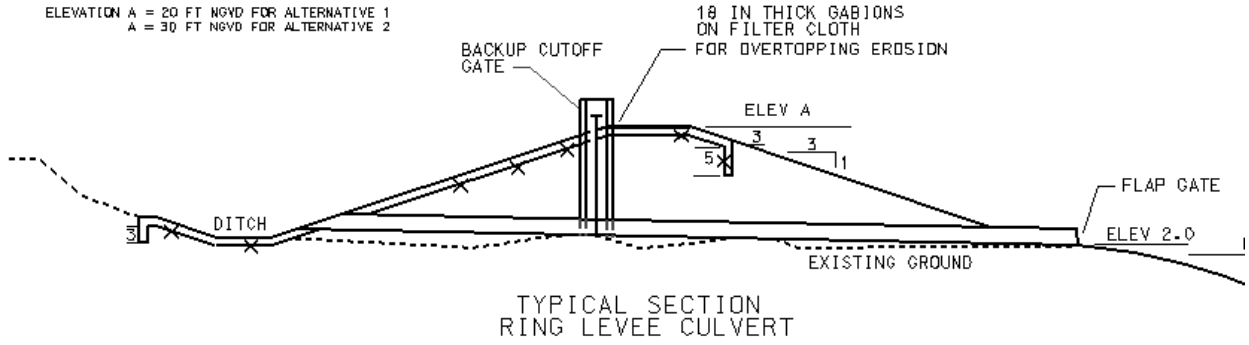


Figure 3.3.3-13. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the ring levee into major sub-basins as shown in Figure 3.3.3-9 and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number. The variation in soil types and their hydrologic soil grouping and sub-basins are shown in Figure 3.3.3-14.

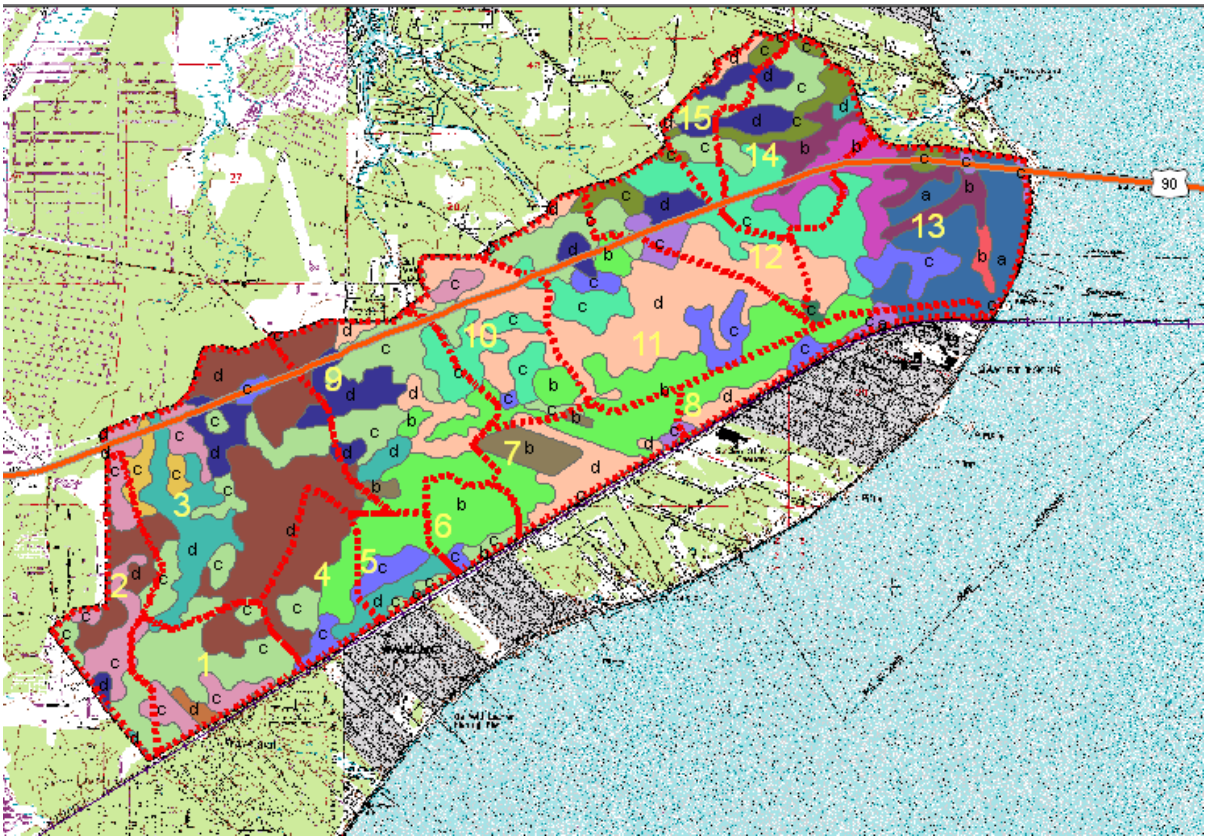


Figure 3.3.3-14. Bay St. Louis Hydrologic Soil Groups

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft above the upstream invert with a tailwater elevation of 2.0 ft above the downstream invert assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico" US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is "National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes

(And Other Tropical Disturbances)", R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report, therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.3.5.2 Geotechnical Data

Geology: Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be

considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.3.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts and pumping facilities. The sites are shown above.

3.3.3.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.3.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.3.5.3.3 Pumping Stations Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric

power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.3.5.3.4 Pumping Stations Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.3.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 12 pumping facilities included in the Bay St. Louis Ring Levee system for the elevation 20 protection level varied from approximately 10 feet to 15 feet and the corresponding flows required varied from 56,695 to 390,483 gallons per minute. The plants thus derived varied in size from a plant having two 36-inch diameter, 125 horsepower pumps, to one having eight 42-inch diameter pumps each running at 290 horsepower.

3.3.3.5.3.6 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.3.5.3.7 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bay St. Louis area to elevation 20, 21 roadway intersections would have to be accommodated. For this study it was estimated that of this number, 4 would require swing gate structures, with the rest requiring roller gates of various heights.

3.3.3.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.3.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.3.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.3.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be

removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.3.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.3.7.Cost Summary. Construction costs for the various options are included in Table 3.3.3-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.3-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.3.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.3.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Bay St. Louis. The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.3.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.3.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.3.6.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

Pumping Facilities. Flow and Pump Sizes. Option B. Design hydraulic heads derived for the 12 pumping facilities included in the Bay St. Louis Ring Levee system for the elevation 30 protection

level varied from approximately 20 feet to 30 feet, and the corresponding flows required varied from 56,695 to 390,483gallons per minute. The plants thus derived varied in size from a plant having 2 36-inch diameter, 250 horsepower pumps, to one having eight 42-inch diameter pumps, each running at 475 horsepower.

3.3.3.6.3.1 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bay St. Louis area to elevation 30, 69 roadway intersections would have to be accommodated. For this study it was estimated that of this number, 62 would require swing gate structures, with the remaining 7 requiring roller gates of various heights.

3.3.3.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.3.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.3.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.3.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.3.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.3.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.3.7 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.3-1 and 3.3.3-2 below. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.3-1.
Bay St Louis Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$283,000,000
Option B – Elevation 30 ft NAVD88	$382,900,000

Table 3.3.3-2.
Bay St Louis Ring Levee O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$2,002,000
Option B – Elevation 30 ft NAVD88	$2,803,000

3.3.3.8 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

National Resource Conservation Service (NRCS). 2003. WinTR5-55 User Guide (Draft). Agricultural Research Service. 7 May 2003.

Environmental Science Services Administration. 1968. “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968.

Weather Bureau and USACE. 1956. National Hurricane Research Project Report No. 3, “Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers.

3.3.4 Hancock County, Elevated Roadway

3.3.4.1 General

Residential and business areas along the coast in Hancock County are susceptible to storm surge damage. A damage reduction option is to raise the beach front road in Hancock County to elevation 11ft NAVD88 was evaluated. The levee alignment is shown in red below. Additional options not evaluated in detail are described elsewhere in this report. The option consists of more than one element and function. This option also contains a provision for a levee at elevation 16 ft NAVD88, shown in blue below. The elevation 16 ft NAVD88 levee functions in coordination with the Harrison County Elevated Hwy 90 Roadway also at elevation 16 ft NAVD and the St. Louis Bay closure structure.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center’s (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.4.2 Location

The location of project in Hancock County is shown below in Figure 3.3.4-1.

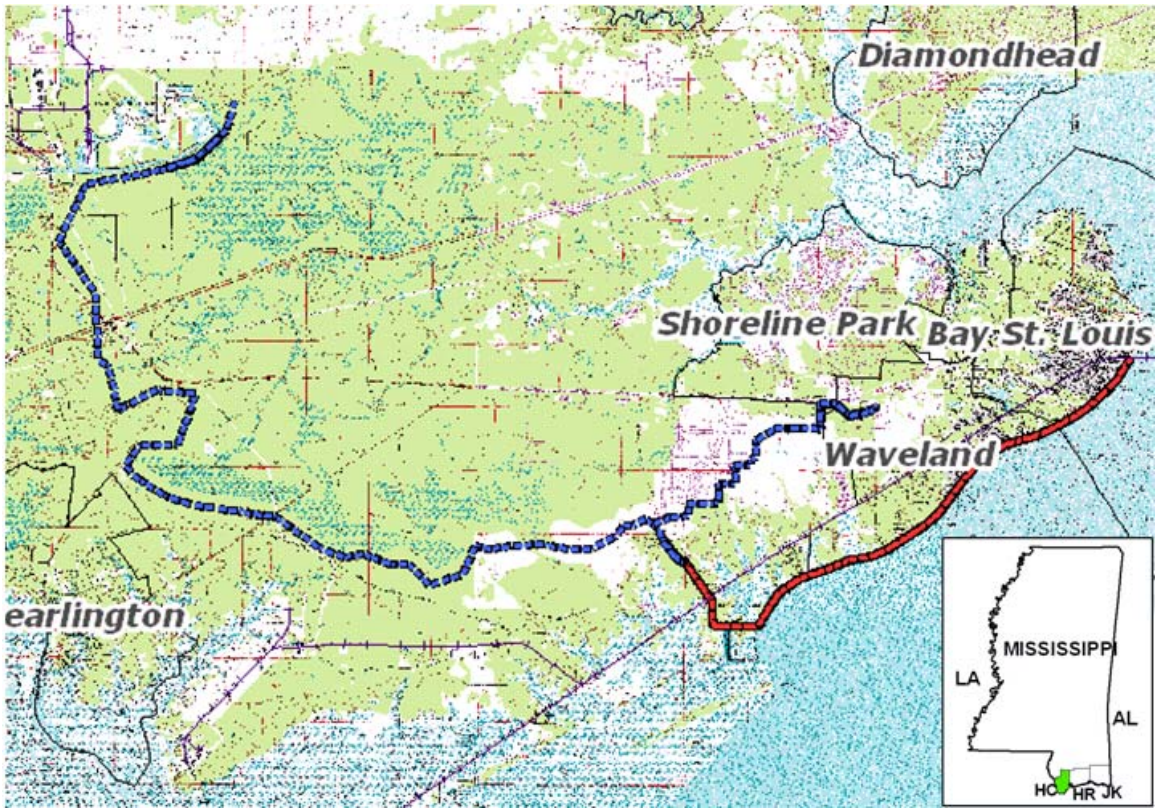


Figure 3.3.4-1. Vicinity Map near Waveland

3.3.4.3 Existing Conditions

The beach front road in Hancock County joins the communities of Bay St. Louis and Waveland at the mouth of St. Louis Bay. The 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown below in Figure 3.3.4-2.

Drainage at Bay St. Louis and Waveland is to the Mississippi Sound to the south and to tributaries of St. Louis Bay to the north. The Shoreline Park subdivision area to the north of Bay St. Louis is very low at elevations of 4-6 ft NAVD88 and subject to frequent flooding from storm surge.

Impacts from hurricanes can be devastating. Damage from Hurricane Katrina in August, 2005 in the Waveland area are shown below in Figures 3.3.4-3 and 3.3.4-4.

3.3.4.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.4-5. The data indicates the Katrina high water was as high as 28 ft NAVD88 near the Mississippi Sound, totally inundating the area.

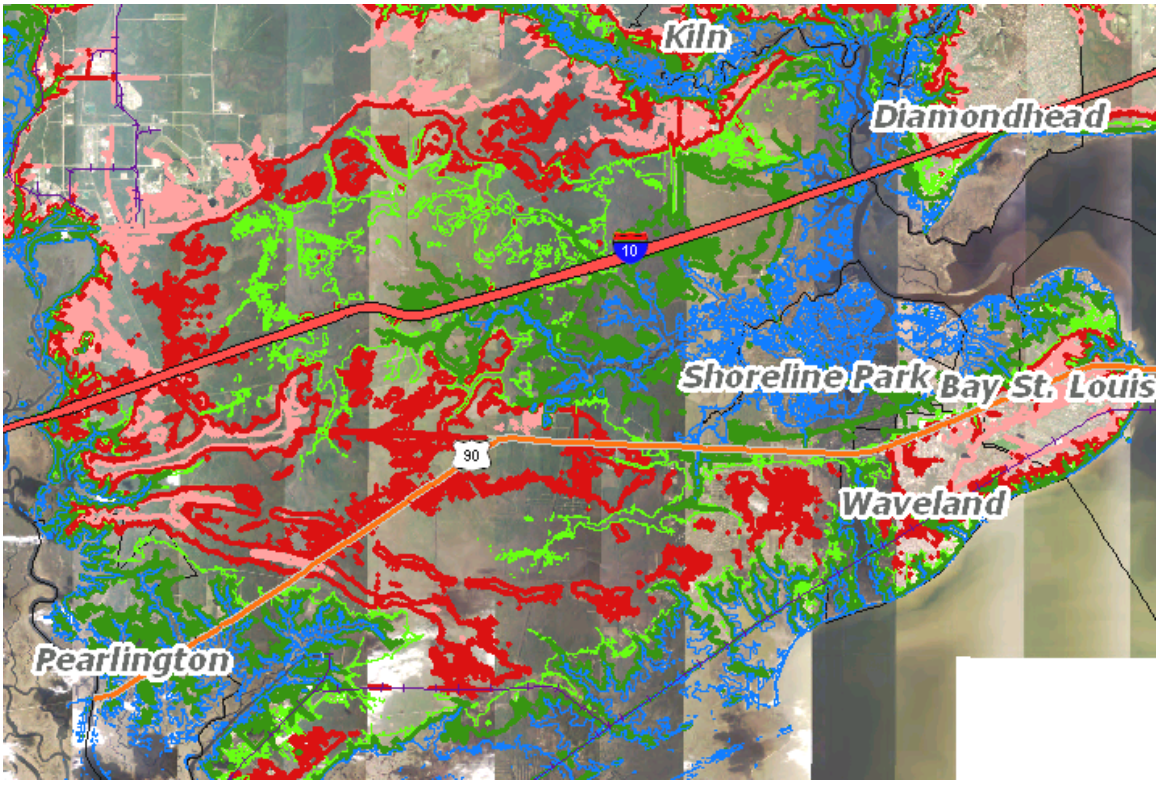


Figure 3.3.4-2. Existing Conditions near Waveland



Source: http://ngs.woc.noaa.gov/storms/katrina/24334552.jpg

Figure 3.3.4-3. Hurricane Katrina Damage near Waveland



Source:G.J. Charlet III, http://www.flickr.com/photo_zoom.gne?id=46937047&size=m

Figure 3.3.4-4. Hurricane Katrina Damage near Waveland

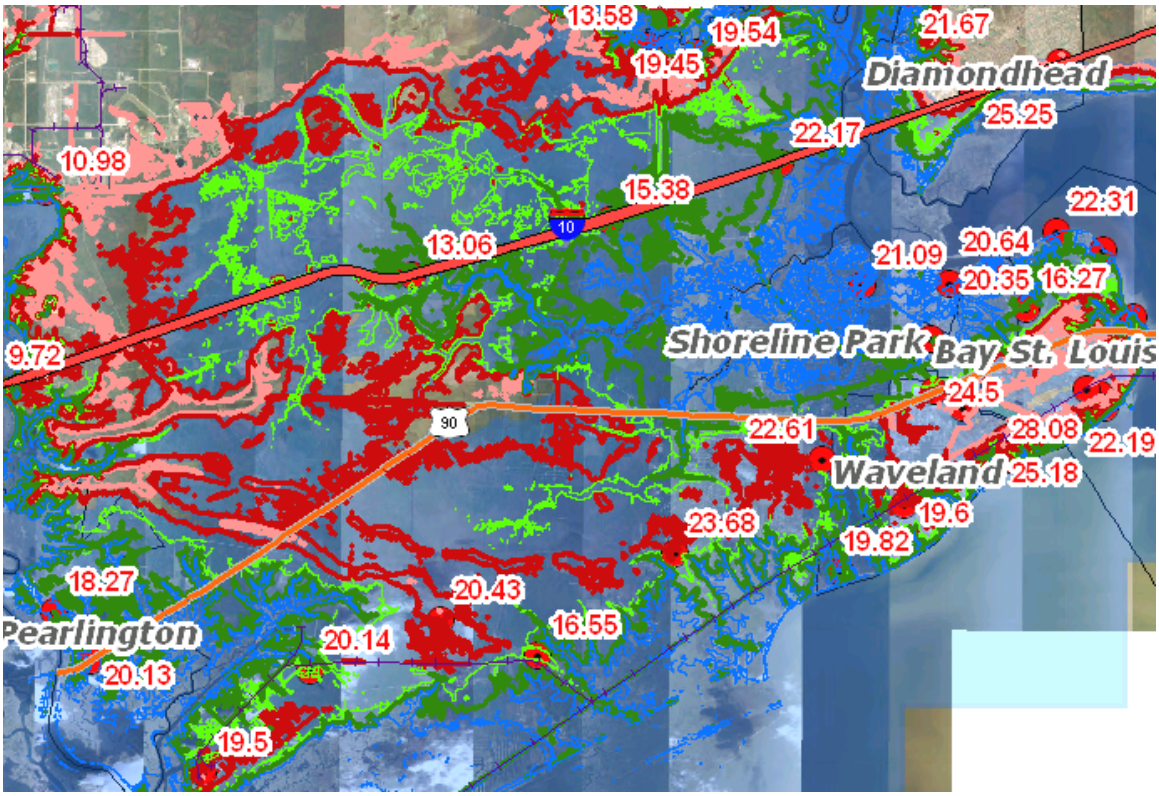


Figure 3.3.4-5. Ground Contours and Katrina High Water, Coastal Hancock Co.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage

frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Ocean Springs at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.4-6.

Existing Condition Stage –Frequency data for Save Point 56, just off the coast of Waveland, is shown below as an example in Figure 3.3.4-7. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

3.3.4.5 Option – Elevate Roadway to 11 ft NAVD88

This option consists of raising the beach front road to elevation 11 ft NAVD88 in the Bay St. Louis/Waveland area as shown on the following Figures 3.3.4-8 and 3.3.4-9, along with the internal sub-basins and levee culvert/pump locations. There is one culvert but no pumps associated with the Elevation 16 ft NAVD88 levee. This levee runs mostly along the ridge line so the drainage is away from the levee. A small boat access structure is also shown at the mouth of one basin. Rising sector gates will be provided at this gate allowing shallow draft traffic most of the time. The gate will be closed prior to hurricane storm surge. A drawing of a typical boat access gate is shown in Figure 3.3.11-15.



Figure 3.3.4-6. Hydrodynamic Modeling Save Points near Waveland

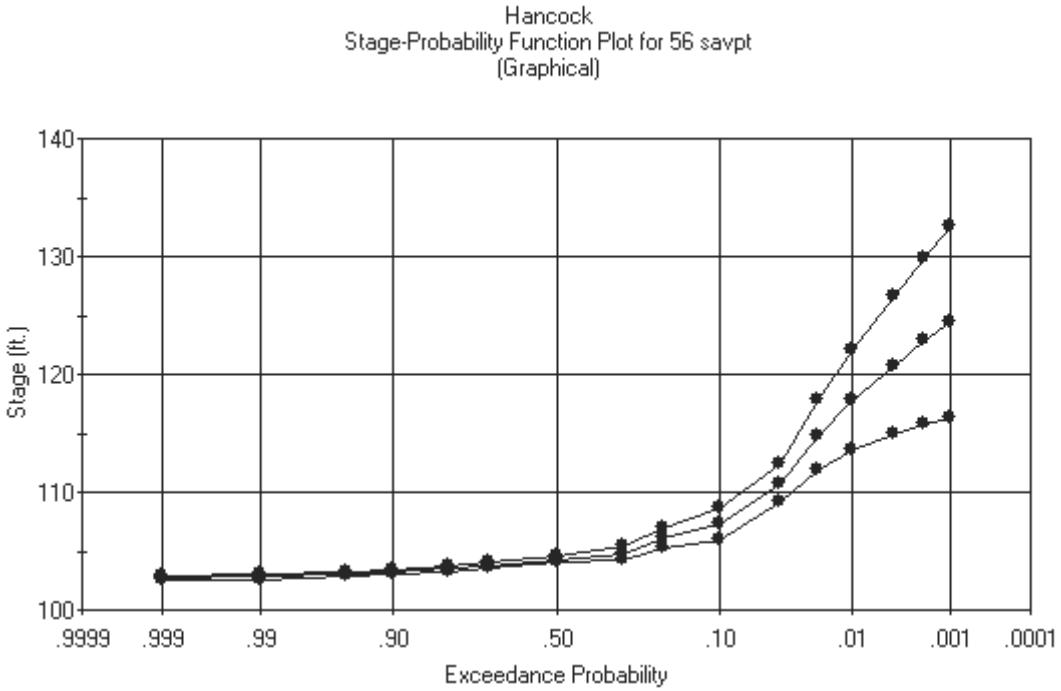


Figure 3.3.4-7. Existing Conditions at Save Point 56, near Waveland

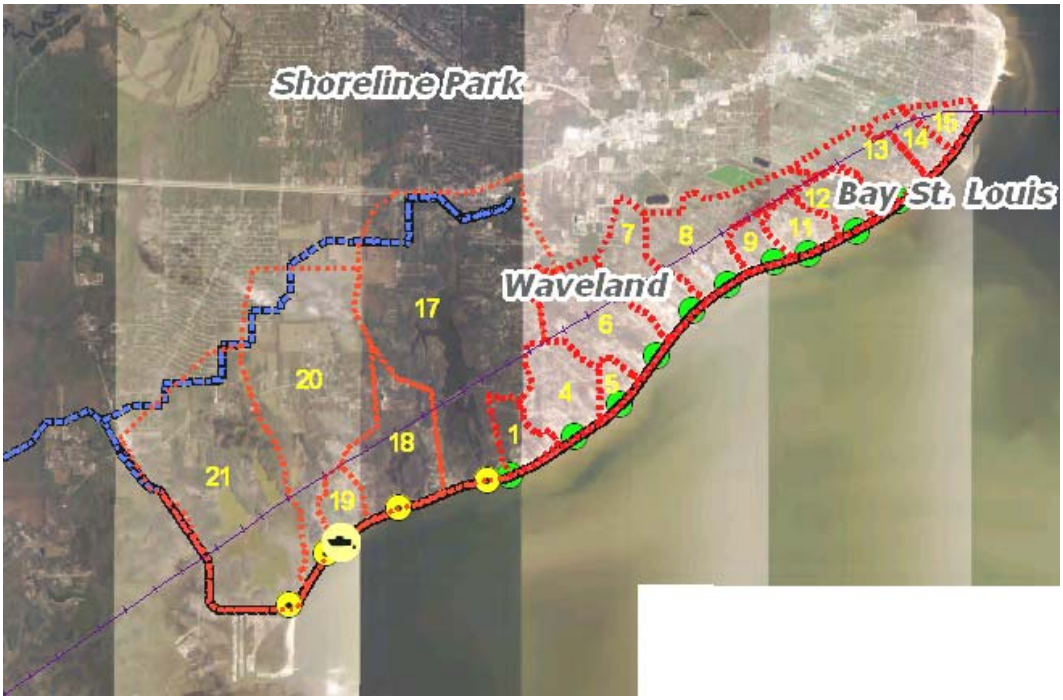


Figure 3.3.4-8. Pump/Culvert/Boat Access Site Locations and Sub-basins

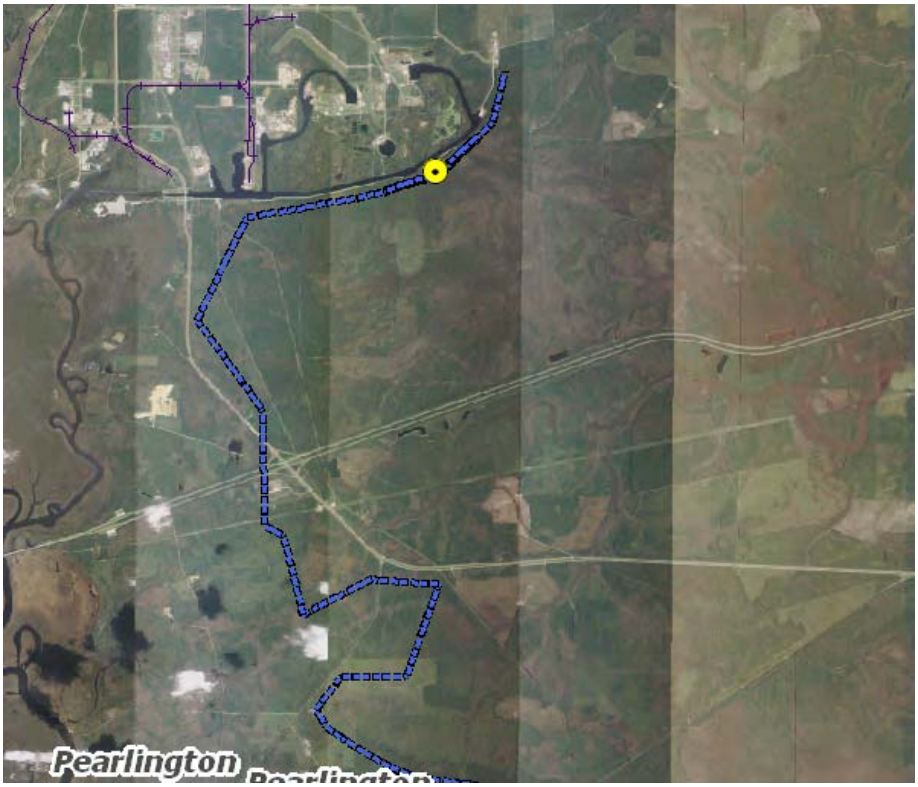


Figure 3.3.4-9. Culvert Site Location

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown on Figure 3.3.4-10.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.4-10. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major

damage did not occur from wave action. The erosion shown below in Figure 3.3.4-11 was caused by approximately 1-2 ft of overtopping crest depth.

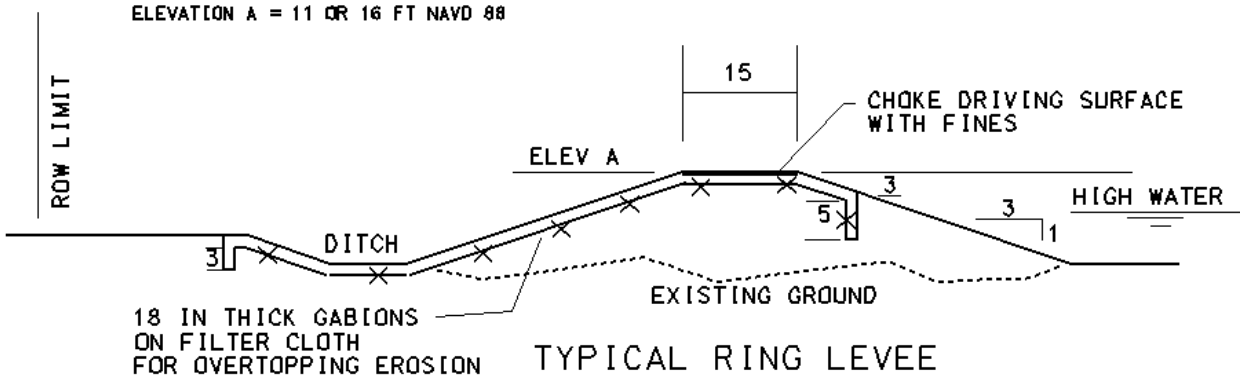


Source: ERDC, Steven Hughes

Figure 3.3.4-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown above on Figure 3.3.4-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.



Source: ERDC, Steven Hughes

Figure 3.3.4-12. Typical Section at Ring Levee

3.3.4.5.1 Interior Drainage

Drainage on the interior of the raised roadway would be collected at the highway and channeled to culverts placed at locations shown above. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.4-13.

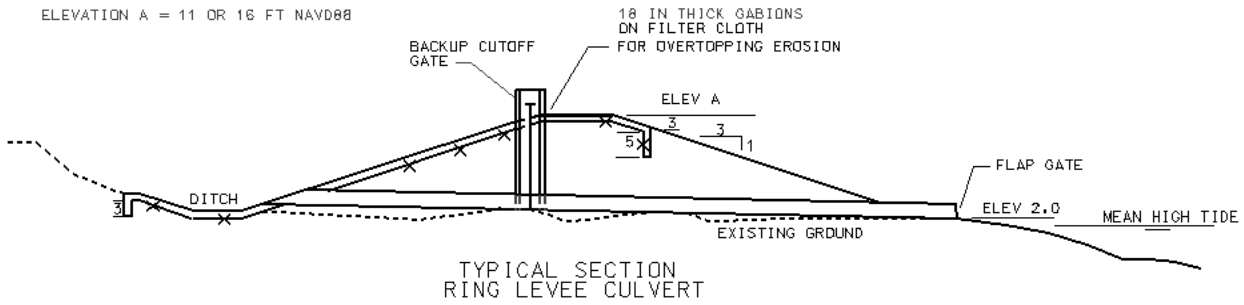


Figure 3.3.4-13. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the drainage basin into major sub-basins as shown above and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number.

Peak flows for the 1-yr to 100-yr storms were computed. Culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater/tailwater elevation difference was maintained at 3.0 ft or less. Drainage ditches along the toe of the highway will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data is considered beyond the level of detail required for this report.

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico" US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is "National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)", R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report, therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.4.5.2 Geotechnical Data

Geology: The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The Line 3 defense elevates the roadway and accompanying seawall to elevation by extending the seaway at its present slope to grade, creating the roadway subgrade then sloping the backside to one vertical to three horizontal side slopes with a twenty five foot toe width for access and drainage. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The embankment will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface on the back side will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the road. The armoring will be anchored on the back face by trenching and extend across the toe easement. All non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate ramping over the embankment where the surface elevation is near that of the crest elevation. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the roadway and the potential for erosion and instability must be considered. Final designs may require the installation of a cutoff wall within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.4.5.3 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 12 pumping facilities included in the Hancock County Raised Roadway at the elevation 11 protection level was constant at 7 feet, and the corresponding flows required varied from 78,994 to 263,913 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 150 horsepower pumps, to one having four 60-inch diameter pumps each running at 750 horsepower.

3.3.4.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.4.5.5 Construction Procedures and Water Control Plan

Construction would be done by heavy construction equipment after removal of structures and relocation of utilities. Water control will be addressed by constructing drainage facilities prior to construction of the levee.

3.3.4.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Boat access gates and power plants would require this level of security.

3.3.4.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Maintenance costs are included in this report.

3.3.4.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.4.6, Cost Summary. Construction costs for the various options are included in Table 3.3.4-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.4-2. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and

coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.4.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.4.6 Hancock County. Elevated Roadway. Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.4-1 and 3.3.4-2 below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.4-1.
Hancock Co Elevated Roadway Construction Cost Summary

Option	Total project cost
Option - Elevated Roadway	$328,000,000

Table 3.3.4-2.
Hancock Co Elevated Roadway O & M Cost Summary

Option	O&M Cost
Option A – Elevated Roadway	$3,831,000

3.3.4.7 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

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Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968.

Weather Bureau and USACE. 1956. National Hurricane Research Project Report No. 3, “Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers.

3.3.5 Harrison County, Elevated Roadway

3.3.5.1 General

Residential and business areas along the coast in Harrison County are susceptible to storm surge damage. A damage reduction option is to raise Highway 90 to elevation 16ft NAVD88 was evaluated. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center’s (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.5.2 Location

The location of Hwy 90 in Harrison County is shown below in Figure 3.3.5-1 extending from Biloxi Bay to Pass Christian.



Figure 3.3.5-1. Vicinity Map, Harrison County

3.3.5.3 Existing Conditions

In Harrison County, ground elevations over most of the residential and business areas vary between elevation 8-12 ft NAVD88 on the coast and rising within 1000 ft to elevation 30-36 along a ridge parallel to the coast line, then decreasing to the north. The 4-ft (blue), 8-ft (green), 20-ft (pink), 30-ft (dark blue) and 34-ft (gold) ground contours shown the pattern at the coastline for the county below in Figure 3.3.5-2.

A close-up near Keesler Air Force Base is shown below. The 4-ft(blue), 8-ft(dark green), 12-ft(light green), 16-ft(brown), 20-ft(pink), 24-ft(light purple), 28-ft (teal), and 32-ft (gold) ground contour lines are shown below in Figure 3.3.5-3.

The area is drained by natural and some improved channels. Above the ridge water drains to the north, thence to either the Back Bay of Biloxi on the east side of the county, or to the west to the St Louis Bay. South of the ridge, the water drains to Mississippi Sound.

Drainage from ordinary rainfall is hindered on occasions when either of the rivers in the area or the gulf is high, but impacts from hurricanes are devastating.

Damage from Hurricane Katrina in August, 2005 in the Pascagoula area are shown below in Figures 3.3.5-4 and 3.3.5-5. Many homes are still un-repaired, pending settlement of insurance claims.

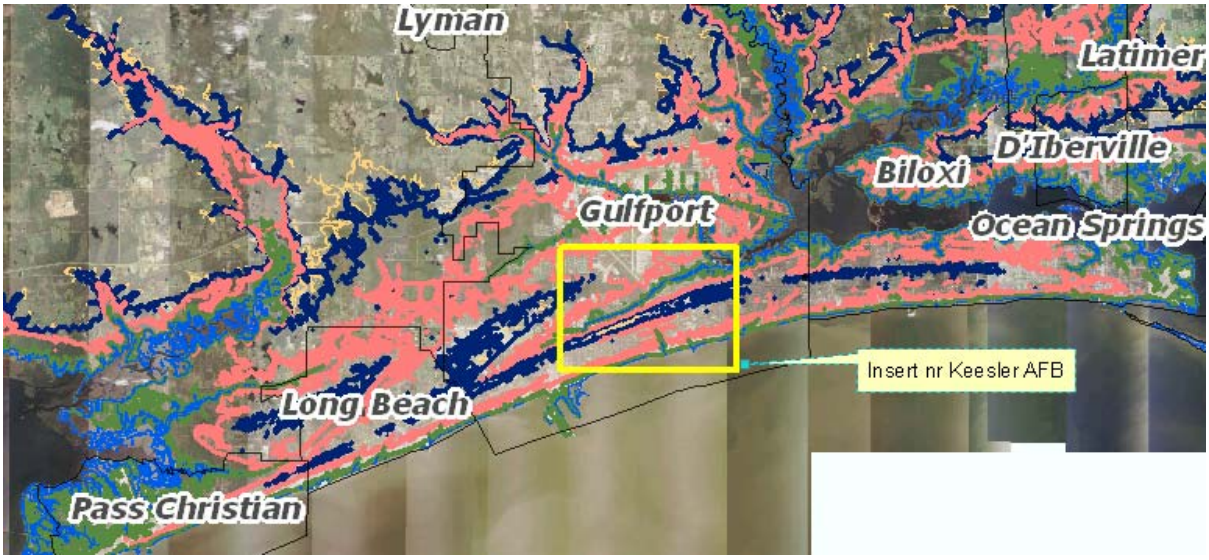


Figure 3.3.5-2. Existing Conditions, Harrison County

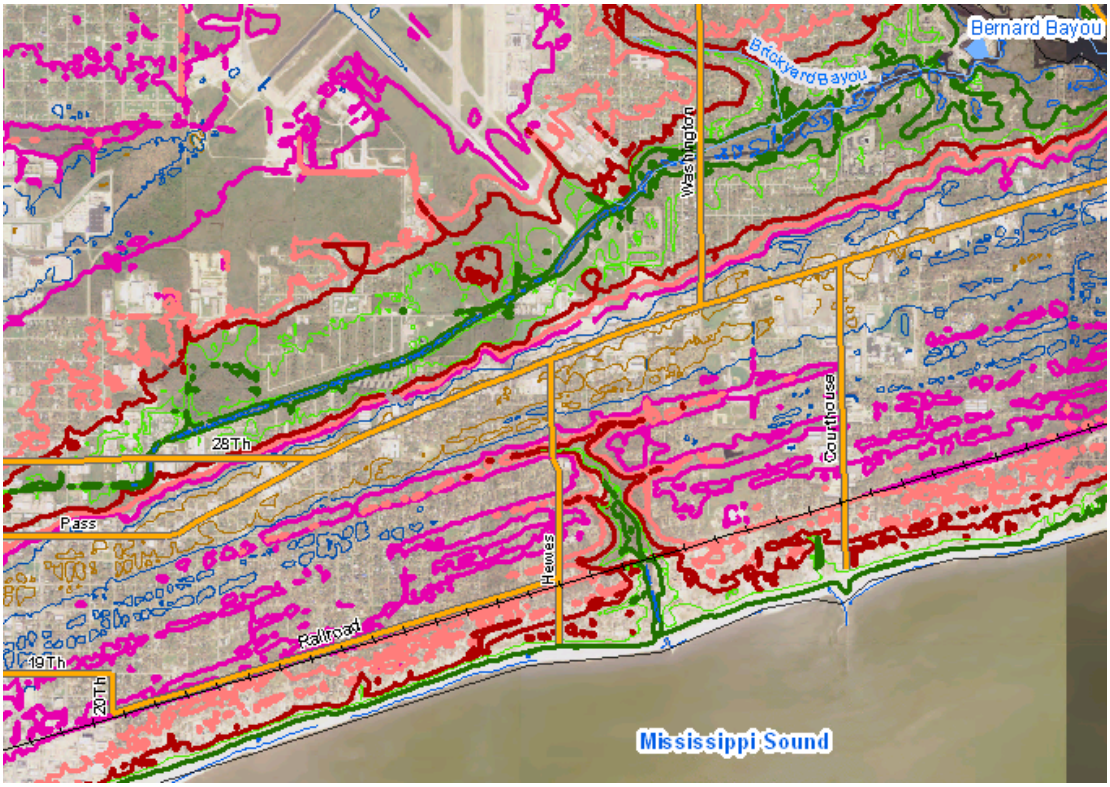
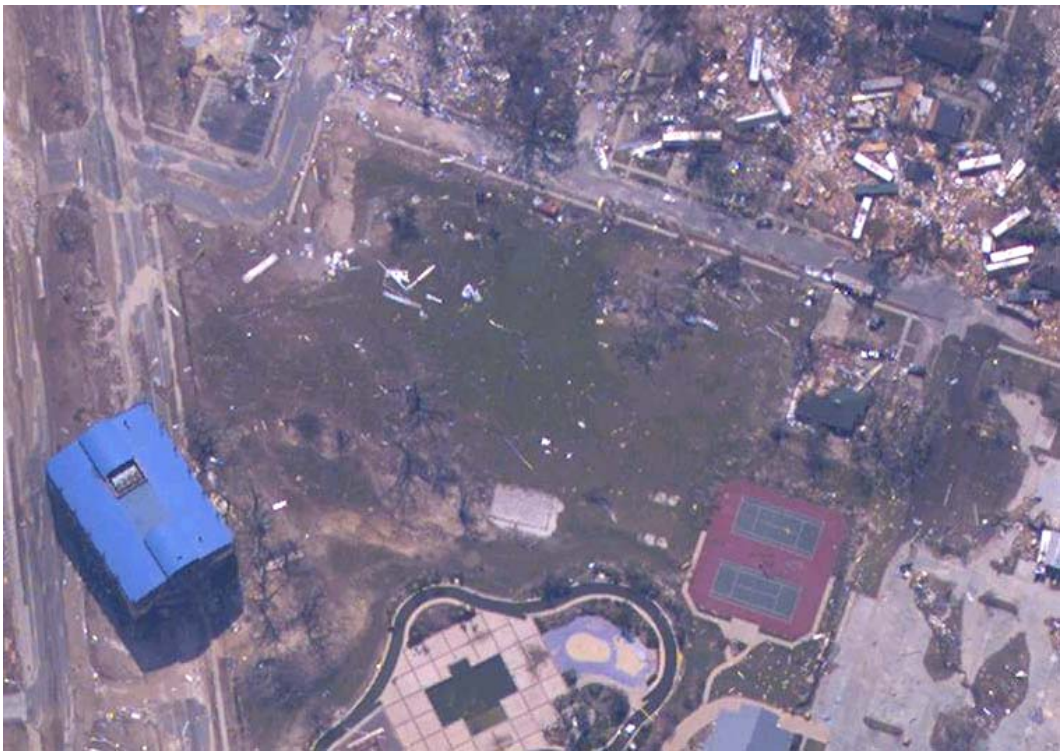


Figure 3.3.5-3. Existing Condition near Keesler AFB



Source : http://ngs.woc.noaa.gov/storms/katrina/24330924.jpg

Figure 3.3.5-4. Hurricane Katrina Damage, Harrison County



Source: danakay, http://www.flickr.com/photo_zoom.gne?id=45235550&size=m

Figure 3.3.5-5. Hurricane Katrina Damage, Harrison County

3.3.5.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the Katrina inundation limits are shown below in Figure 3.3.5-6 and 3.3.5-7. The data indicates the Katrina high water was as high as 21 ft NAVD88 Biloxi, and 28 ft NAVD88 at Pass Christian.

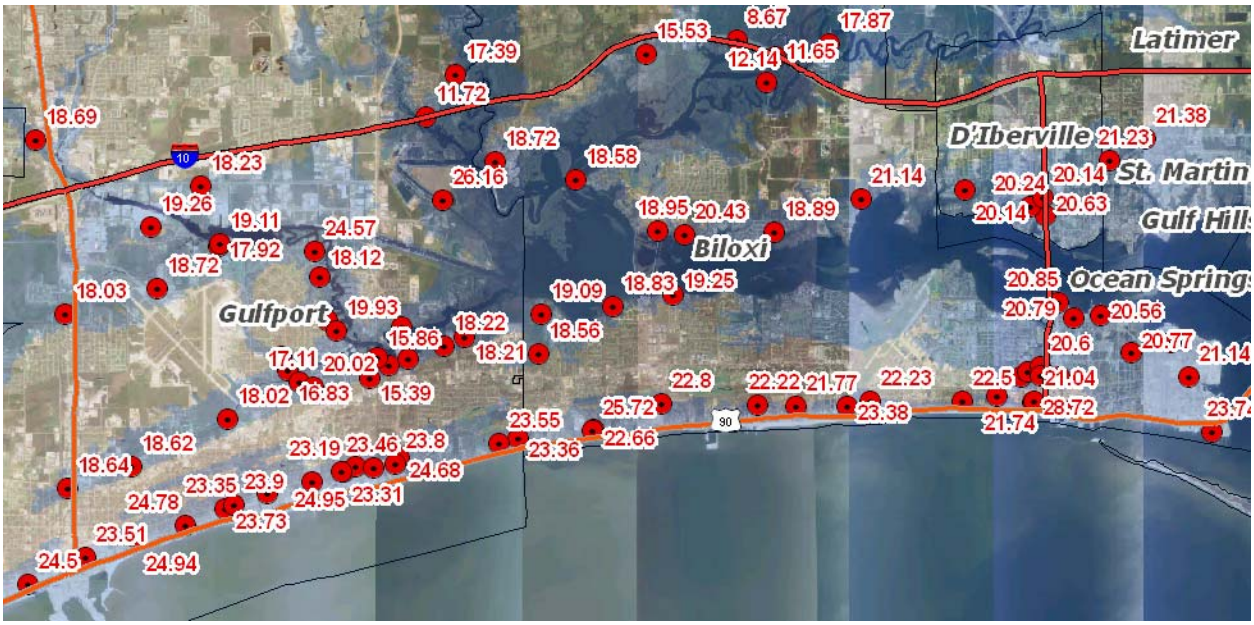


Figure 3.3.5-6. Katrina High Water Elevations, Harrison County

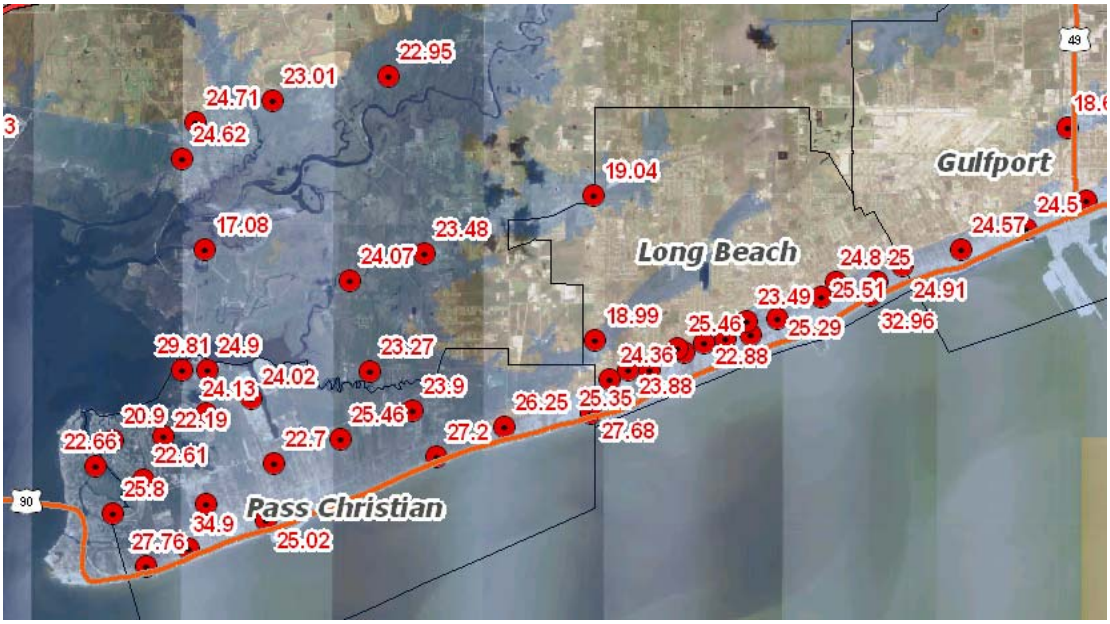


Figure 3.3.5-7. Katrina High Water Elevations, Harrison County

A closer view at the intersection of Hwy 90 and US Hwy 49 in Gulfport of existing flooding potential along Harrison County is shown below in Figure 3.3.5-8. Ground contours shown are 4-ft(blue), 8-ft(dark green), 12-ft(light green), 16-ft(brown), 20-ft(pink), 24-ft(light purple), 28-ft (teal), and 32-ft (gold).

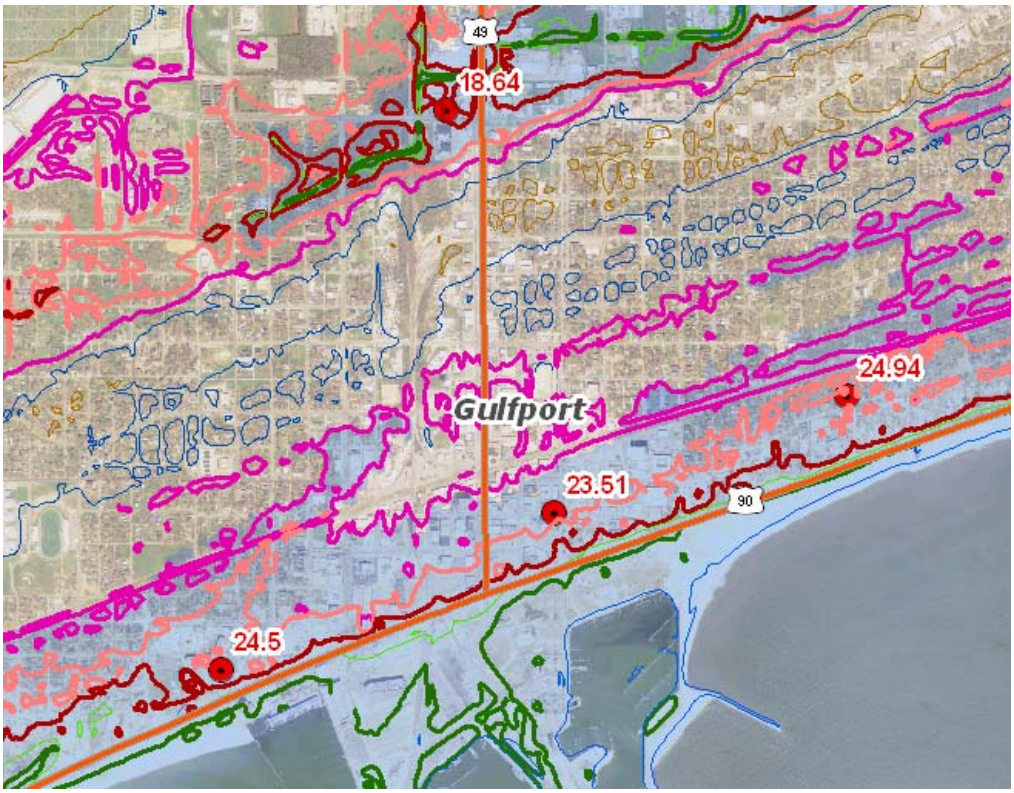


Figure 3.3.5-8. Ground Contours and Katrina High Water Elevations at Hwy 49

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near the coast in Harrison County at which data from hydrodynamic modeling was saved are shown below in Figures 3.3.5-9 and 3.3.5-10.

Existing Condition Stage –Frequency data for Save Point 50, just off the coast of Harrison County, is shown below as an example in Figure 3.3.5-11. The 95% confidence limits, approximately equal to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

3.3.5.5 Option – Elevate US Highway 90 to Elevation 16.0 ft NAVD88

This option consists of raising US Hwy 90 to elevation 16 ft NAVD88 along the coast of Harrison County as shown on the following Figures 3.3.5.12 through 3.3.5.15, along with the internal sub-basins and levee culvert/pump locations.

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown below on Figure 3.3.5-16.



Figure 3.3.5-9. Hydrodynamic Modeling Save Points in Harrison County



Figure 3.3.5-10. Hydrodynamic Modeling Save Points in Harrison County

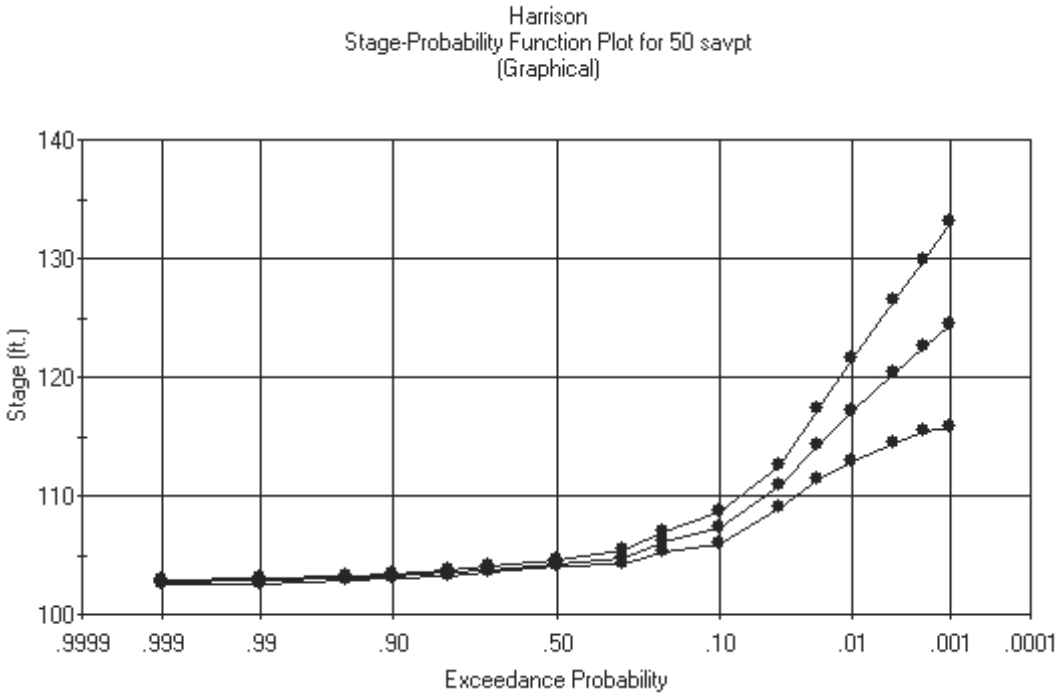


Figure 3.3.5-11. Existing Conditions at Save Point 50, near Pass Christian, MS



Figure 3.3.5-12. Pump/Culvert/Sub-basin Site Locations, Harrison County



Figure 3.3.5-13. Pump/Culvert/Sub-basin Site Locations, Harrison County



Figure 3.3.5-14. Pump/Culvert/Sub-basin Site Locations, Harrison County

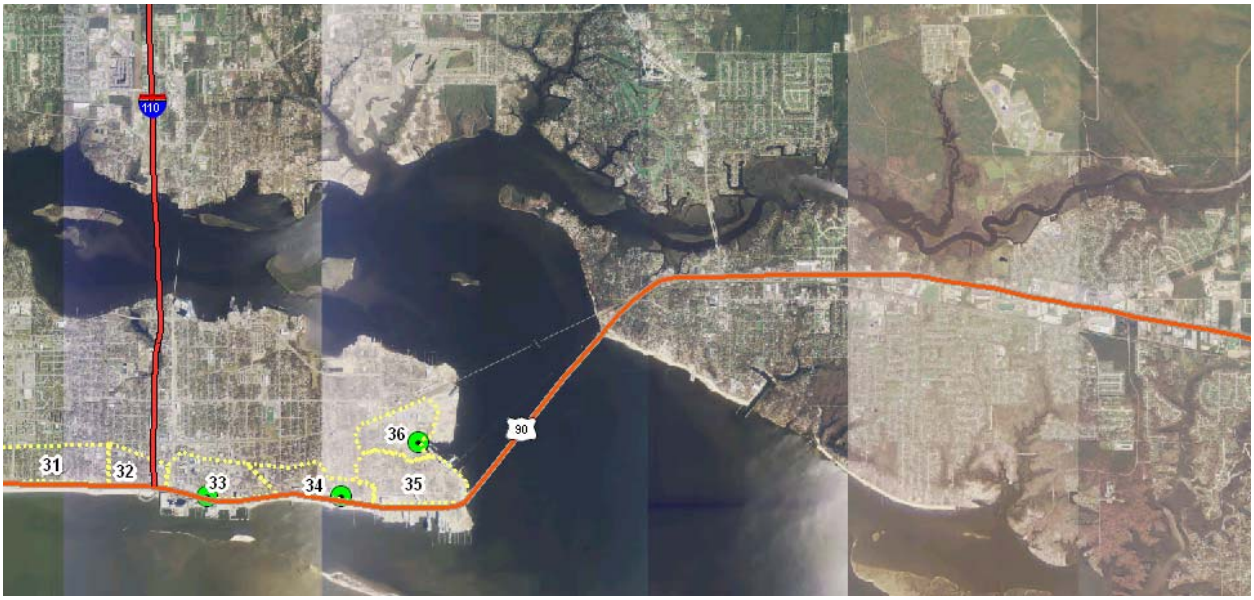


Figure 3.3.5-15. Pump/Culvert/Sub-basin Site Locations, Harrison County



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.5-16. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown on Figure 3.3.5-17, below was caused by approximately 1-2 ft of overtopping crest depth.



Source: ERDC, Steven Hughes

Figure 3.3.5-17. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown above in Figure 3.3.5-18, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

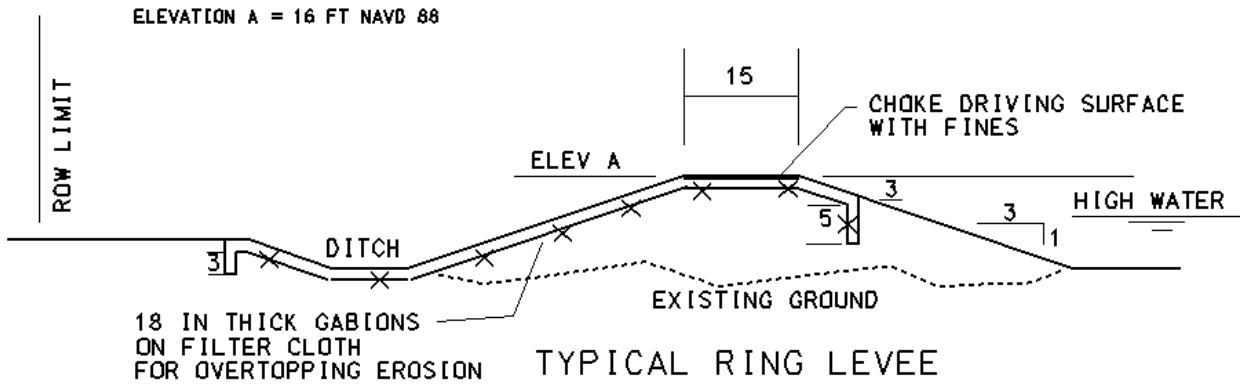


Figure 3.3.5-18. Typical Section at Ring Levee

3.3.5.5.1 Interior Drainage

Drainage on the interior of the raised highway would be collected at the highway and channeled to culverts placed at locations shown above. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.5-19.

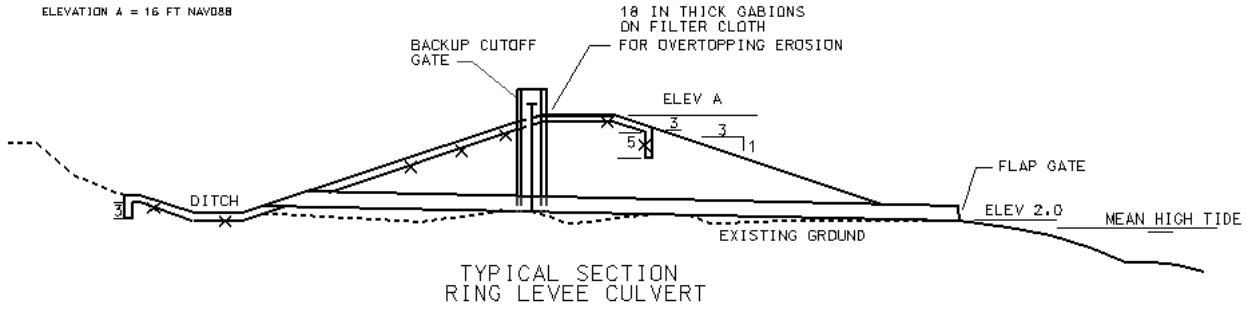


Figure 3.3.5-19. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

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3.3.5.5.3 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 15 pumping facilities included in the Harrison County Raised Roadway at the elevation 16 protection level was constant at 7 feet, and the corresponding flows required varied from 39,945 to 515,258 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 475 horsepower pumps, to one having six 60-inch diameter pumps each running at 1000 horsepower.

3.3.5.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.5.5.5 Construction Procedures and Water Control Plan

Construction would be done by heavy construction equipment after removal of structures and relocation of utilities. Water control will be addressed by constructing drainage facilities prior to construction of the levee.

3.3.5.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would

possess the highest threat level of all the critical assets. Boat access gates and power plants would require this level of security.

3.3.5.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Maintenance costs are included in this report.

3.3.5.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.5.6, Cost Summary. Construction costs for the various options are included in Table 3.3.5-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.5-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.5.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.5.6 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.5-1 and 3.3.5-2 below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.5-1.
Harrison Co Elevated Roadway Construction Cost Summary

Option	Total project cost
Option - Elevated Roadway	$1,989,200,000

Table 3.3.5-2.
Harrison Co Elevated Roadway O & M Cost Summary

Option	O&M Cost
Option A – Elevated Roadway	$19,586,000

3.3.5.7 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

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Environmental Science Services Administration. 1968. “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968.

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3.3.6 Forrest Heights Levee, City of Gulfport, Harrison County

3.3.6.1 General

The culturally historical Forest Heights residential community in the City of Gulfport, Harrison County, Mississippi, has frequently been inundated by flood waters due to storm surges from the Mississippi Sound and from inland flooding along the lower Turkey Creek. Water reached a depth of 2-8 ft over the entire community during Hurricane Katrina inundation. The Forest Heights levee is proposed to be constructed as a pilot project for the MsCIP comprehensive plan. The levee will address the combination of storm surge protection, inland flooding protection, and evacuation. The levee is intended to be constructed to a height such that the levee might be certified under the National Flood Insurance Program. A preliminary engineering analysis suggests a levee built to approximately elevation 21 feet NAVD ’88 would satisfy or exceed certification elevation criteria.

Engineering performance and economic evaluations of protection options were done using the Hydrologic Engineering Center’s (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA. HEC-FDA modeling was done using variations in with-project conditions compared to the future without-project conditions for the Turkey Creek study. Details regarding the methodology are presented in the Economic Appendix. Additional evaluation to determine the precise levee height will be performed during final engineering and design based upon analyzing the risk and uncertainty associated with the coincident occurrence of inland flooding and storm surge impacts.

3.3.6.2 Location

The Forrest Heights community is located in an area known as North Gulfport within the City of Gulfport on the Mississippi Gulf Coast. The location of the levee at Forrest Heights is shown below in Figures 3.3.6-1 and 3.3.6-2. The community lies along the lower Turkey Creek floodplain, which has a tendency to frequently exceed its stream channel capacity and flood adjacent low-lying areas.

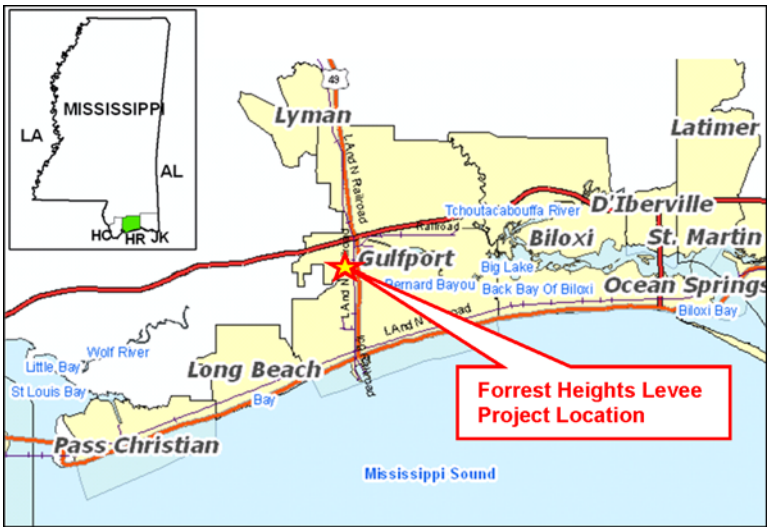


Figure 3.3.6-1. Vicinity Map

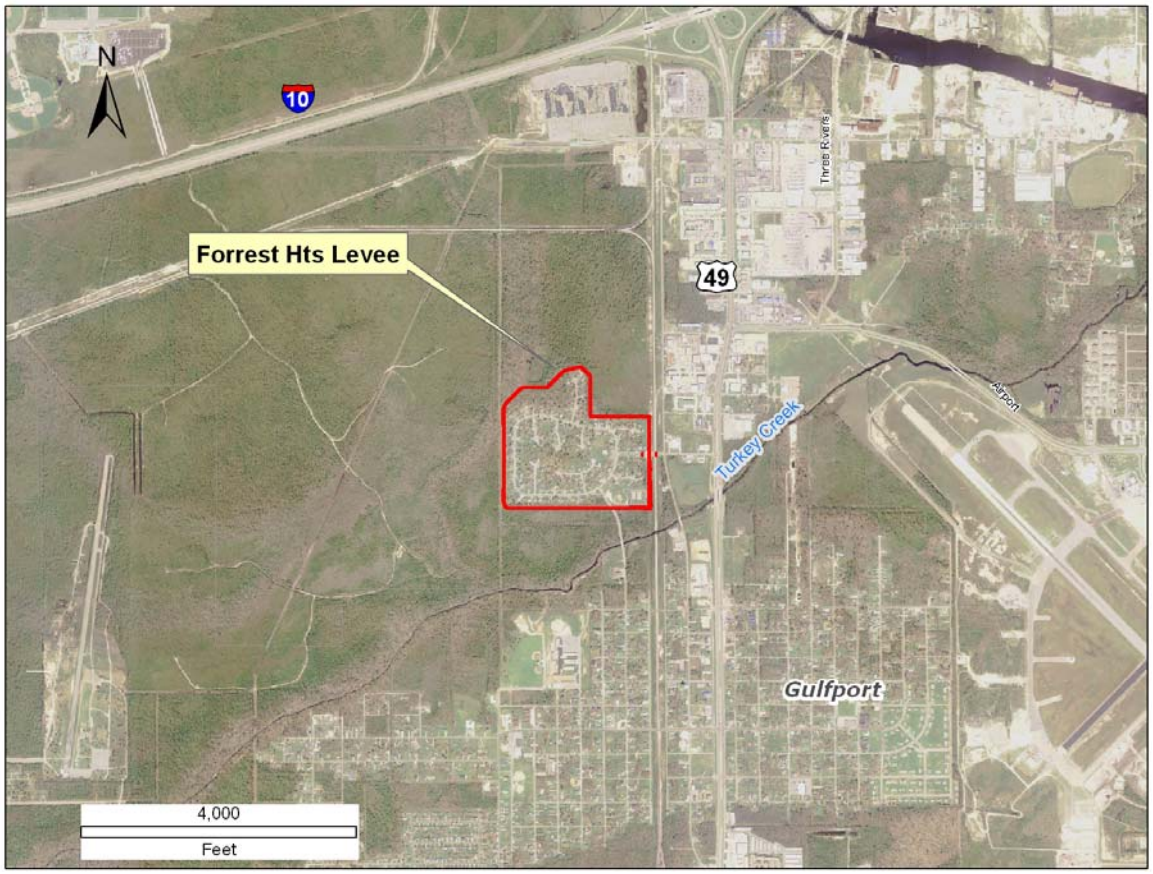


Figure 3.3.6-2. Forrest Heights Ring Levee Location

3.3.2.3 Existing Conditions

The community of Forrest Heights lies on the bank of Turkey Creek about 2.6 miles from the mouth at Bernard Bayou. Ground elevations over most of the residential area are between elevations 10-14 ft NAVD88. Drainage is mostly along streets and through natural drainage ways to the Turkey Creek. Impacts from flooding and hurricanes have been devastating. Hurricane Katrina in August, 2005 resulted in significant flood damages to residences in the Forrest Heights community. A levee with top width of 6 ft was constructed around the community to elevation 16.5 ft NGVD with sideslopes of 1 vertical to 1.5 horizontal in 1969, prior to Hurricane Camile. It has not had adequate maintenance and is a state of disrepair. It is scheduled to be restored to as-built condition by January of 2009. However, the restored levee will not be sufficient to meet the present day standard for certification according to the existing FEMA flood profiles in the vicinity. It is assumed that the as-built condition of this restored levee will be the existing condition for this report.

3.3.6.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), 20-ft(orange), and 20-ft(pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.6-3. The data indicates the water was as high as 18-20 ft NAVD88 near the site, totally inundating the entire area.

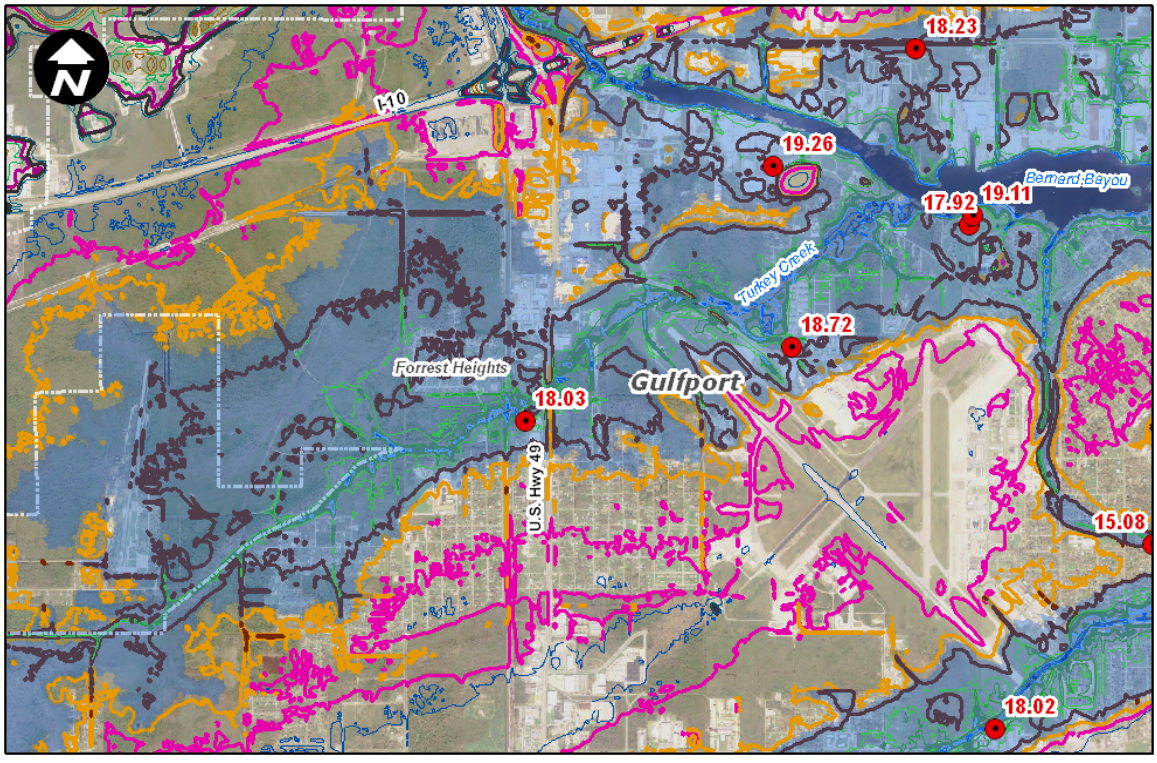


Figure 3.3.6-3. Hurricane Katrina Inundation and High Water, Forrest Heights

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical coastal tide gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area. An expanded description of the procedure is presented in Section 2.13 of the

Engineering Appendix and in the Economic Appendix. Points near Forrest Heights at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.6-4, and the stage frequency curve for that location is shown in Figure 3.3.6-5. Hydrodynamic output stage-frequency pairs, with uncertainty, are displayed in Table 3.3.6-1.

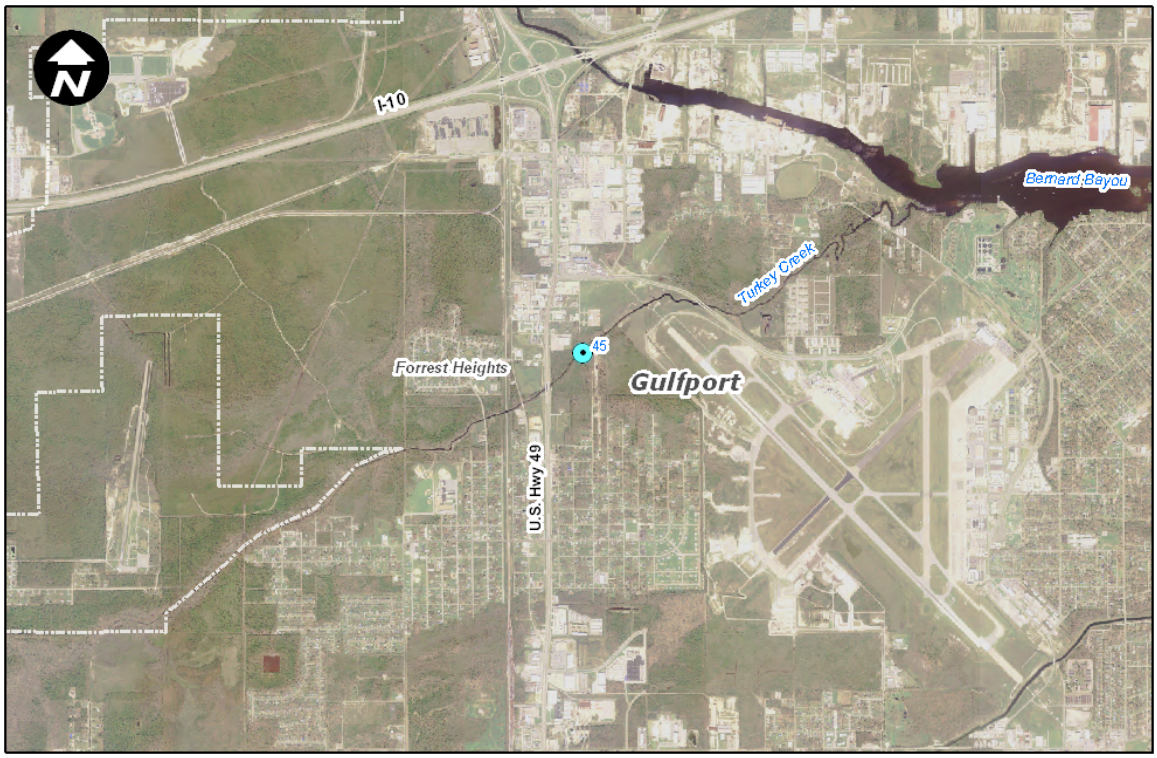


Figure 3.3.6-4. Hydrodynamic Modeling Save Point near Forrest Heights

It should be noted that the frequency curve reflects only that flooding resulting from storm surge in the gulf. The Forrest Heights community is also subject to riverine flooding by Turkey Creek. The preliminary FEMA Harrison County Flood Insurance Study (FIS) dated November 2007 provides computed Turkey Creek flood profiles which appear to have been adjusted for the effects of coincident surge in Back Bay of Biloxi. Table 3.3.6-2 shows relevant discharge and stage information from the FIS for Turkey Creek at Ohio Avenue, the southern entrance to the Forrest Heights community. In comparison to the preliminary FEMA Flood Insurance Study dated November 2007, which is based on contemporary (post-Katrina) FEMA contractor hydrodynamic modeling, the ERDC frequency curve, which is based on surge alone, suggests a lower stage associated with the annual one in one hundred chance (0.01 exceedance probability) event.

Figure 3.3.6-6 shows a portion of the preliminary Harrison County Flood Insurance Rate Map in the vicinity of Forrest Heights. Low-lying peripheral areas of the neighborhood are shown in a shaded blue field as being in the 1% annual chance ('100-yr') regulatory floodplain, with the remainder of the community occupying a shaded Zone X field, being areas subject to shallow flooding at annual probabilities of occurrence between 0.02 (2%) and 0.01 (1%).

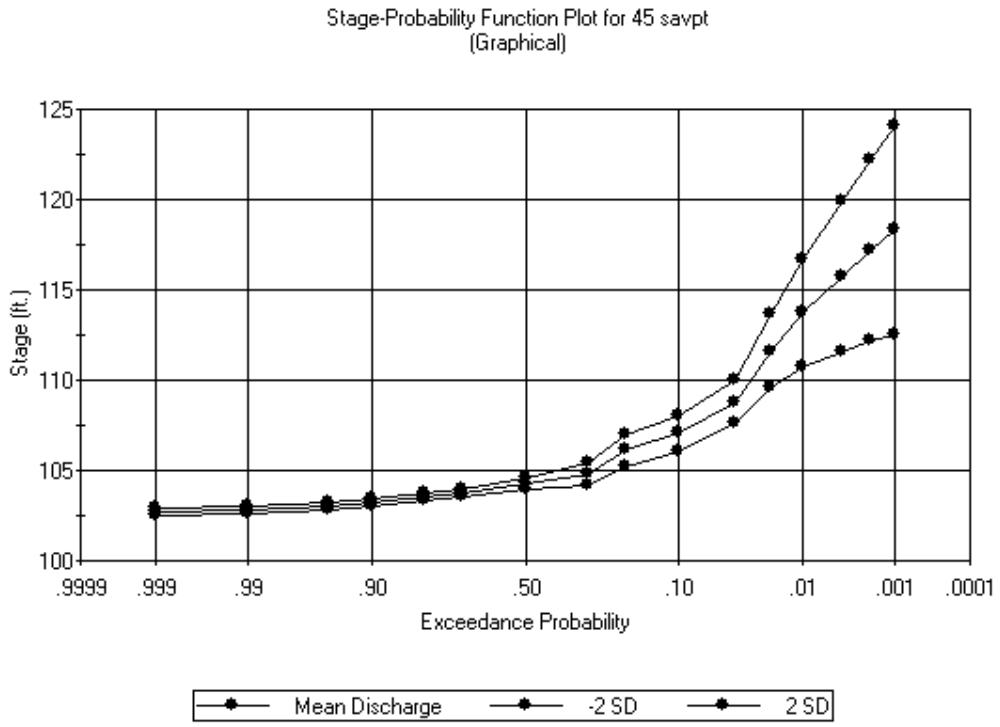


Figure 3.3.6-5. Surge-only Stage Frequency Curve, Vicinity of Forrest Heights

Table 3.3.6-1.
Surge Stage-Probability and Uncertainty

Annual Probability	Stage (Ft. NAVD88)	Standard Deviation (Feet)
0.04	8.8	0.6
0.02	11.6	1
0.01	13.7	1.5
0.002	17.2	2.5
0.001	18.3	2.9

Table 3.3.6-2.
Turkey Creek Flood Stages at Ohio Avenue, Harrison County FIS

Exceedance Probability	Discharge (cfs)	Stage (ft. NAVD '88)
0.1	2600	12
0.02	3650	14.2
0.01	5500	15.5
0.002	7950	18.3

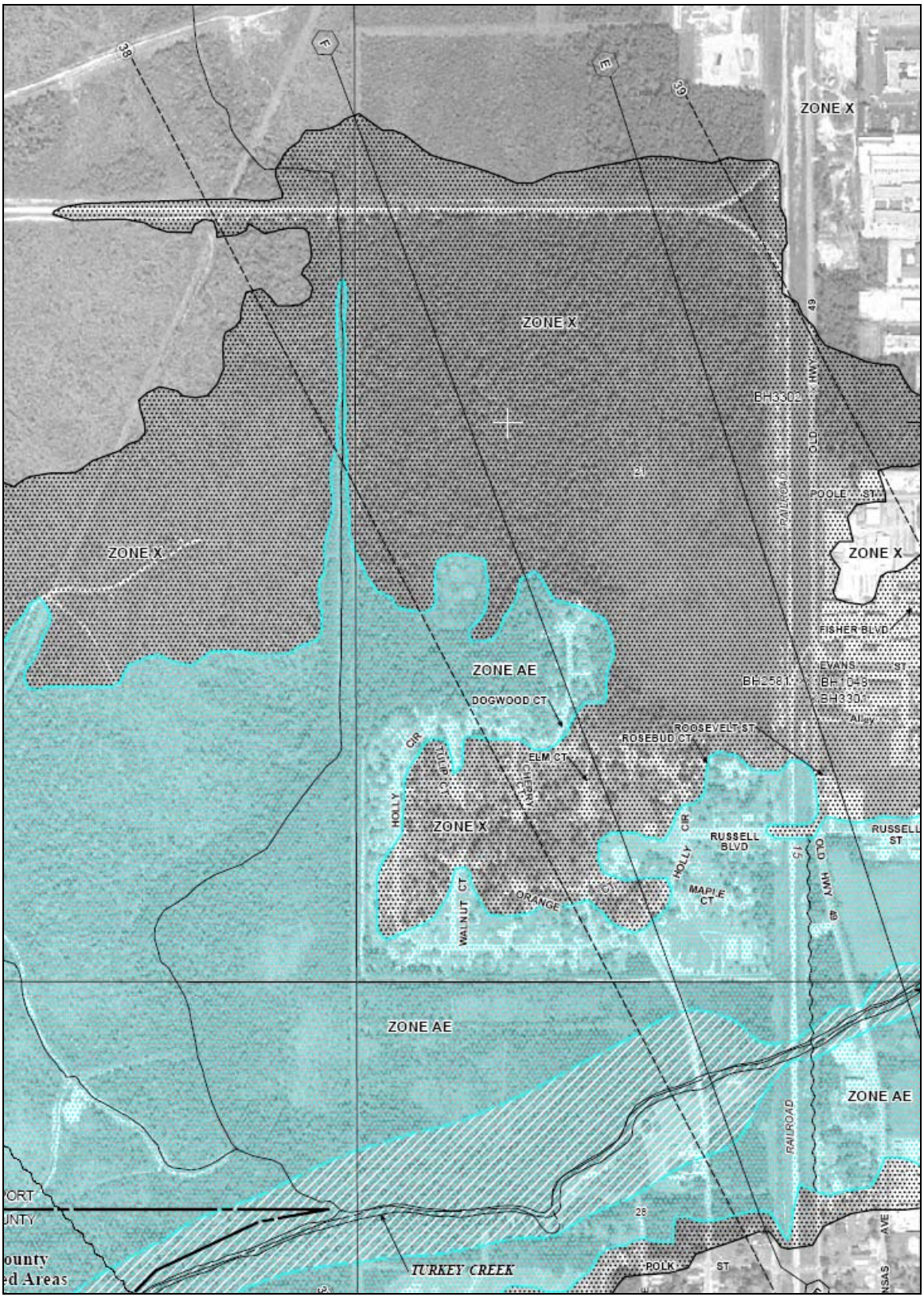


Figure 3.3.6-6. Preliminary FEMA Flood Insurance Rate Map, Vicinity of Forrest Heights

Hydraulic data was developed for use in the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) program. The HEC-FDA program uses risk-based analysis methods for evaluating flood damage and flood damage reduction alternatives. The program relies on hydrologic, hydraulic, and economic data input. Uncertainties in these data are input and used by the model for computing annual damages. Version 1.2.3b dated August 2007 was used. As described in chapter 2 of this appendix, this is a customized version of the current official release version 1.2 dated March 2000. This section describes the model's hydrologic and hydraulic input as applied to the Forrest Heights community. The Economic appendix describes the economic input and results. The Main Report describes how the model output was examined and used in the plan formulation process.

Forrest Heights is subject to both riverine and surge flooding. For this reason, a discharge-frequency curve and a stage-discharge relationship (also known as a 'rating curve') were developed for input into the HEC-FDA model. The discharge-frequency curve was computed in FDA using synthetic statistics using the 0.5-, 0.1-, and 0.01 annual exceedance probability discharges from the preliminary Harrison County FIS (see Table 3.3.6-2). The version of FDA used extends the stage frequency curve to the 0.999 and 0.0001 annual exceedance values. Uncertainty about the discharge-frequency curve was computed by the FDA program assuming an equivalent period of record. Sensitivity analysis of discharge uncertainty with respect to the equivalent period of record was conducted. Interpretation of the standard error and apparent period of record of the underlying hydrologic information used to develop the FIS discharge values versus discharge uncertainty computed by the FDA program suggested that an equivalent period of record of 20 years provided a reasonable preliminary estimate of uncertainty of discharge in the un-gaged stream. The resultant discharge-frequency curve and curves at the 5% and 95% confidence limits are shown below in Figure 3.3.6-7 and the values are shown in Table 3.3.6-3. These relationships are representative in the vicinity of Ohio Avenue.

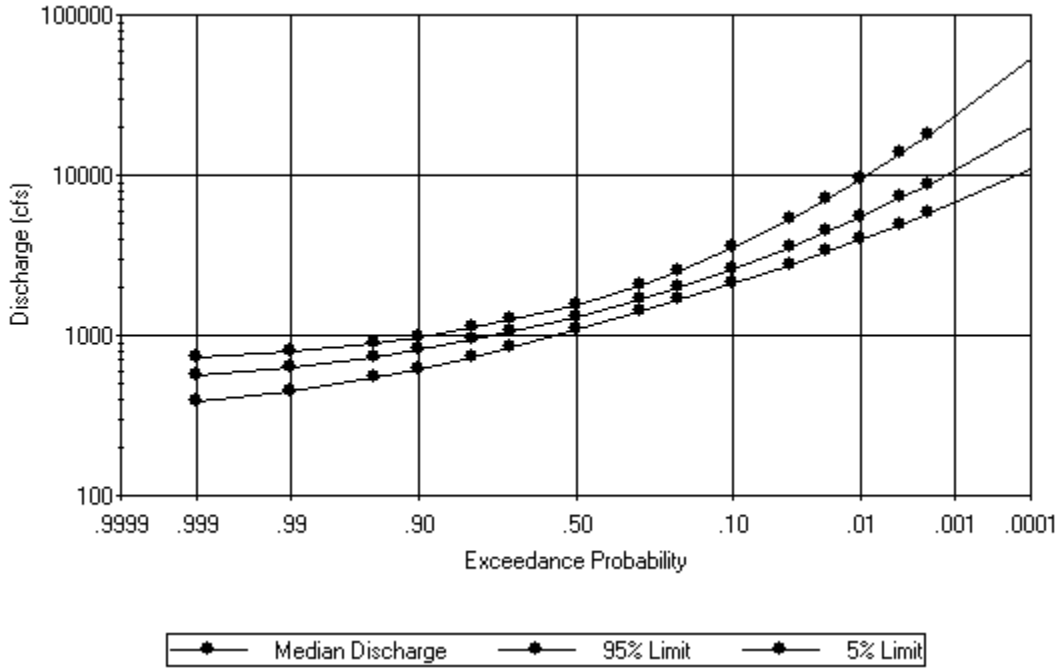


Figure 3.3.6-7. Computed Discharge-Frequency Curve, Turkey Creek at Ohio Avenue.

Table 3.3.6-3.
Discharge-Frequency, Turkey Creek at Ohio Avenue

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves			
		Discharge (cfs)			
		95%	75%	25%	5%
0.9990	563	383	458	660	720
0.9900	634	447	525	733	795
0.9500	735	542	622	839	904
0.9000	811	614	696	918	986
0.8000	932	731	814	1,044	1,118
0.7000	1,045	840	924	1,165	1,245
0.5000	1,300	1,081	1,167	1,443	1,548
0.3000	1,678	1,412	1,511	1,882	2,051
0.2000	1,995	1,669	1,785	2,274	2,522
0.1000	2,601	2,118	2,281	3,066	3,515
0.0400	3,563	2,770	3,027	4,411	5,296
0.0200	4,449	3,330	3,684	5,716	7,104
0.0100	5,500	3,961	4,439	7,334	9,428
0.0040	7,211	4,935	5,625	10,093	13,561
0.0020	8,771	5,778	6,671	12,723	17,655
0.0001	19,704	11,042	13,464	33,224	52,792

The stage-discharge curve was developed by fitting an equation of the form $H = CQ^a$ (H = water surface elevation; Q is discharge; C and a determined by regression) through the Turkey Creek stage at cross section F as shown on the Turkey Creek Flood Profile, Plate 83P, of the preliminary FIS. The profile plate shows this location to have been adjusted for coincident probability of surge. The equation thus developed was used to extend the rating curve through a broader range of discharges than represented on the flood profiles. Uncertainty about the rating curve was assumed to be 1.5 feet at the 10-year and higher discharges based on FIS hydraulic modeling techniques and assuming a poor historic hydrologic data record (Turkey Creek is ungaged). The rating curve is shown in Figure 3.3.6-8.

3.3.6.4.1 Engineering Performance

Project engineering performance was computed using HEC-FDA. Engineering performance was computed for the existing and future without project conditions; and a variety of existing and future with-project conditions. Performance was computed with risk and uncertainty. The base year was assumed to be 2012, and the future year was assumed to be 2061 (50 year period of analysis). Scenarios were also evaluated assuming (a) existing sea level, (b) expected sea level rise, and (c) high sea level rise.

The existing condition assumes that the NRCS has reconstituted their levee around the Forest Heights community to a crest elevation of 16.5 feet. The existing and future hydrologic and hydraulic conditions are presumed to be as represented by the FIS hydrology and flood profiles with uncertainty. Typically, one would consider increasing future flood discharges to account for possible increases in runoff due to development and urbanization. However, in this case, the underlying FIS hydrologic information is dated, being circa 1976, and subsequent studies have suggested that the effective tributary drainage area in this relatively flat and undifferentiated portion of the Turkey Creek watershed is less than the 25 or so square miles attributed to the creek at the location of Forest Heights. The existing hydrology is most likely conservative, and revisions downward for an un-gaged stream seem ill-advised. Additionally, the area in question benefits from an updated and contemporary FIS, where the Turkey Creek profiles have been adjusted for coincident surge

elevations, and the floodplain has been re-mapped accordingly. In the end, it seems advisable to rely on the existing FIS profiles and hydrology for conservative results.

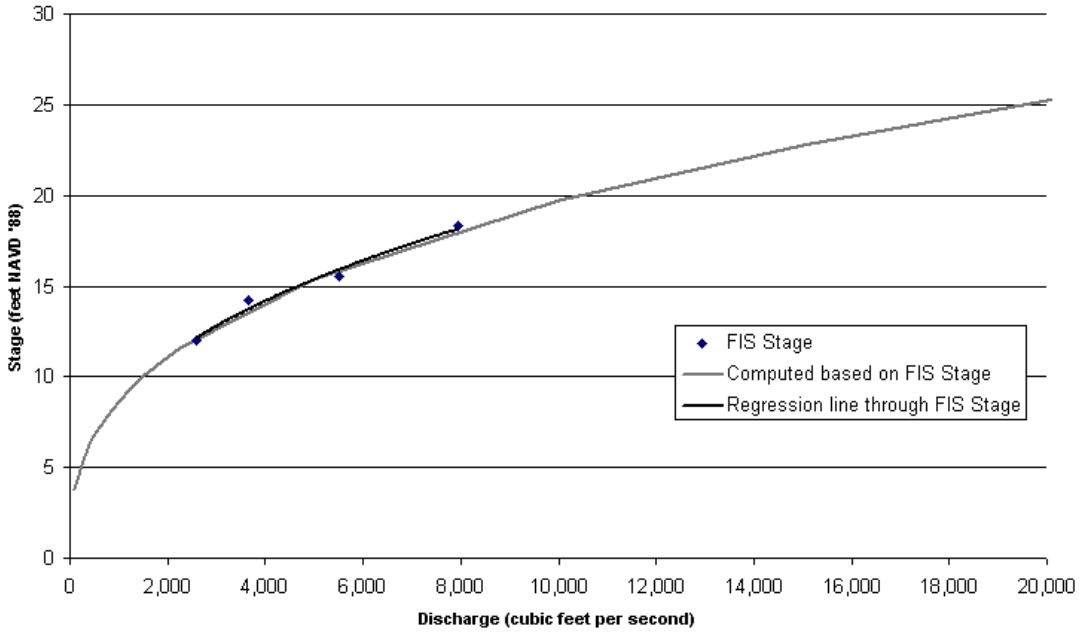


Figure 3.3.6-8. Computed Rating Curve, Turkey Creek at Ohio Avenue.

With-project conditions were evaluated for levees with crest elevations of 17 and 21 feet. The existing with-project condition assumes clearing and snagging of debris in Turkey Creek will counteract any local water surface profile impact due to flow obstruction by the levee. Future with-project conditions assume that the channel maintenance has been neglected, and thus the rating curve at Ohio Avenue is shifted upwards by 0.3 feet,

Performance was also evaluated assuming a levee built to the local Base Flood Elevation (BFE, the regulatory one in one hundred annual chance ('100-year') water surface elevation plus three feet. Historically, FEMA required levees to be built to the BFE plus three feet for certification. This condition no longer in and of itself satisfies certification criteria, which now requires that risk and uncertainty also be considered, as illustrated in Figure 3.3.6-9. This condition was evaluated for the purposes of levee certification. Assuming the BFE is defined by the FIS water surface elevation at Ohio Avenue as described on the FIS Turkey Creek Flood Profile, this elevation is 15.5 feet plus 3 feet, or elevation 18.5 feet.

Forest Heights occupies a small fringe of the floodplain, and the FDA simulations assume that when the levee is overtopped, the interior floods to the exterior flood elevation.

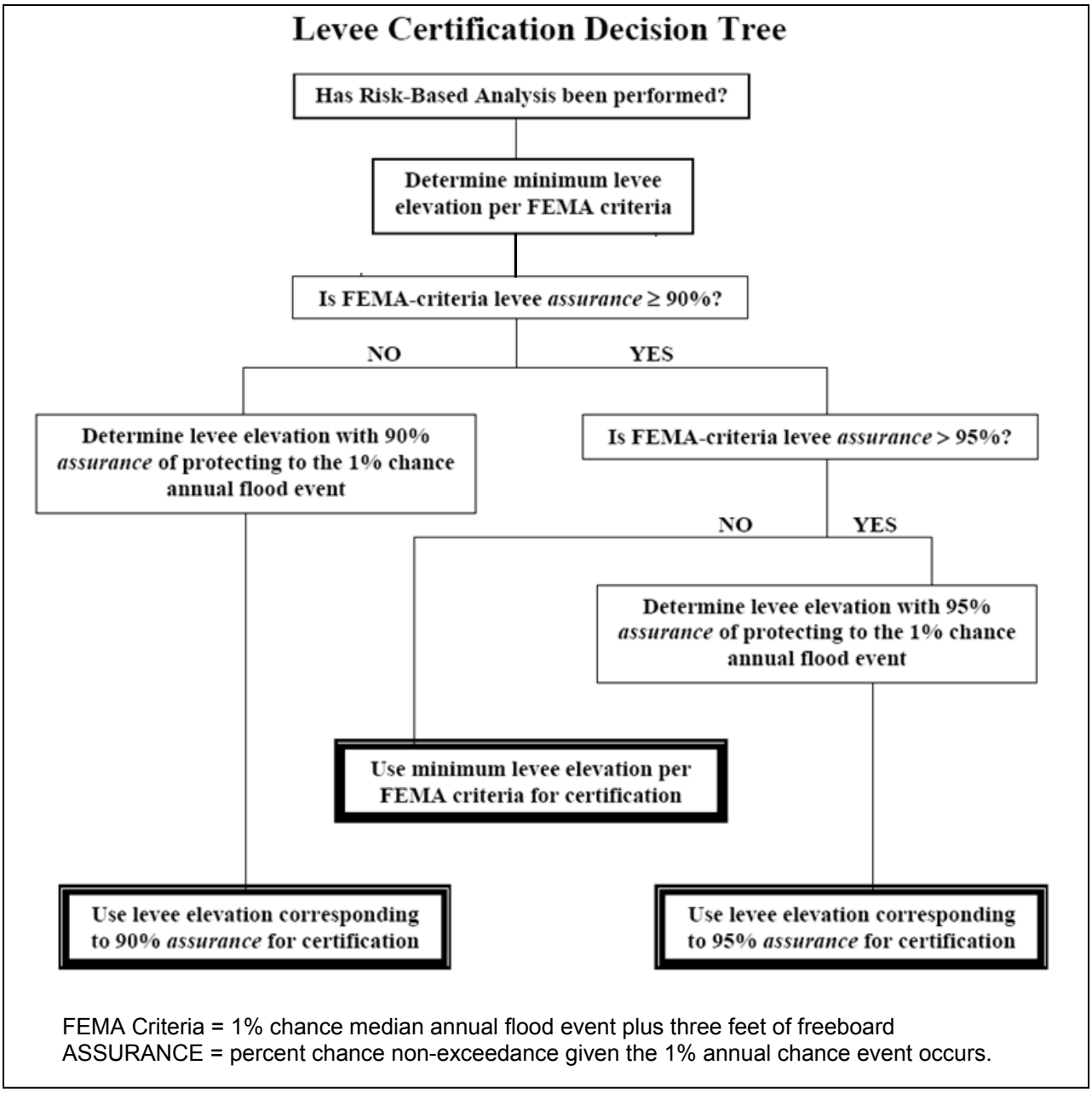


Figure 3.3.6-9. USACE Levee Certification Decision Tree, circa 2007

3.3.6.4.2 Performance Results

Engineering performance results as computed by HEC-FDA are shown in Figure 3.3.6-10. Base year 2012 results are the same regardless of the sea level scenario and are thus only reported once. Note that 'without project' implies that an NRCS levee built to elevation 16.5 feet.

In this, and similar tables, the median target stage describes the probability each year of the water surface elevation exceeding the levee crest elevation according to the best estimates of the discharge frequency curve and rating curve (i.e. uncertainty is not accounted for). The expected

annual exceedance probability takes discharge-frequency and stage-frequency into account when estimated the annual probability of exceeding the levee crest.

Long term risk describes the probability that the water surface would exceed the levee crest elevation in the specified time period. For example, according to these calculations, there is a 32.3 percent change that the NRCS levee (aka 'without project) elevation would be equaled or exceeded in a 30 year period. The expected probability is used in estimating long term risk.

The conditional non-exceedance probability describes the probability, given the occurrence of some event, that the levee crest elevation would not be exceeded. For example, given the occurrence of the 1% annual water surface elevation, there is about a 55% chance that the levee would not be overtopped. Discharge and stage uncertainty is accounted for in this computation.

Figure 3.3.6-10 shows that the FEMA criteria levee at elevation 18.5 feet provides an assurance at 78.9%, which is less than 90%. With respect to the levee certification decision tree shown in Figure 3.3.6-9, and according to these analyses, the minimum certifiable levee elevation is that elevation corresponding to 90% assurance (i.e. conditional non-exceedance probability). The el. 21 feet levee is the only levee evaluated that exceeds the required assurance (92.9% base year, 91.9% future year). Sensitivity analysis shows that the 90% assurance levee crest elevation is approximately 20.2 feet NAVD '88.

Note that crest elevation is not the sole determinant for levee certification; amongst other things, the levee must be properly constructed of sound material; the levee must be properly maintained by the owner; and interior flooding must be properly accounted for. Levee certification may be reconsidered over time as physical conditions change. For example, Figure 3.3.6-10 shows that, all else remaining the same, if sea level rises one foot in 50 years, a levee built to elevation 21 feet would provide an assurance of 87.4 percent, and the probability that it would be overtopped in a 50 year time frame would change from 11.6% to 16.9%. The point here is that, as the environment changes, the benefits of investments change.

Engineering analyses for sufficiently demonstrating a certifiable levee will be carried forward in the planning, engineering, and design phase of this project.

3.3.6.5 Option A - Elevation 17 ft NAVD88

This option consists of an earthen dike around the Forrest Heights community as shown on the following Figure 3.3.6-11, along with the levee culvert/interior pump/detention location. The earth dike will be trapezoidal in shape with a 12-foot top width with one foot vertical to three foot horizontal slopes on both sides (1H:3V). For this option the two existing roadway entrances will be ramped over the restored levee. The total length of the levee will be approximately 7900 feet.

Levees reduce the storage capacity and overbank flow conveyance of the adjacent floodplain. The reductions in overbank flow area could induce higher water levels upstream. An HECRAS model was used to evaluate the potential for induced damages and solutions. The modeling indicates that selective clearing and snagging would prevent increases in water surface elevations upstream that would occur due the placement of the levees in the floodplain.

The selective clearing and snagging would extend for approximately 4.5 miles from the mouth of Turkey Creek at Bernard Bayou to the upstream limits as shown in Figure 3.3.6-12. Selective clearing and snagging would remove obstructions such as debris dams and excessive sedimentation that hinders the flow through the Turkey Creek channel. While the selective clearing and snagging component of the plan does not eliminate flooding along Turkey Creek, the plan does reduce flood damages along the creek and at the upper end of the canals at 28th Street. The main purpose of the

selective clearing and snagging is to make sure that induced damages do not occur due to the construction of the levee.

Note: FEMA Base Flood Elevation at FIS x-section F, Turkey Ck. at Ohio Avenue, is 15.5 feet. Levee height then for "FEMA plue 3 ft" plan is 15.5 ft. + 3 ft. = 18.5 feet NAVD '88. FIS: Harrison County FIS, Preliminary, dated 15 November 2007.

Forrest Heights Project Performance
by Plans and Damage Reaches by Analysis Year 2012
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probability = 0.01
Residual Damage = 5.00 %

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
					Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Without	Harrison Stream	12	Forrest Heights Reach	levee	0.0064	0.0155	0.1447	0.3235	0.5424	0.9901	0.8957	0.7398	0.5493	0.3239	0.1998
17-FT Levee	Harrison Stream	12	Forrest Heights Reach	levee	0.0047	0.0123	0.1160	0.2654	0.4603	0.9950	0.9281	0.7978	0.6227	0.3894	0.2518
21-FT Levee	Harrison Stream	12	Forrest Heights Reach	levee	0.0006	0.0022	0.0218	0.0536	0.1043	1.0000	0.9976	0.9792	0.9290	0.8024	0.6715
FEMA plus 3 ft	Harrison Stream	12	Forrest Heights Reach	levee	0.0022	0.0063	0.0610	0.1456	0.2699	0.9995	0.9784	0.9114	0.7890	0.5725	0.4118

Forrest Heights Project Performance
by Plans and Damage Reaches by Analysis Year 2061
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probability = 0.01
Residual Damage = 5.00 %

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
					Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Without	Harrison Stream	12	Forrest Heights Reach	levee	0.0064	0.0155	0.1447	0.3235	0.5424	0.9901	0.8957	0.7398	0.5493	0.3239	0.1996
17-FT Levee	Harrison Stream	12	Forrest Heights Reach	levee	0.0057	0.0139	0.1305	0.2951	0.5030	0.9934	0.9127	0.7661	0.5819	0.3503	0.2202
21-FT Levee	Harrison Stream	12	Forrest Heights Reach	levee	0.0007	0.0025	0.0244	0.0599	0.1163	1.0000	0.9968	0.9752	0.9191	0.7827	0.6454
FEMA plus 3 ft	Harrison Stream	12	Forrest Heights Reach	levee	0.0025	0.0071	0.0689	0.1636	0.3004	0.9992	0.9724	0.8954	0.7611	0.5386	0.3789

Forrest Heights Project Performance
by Plans and Damage Reaches by Analysis Year 2061
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probability = 0.01
Residual Damage = 5.00 %

Expected Sea Level Rise, 1.0 feet

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
					Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Without	Harrison Stream	12	Forrest Heights Reach	levee	0.0126	0.0257	0.2289	0.4779	0.7274	0.9640	0.7926	0.5888	0.3905	0.1996	0.1118
17-FT Levee	Harrison Stream	12	Forrest Heights Reach	levee	0.0110	0.0223	0.2019	0.4309	0.6762	0.9763	0.8255	0.6280	0.4266	0.2238	0.1278
21-FT Levee	Harrison Stream	12	Forrest Heights Reach	levee	0.0012	0.0037	0.0365	0.0887	0.1694	0.9999	0.9922	0.9558	0.8744	0.7025	0.5488

Forrest Heights Project Performance
by Plans and Damage Reaches by Analysis Year 2061
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probability = 0.01
Residual Damage = 5.00 %

High Sea Level Rise, 1.5 feet

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
					Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Without	Harrison Stream	12	Forrest Heights Reach	levee	0.0167	0.0331	0.2857	0.5688	0.8141	0.9378	0.7225	0.5042	0.3139	0.1482	0.0791
17-FT Levee	Harrison Stream	12	Forrest Heights Reach	levee	0.0150	0.0282	0.2489	0.5110	0.7609	0.9584	0.7646	0.5480	0.3490	0.1698	0.0919
21-FT Levee	Harrison Stream	12	Forrest Heights Reach	levee	0.0016	0.0046	0.0449	0.1084	0.2051	0.9998	0.9882	0.9411	0.8449	0.6540	0.4961

Figure 3.3.6-10. Engineering Performance

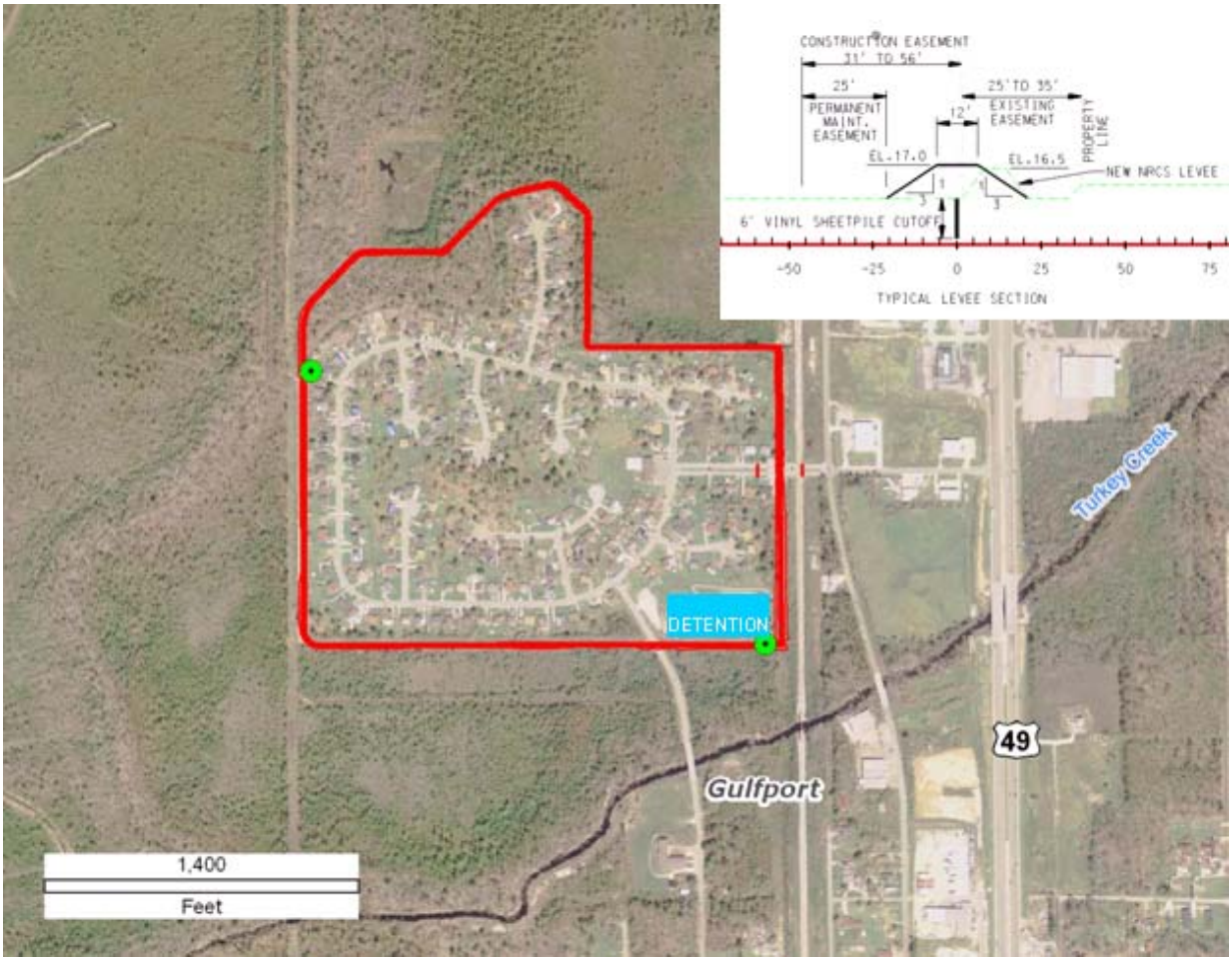


Figure 3.3.6-11. 17-ft Elevation Levee Alignment with Culvert and Pump/Detention Basin Locations

The selective clearing and snagging work will follow Stream Obstruction Removal Guidelines established by the American Fisheries Society. Only debris, snags and sediment that obstruct the flow will be removed. Material to be removed includes: 1) fine sediment accumulations that obstruct flows and alter flow patterns; 2) Debris blockages that currently or in the near future cause obstructed flow and altered flow patterns; and 3) Rooted trees that obstruct flow or need to be cleared for equipment access. Access areas that are cleared will be reestablished at the conclusion of the selective clearing and snagging activities. Some access points, however, may remain for the non-Federal sponsor to use for maintenance activity of the completed project. The existing bank alignment along the entire reach will not be changed, including the downstream reaches of Turkey Creek along the meander bends. Specific reaches to be cleared and snagged will be identified by an interdisciplinary team prior to construction.

Damage and failure by overtopping of levees could be caused by storm surges greater than the levee crest. Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.6-13 was caused by approximately 1-2 ft of overtopping crest depth.

An overtopping reach of the levee with a revetment at the detention/culvert location would be included in the levee design to prevent overtopping failure. The levee would be protected by gabions

on filter cloth as shown in Figure 3.3.6-14, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.



Figure 3.3.6-12. Channel Clearing and Snagging Limits



Source: ERDC, Steven Hughes

Figure 3.3.6-13. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

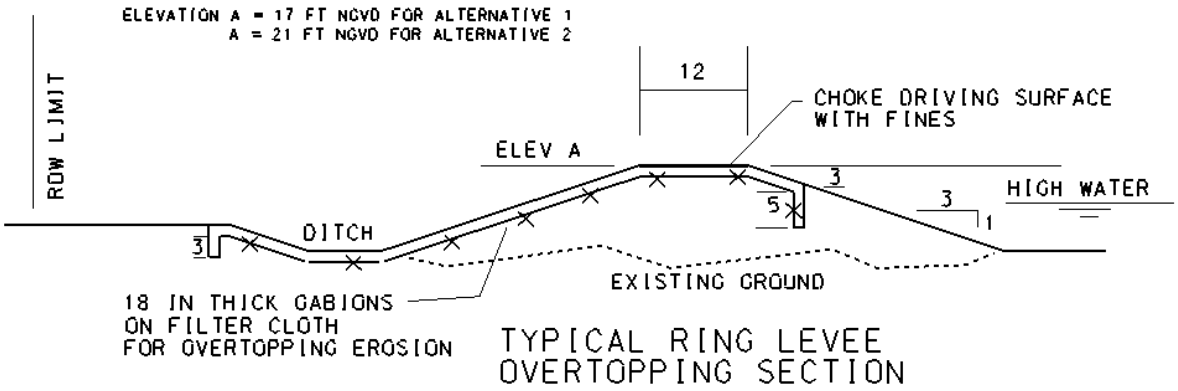


Figure 3.3.6-14. Typical Levee Overtopping Section

3.3.6.5.1 Interior Drainage

Drainage at the site is impacted by hurricanes in the gulf and by adjacent flooding from Turkey Creek. Backwater from each of these sources prevents water from running off. The existing NRCS levee at elevation 16.5 NAVD88 protects the neighborhood to some degree from these sources, but does not eliminate the flooding during times when the water outside the levee is up and there is rainfall inside the levee. This is the present condition at the site. Construction of the Corps levee will follow the footprint of the NRCS levee and provide additional protection from flooding from hurricanes and Turkey Creek. The interior flooding will be improved by adding a detention basin and pumping facility.

Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee at the locations shown in Figure 3.3.6-9. The culverts would have flap gates on the outside ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided in the levee for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.6-15.

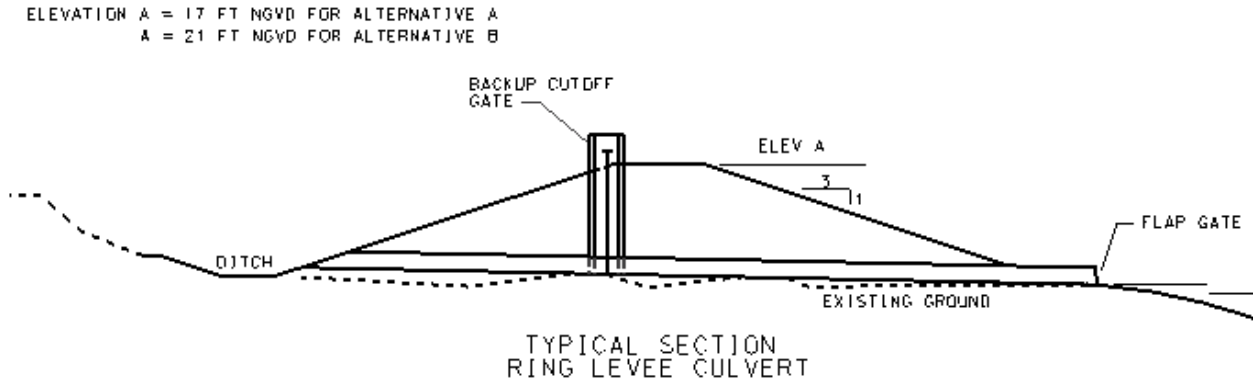


Figure 3.3.6-15. Typical Section at Culvert

Flow within the levee interior was determined by subdividing the interior of the ring levee into major sub-basins shown below in Figure 3.3.6-16 and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number. The curve number was determined from previous studies done for Turkey Creek.

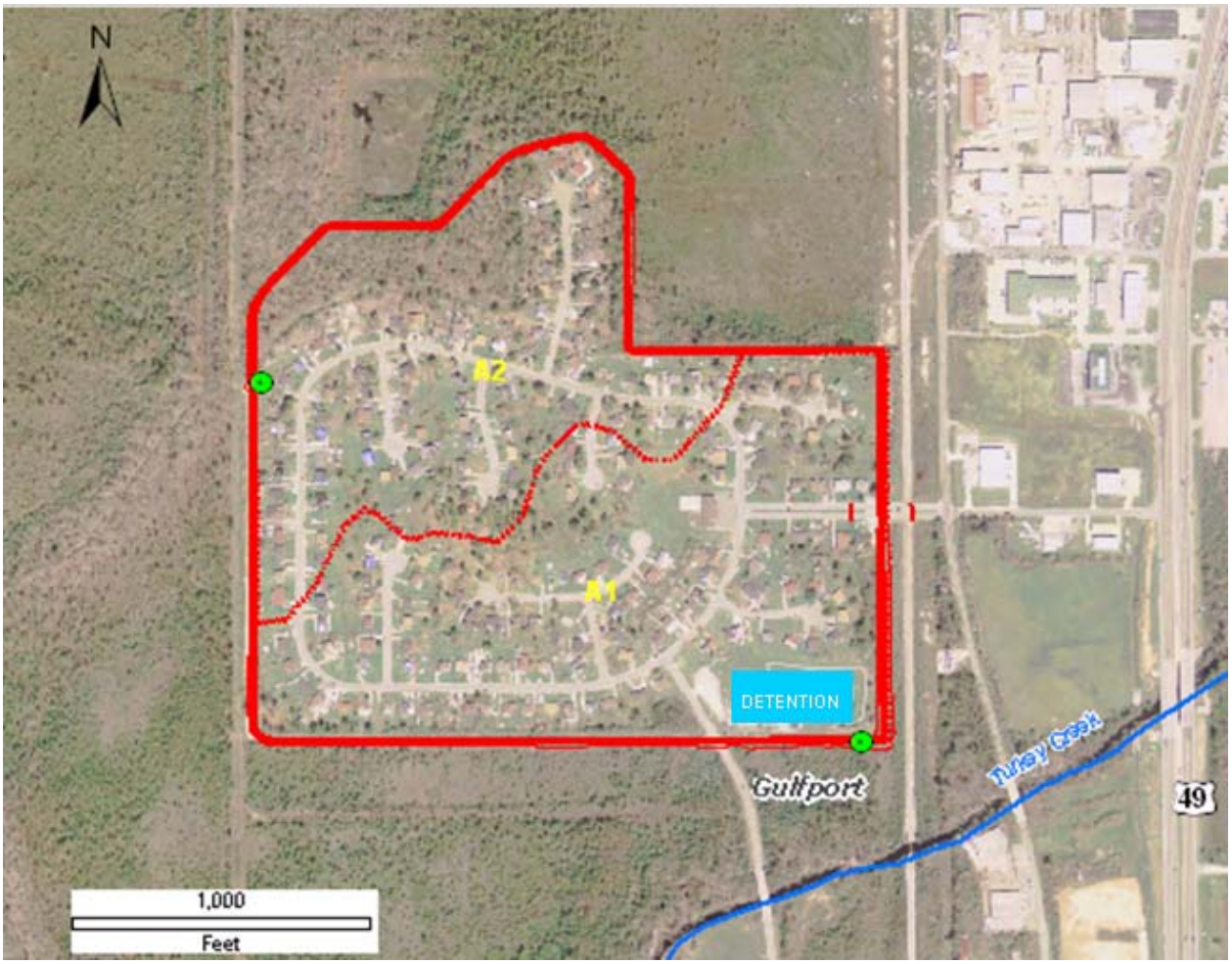


Figure 3.3.6-16 17-ft Elevation Levee Sub-basins

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 10 ft NAVD88 with a tailwater elevation of 6 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

During periods of high water in Turkey Creek or Mississippi Sound, pumping would be required to evacuate rainfall. Pump size was determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is “National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events or high water in Turkey Creek, when the culvert gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. A detention basin was added to help reduce the size of required pumps. The detention basin would have an area of approximately 3 acres but would not be excavated. The area is the lowest site in the subdivision and is presently is used for recreation facilities such as baseball and tennis. Detailed modeling of the area was not possible for this report, therefore the exact extent of the detention basin is not precisely defined. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further design during construction will refine the requirement for the appropriate detention area and pump sizes to provide protection from 100-yr rainfall.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pump could also be used to augment the flow capacity of the levee culverts.

3.3.6.5.2 Geotechnical Data

Geology: Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within

the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.6.5.3 Structural, Mechanical and Electrical

3.3.6.5.3.1 Culverts

Culverts for the project were assumed to be reinforced concrete box structures fitted with flap gates and sluice gates to provide protection from high water outside the levee. An automated system could be incorporated whereby the gates could be monitored and operated from some central location. Detailed design of these monitoring and operating systems is beyond the scope of this study.

3.3.6.5.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Forrest Heights community 2 roadway intersections would have to be accommodated. For this study it was estimated that for option 1 both roadway entrances could use ramps for crossing the restored levee. For option 2 both roadway entrances would use sliding flood gates.

3.3.6.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.6.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.6.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.6.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All gates will be operated to assure proper working order. Debris and shoaled sediment will be removed from the interior ponding area. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. An operation and maintenance (O&M) manual for the levee will be developed for the non-Federal sponsor. The O&M manual will include guidelines for maintaining the integrity of the levee over the 50-year life of the project. Regular inspections and maintenance of the levees would be performed by the non-federal sponsor and USACE personnel. Maintenance costs are included in this report.

3.3.6.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.6.7., Cost Summary. Construction costs for the various options are included in Table 3.3.6-4 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.6-5. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.6.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.6.6 Option B - Elevation 21 ft NAVD88

This option consists of an earthen levee around northern, western, and southern sides of the Forrest Heights community. Because of the height of the levee, the eastern side will be constructed with a concrete “T”-wall structure. The “T” wall will take less space than an earthen levee and encroach less into property along the alignment. The alignment of the levee is generally the same as Option A, but is shown below in Figure 3.3.6-17. Closure gates across the two access roads to the subdivision will be required. The lengths of the levee culverts will be slightly longer than those used in Option A. Other features and methods of analysis are the same.

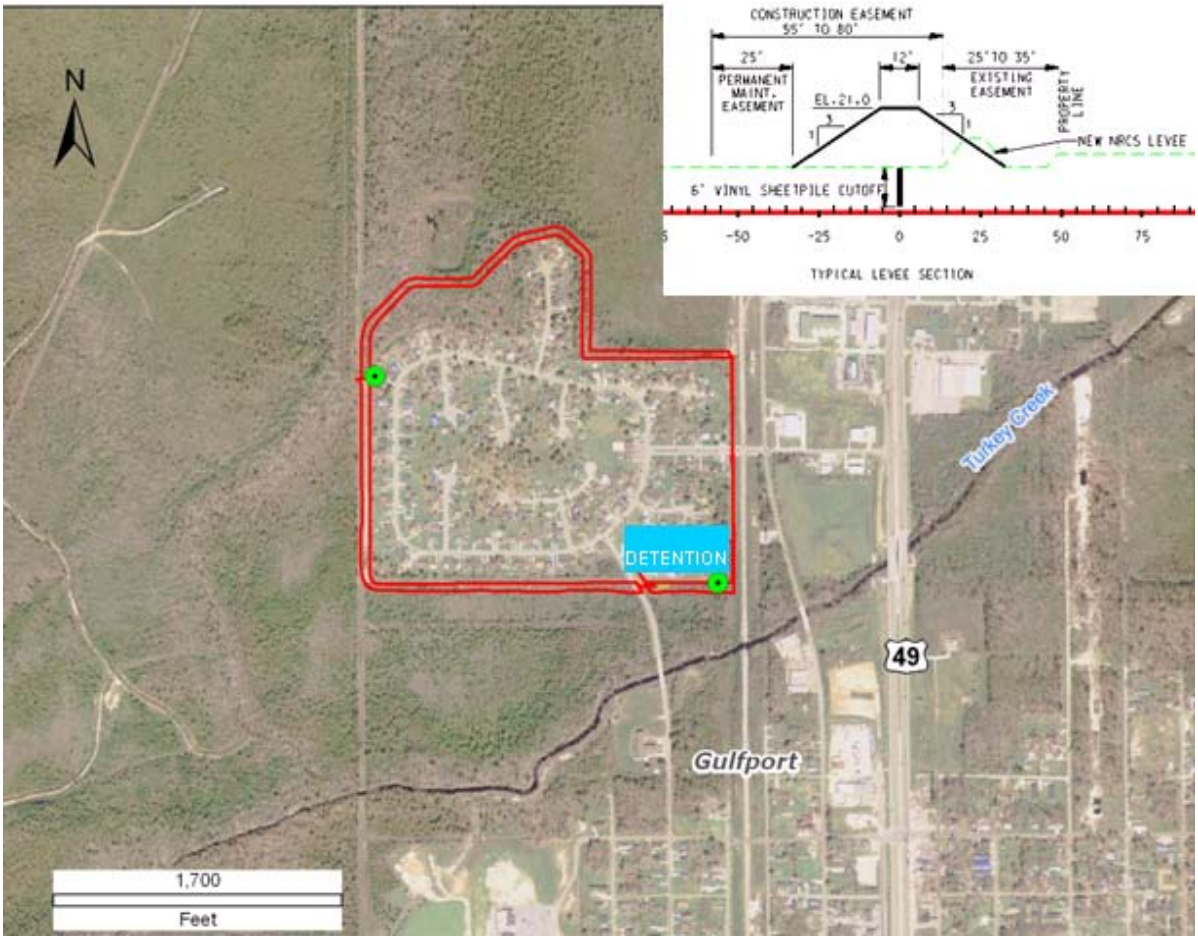


Figure 3.3.6-17. 21-ft Elevation Levee Alignment with Culvert and Detention Basin/Pump Locations

3.3.6.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.6.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.6.6.3 Structural, Mechanical and Electrical

Culvert lengths are not presented but are incorporated into the cost estimate. The “T” wall is shown below in Figures 3.3.6-18.

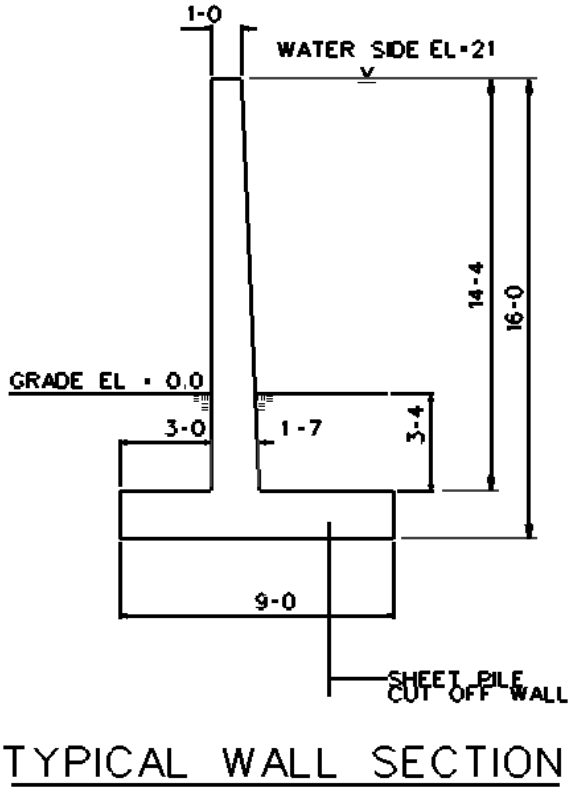


Figure 3.3.6-18. 21-ft Elevation Flood Wall Section

3.3.6.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.6.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.6.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.6.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above, with additional requirements for periodic inspection and operation of the flood gates.

3.3.6.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.6.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.6.7 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.6-4 and 3.3.6-5 below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.6-4.
Construction Cost Summary

Option	Total project cost
Option A – Elevation 17 ft NAVD88	$6,100,000
Option B – Elevation 21 ft NAVD88	$11,400,000

Table 3.3.6-5.
O & M Cost Summary

Option	O&M Cost
Option A – Elevation 17 ft NAVD88	$42,000
Option B – Elevation 21 ft NAVD88	$114,000

3.3.6.8 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Regulation ER 1105-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Regulation ER 1105-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

3.3.7 Jackson County, Ocean Springs Elevated Roadway

3.3.7.1 General

Residential and business areas along the coast in Jackson County are susceptible to storm surge damage. A damage reduction option is to raise the beach front road in Ocean Springs to elevation 11ft NAVD88 was evaluated. This option entails the raising of the Beach Road and the adjoining

seawall to Elevation 11.00 from Highway 90 eastward to the Jackson County Marina. The project also provides for all utility infrastructure such as water, sewer, storm drain, gas and electric lines to be removed and reinstalled to meet the new grades. Several options of this measure were considered before selecting the final one for cost and economic comparisons. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented elsewhere in this report.

3.3.7.2 Location

The location of project in Ocean Springs is shown below in Figure 3.3.7.1.

3.3.7.3 Existing Conditions

The city of Ocean Springs lies at the eastern side of the Back Bay of Biloxi. Ground elevations over most of the residential and business areas vary between elevation 16-24 ft NAVD88, with houses along the coast at between 8-16 ft NAVD88. The 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown below in Figure 3.3.6-2.

Drainage is mostly through natural drainage ways, drowned at the mouth by Mississippi Sound.

Impacts from hurricanes can be devastating. Damage from Hurricane Katrina in August, 2005 in the Ocean Springs area are shown below in Figure 3.3.7-3 and 3.3.7-4.

3.3.7.4 Coastal and Hydraulic Data

Typical coastal data is shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.7-5. The data indicates the Katrina high water was as high as 22.5 ft NAVD88 near the Mississippi Sound.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Ocean Springs at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.7-6.

Existing Condition Stage–Frequency data for Save Point 33, just off the coast of Ocean Springs, is shown below in Figure 3.3.7-7. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

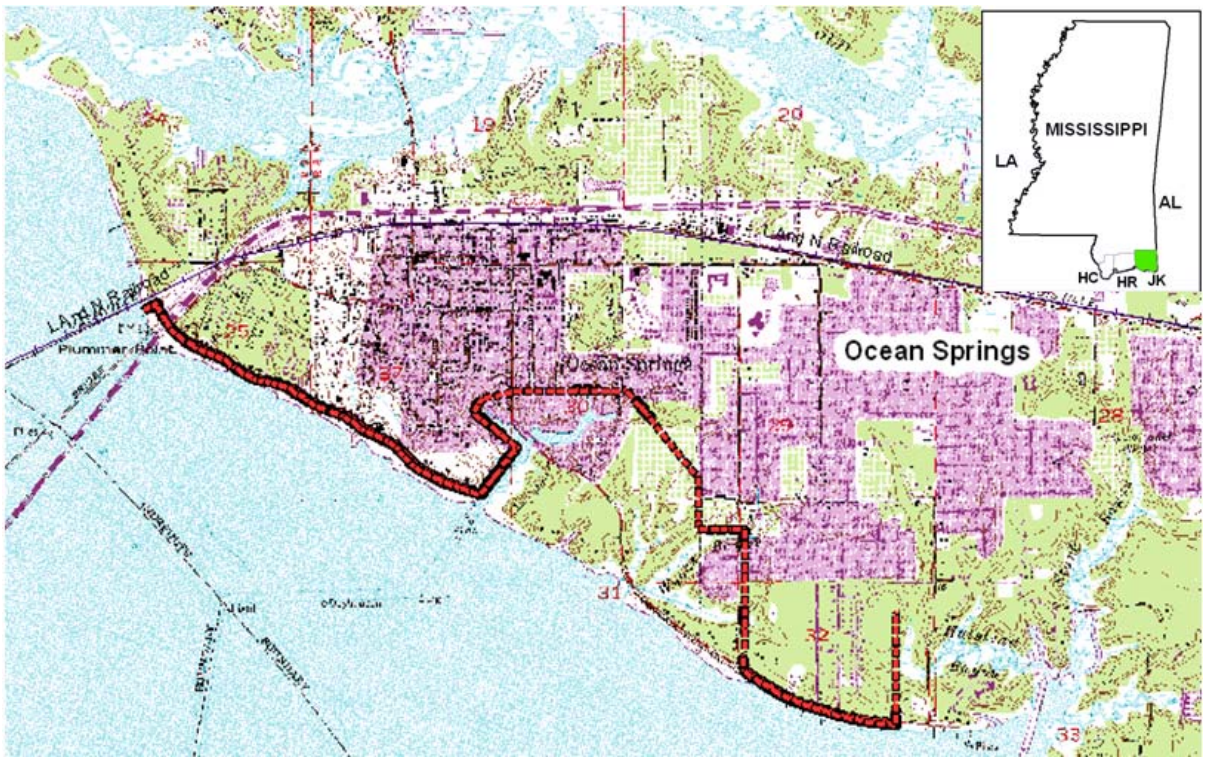


Figure 3.3.7-1. Vicinity Map, Ocean Springs



Figure 3.3.7-2. Existing Conditions



Source: http://ngs.woc.noaa.gov/storms/katrina/24834173.jpg

Figure 3.3.7-3. Hurricane Katrina Damage, Jackson County



Source:B&B Sanders, http://www.flickr.com/photo_zoom.gne?id=355219026

Figure 3.3.7-4. Hurricane Katrina Damage, Jackson County



Figure 3.3.7-5. Ground Contours and Katrina High Water, Ocean Springs



Figure 3.3.7-6. Hydrodynamic Modeling Save Points near Ocean Springs

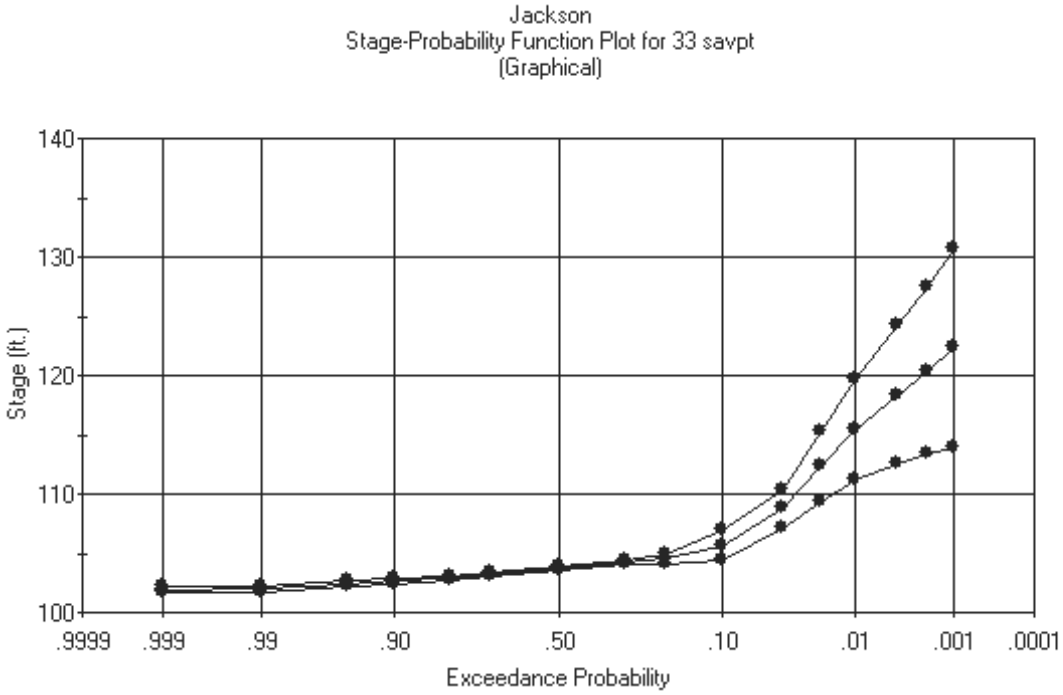


Figure 3.3.7-7. Existing Conditions at Save Point 33, near Ocean Springs

3.3.7.5 Option – Elevate Roadway to 11 ft NAVD88

This option consists of raising the beach front road to elevation 11 ft NAVD88 in Ocean Springs as shown on the following Figure 3.3.7-8, along with the internal sub-basins and levee culvert/pump locations.



Figure 3.3.7-8. Pump/Culvert/Sub-basin Site Location

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in Figure 3.3.7-9.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.7-9. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.7-10 was caused by approximately 1-2 ft of overtopping crest depth.



Source: ERDC, Steven Hughes

Figure 3.3.7-10. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown above in Figure 3.3.7-11, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

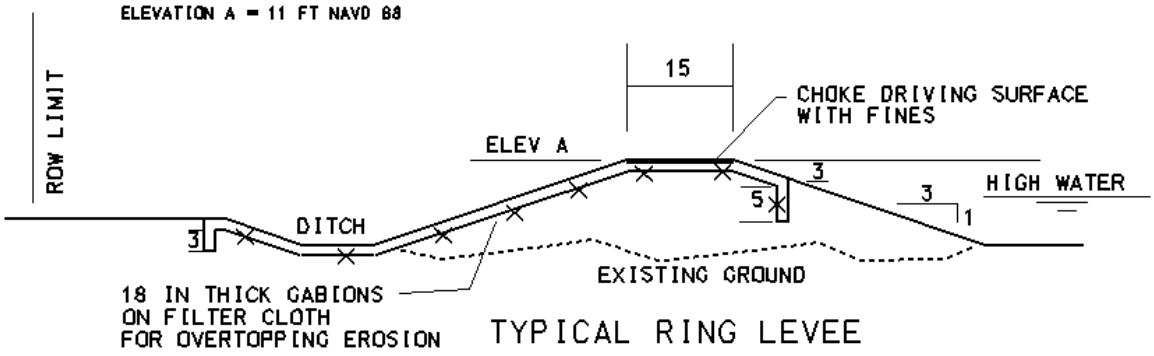


Figure 3.3.7-11. Typical Section at Ring Levee

3.3.7.5.1 Interior Drainage

Drainage on the interior of the raised highway would be collected at the highway and channeled to culverts placed at locations shown above. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.7-12.

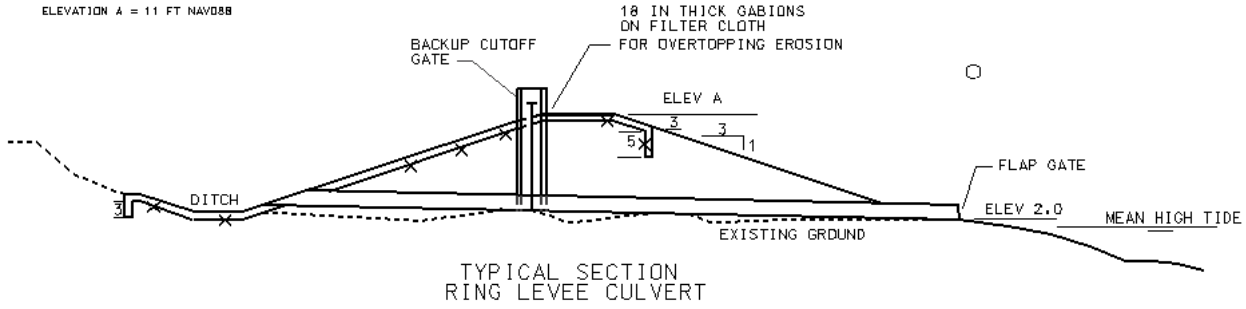


Figure 3.3.7-12. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the drainage basin into major sub-basins as shown above and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number.

Peak flows for the 1-yr to 100-yr storms were computed. Culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater/tailwater elevation difference was maintained at 3.0 ft or less. Drainage ditches along the toe of the highway will be required to

assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data is considered beyond the level of detail required for this report.

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico" US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is "National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)", R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report, therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.7.5.2 Geotechnical

Geology: The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The Line 3 defense elevates the roadway and accompanying seawall to elevation by extending the seaway at its present slope to grade, creating the roadway subgrade then sloping the backside to one vertical to three horizontal side slopes with a twenty five foot toe width for access and drainage. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The embankment will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface on the back side will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the road. The armoring will be anchored on the back face by trenching and extend across the toe easement. All non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate ramping over the embankment where the

surface elevation is near that of the crest elevation. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the roadway and the potential for erosion and instability must be considered. Final designs may require the installation of a cutoff wall within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.7.5.3 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 7 pumping facilities included in the Jackson County Raised Roadway at the elevation 11 protection level were approximately constant at 7 feet, and the corresponding flows required varied from 83,926 to 237,864 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 150 horsepower pumps, to one having six 60-inch diameter pumps each running at 150 horsepower.

3.3.7.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.7.5.5 Construction Procedures and Water Control Plan

Construction would be done by heavy construction equipment after removal of structures and relocation of utilities. Water control will be addressed by constructing drainage facilities prior to construction of the levee.

3.3.7.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm

sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Boat access gates and power plants would require this level of security.

3.3.7.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Maintenance costs are included in this report.

3.3.7.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.7.6 Cost Summary. Construction costs for the various options are included in Table 3.3.7-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.7-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.7.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years

3.3.7.6 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.7-1 and 3.3.7-2 below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.7-1.
Jackson Co Ocean Springs Elevated Roadway
Construction Cost Summary

Option	Total project cost
Option - Elevated Roadway	$67,500,000

Table 3.3.7-2.
Jackson Co Ocean Springs Elevated Roadway O & M Cost Summary

Option	O&M Cost
Option A – Elevated Roadway	$287,000

3.3.7.7 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

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Weather Bureau and USACE. 1956. National Hurricane Research Project Report No. 3, “Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers.

3.3.8 Jackson County, Ocean Springs Ring Levee

3.3.8.1 General

Several high density residential and business areas in Jackson County were identified. They are: Pascagoula/Mosspoint, Gautier, Belle Fontaine, Gulf Park Estates, and Ocean Springs. These are subject to damage from storm surges associated with hurricanes. Earthen ring levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center’s (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.8.2 Location

The location of the Ocean Springs ring levee in Jackson County is shown below in Figures 3.3.8-1 and 3.3.8-2.

3.3.8.3 Existing Conditions

The city of Ocean Springs lies at the eastern side of the Back Bay of Biloxi. Ground elevations over most of the residential and business areas vary between elevation 16-24 ft NAVD88, with houses along the coast at between 8-16 ft NAVD88. The 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown below in Figure 3.3.8-3.

Drainage is mostly through natural drainage ways, drowned at the mouth by Mississippi Sound.

Impacts from hurricanes can be devastating. Damage from Hurricane Katrina in August, 2005 in the Ocean Springs area are shown below in Figure 3.3.8-4 and 3.3.8-5.

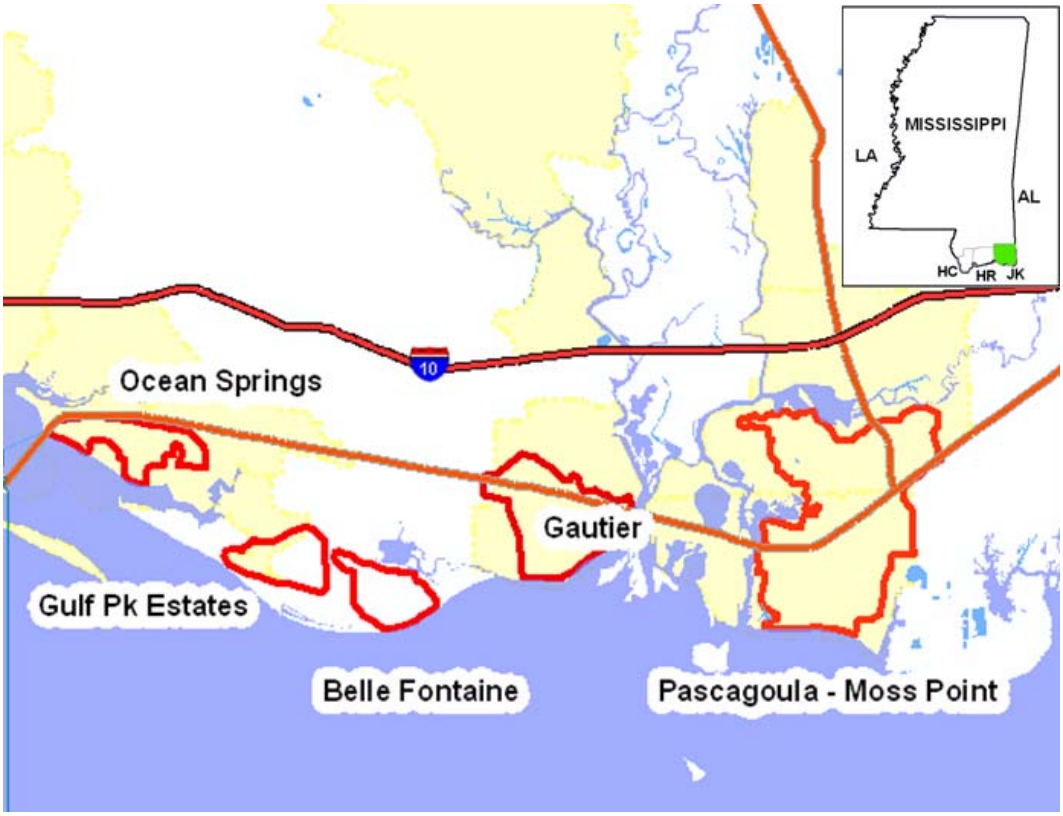


Figure 3.3.8-1. Vicinity Map Ocean Springs, MS



Figure 3.3.8-2. Ocean Springs Ring Levee



Figure 3.3.8-3. Existing Conditions Ocean Springs, MS



Source: http://ngs.woc.noaa.gov/storms/katrina/24834173.jpg

Figure 3.3.8-4. Hurricane Katrina Damage Ocean Springs, MS



Source: B&B Sanders, http://www.flickr.com/photo_zoom.gne?id=355219026

Figure 3.3.8-5. Hurricane Katrina Damage Ocean Springs, MS

3.3.8.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.8-6. The data indicates the Katrina high water was as high as 22.5 ft NAVD88 near the Mississippi Sound.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Ocean Springs at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.8-7.

Existing Condition Stage –Frequency data for Save Point 33, just off the coast of Ocean Springs, is shown below in Figure 3.3.8-8. The 95% confidence limits, approximately equal to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

3.3.8.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 1752 acres around the most densely populated areas of Ocean Springs as shown on the following Figure 3.3.8-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal.



Figure 3.3.8-6. Ground Contours and Katrina High Water



Figure 3.3.8-7. Hydrodynamic Modeling Save Points near Ocean Springs

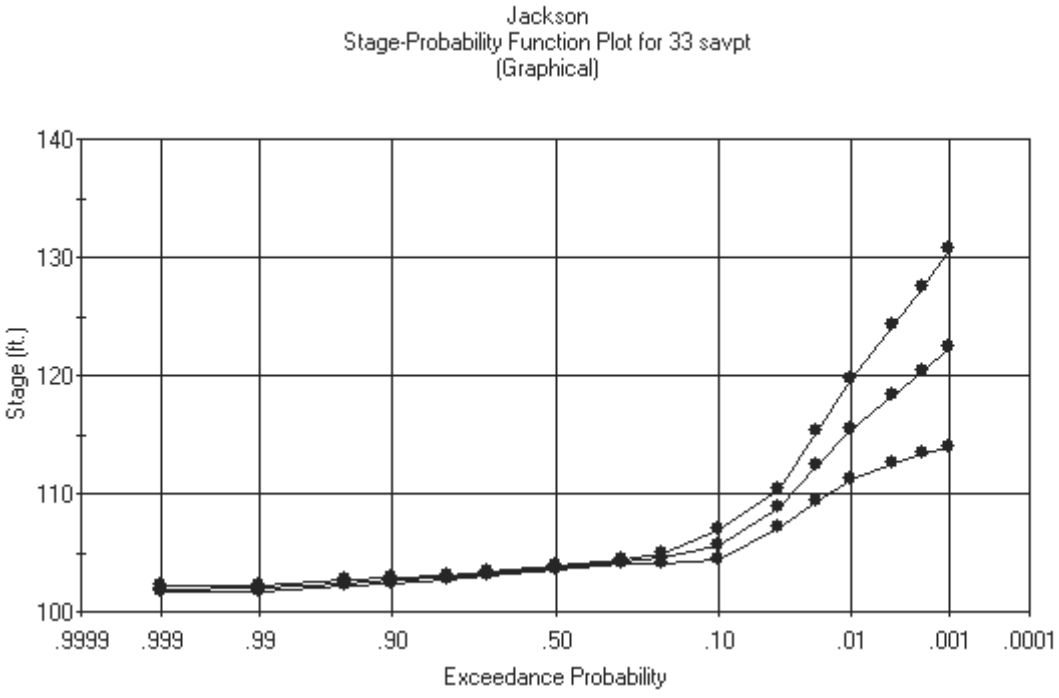


Figure 3.3.8-8. Existing Conditions at Save Point 33, near Ocean Springs



Figure 3.3.8-9. Pump/Culvert/Sub-basin Locations

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in Figure 3.3.8-10.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.8-10. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred

during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.8-11 was caused by approximately 1-2 ft of overtopping crest depth.



Source: ERDC, Steven Hughes

Figure 3.3.8-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.8-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

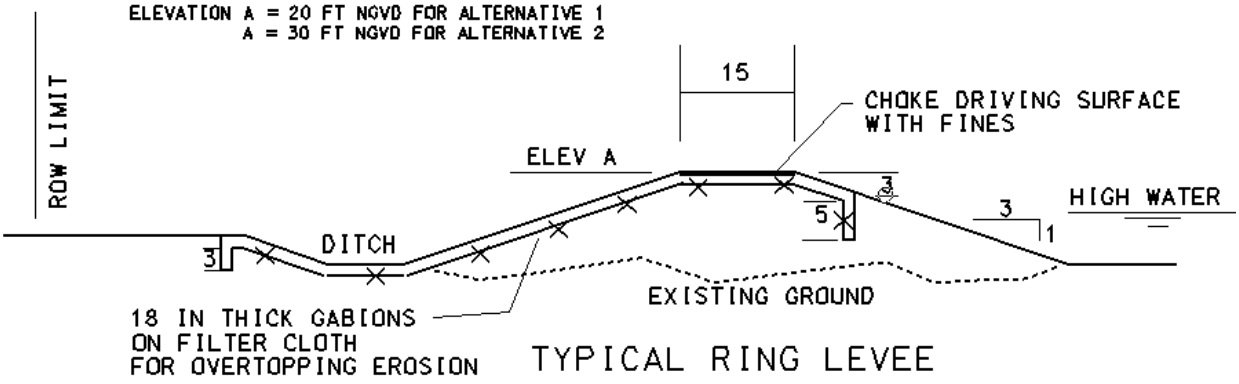


Figure 3.3.8-12. Typical Section at Ring Levee

3.3.8.5.1 Interior Drainage

Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee at the locations shown above in Figure 3.3.8-9. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.8-13.

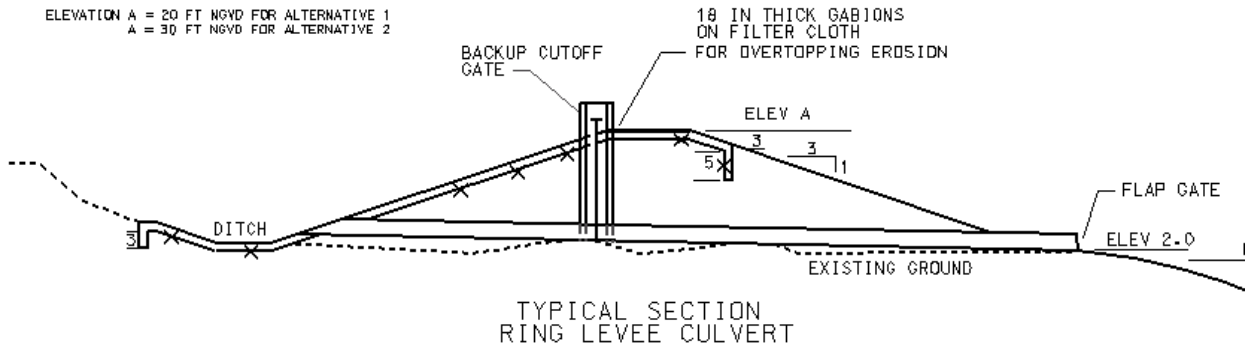


Figure 3.3.8-13. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the ring levee into major sub-basins as shown above in Figure 3.3.8-9 and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number. The variation in soil types, hydrologic soil groups, and sub-basins is shown below in Figure 3.3.8-14.

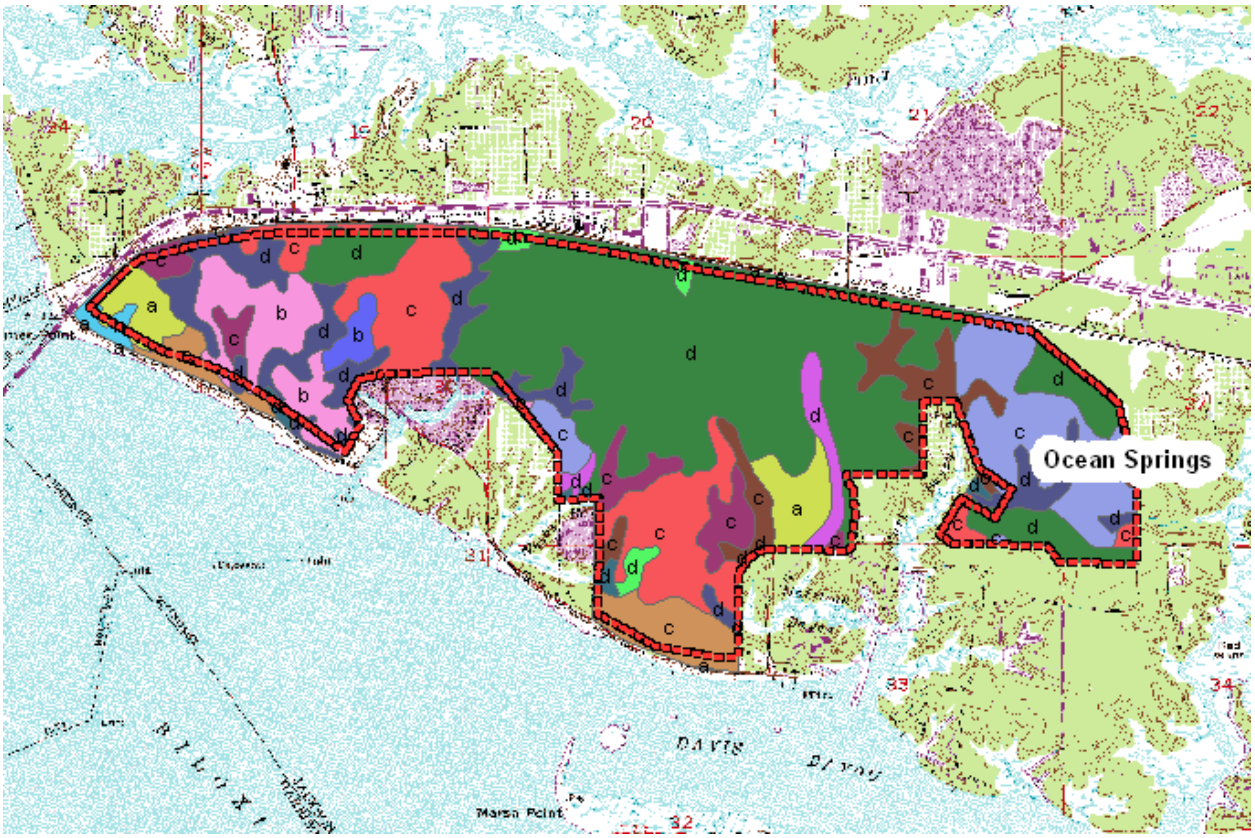


Figure 3.3.8-14. Ocean Springs Hydrologic Soil Groups

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is “National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report, therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.8.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation

consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.8.5.3 Jackson County Ring Levee. Ocean Springs. Option A - Elevation 20 ft NAVD88. Structural, Mechanical and Electrical

3.3.8.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.8.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal

sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.8.5.3.3 Pumping Stations Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.8.5.3.4 Pumping Stations Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.8.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 14 pumping facilities included in the Ocean Springs Ring Levee system for the elevation 20 protection level varied from approximately 10 to 15 feet and the corresponding flows required varied from 70,915 to 401,703 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 150 horsepower pumps, to one having four 60-inch diameter pumps each running at 560 horsepower.

3.3.8.5.3.6 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was

assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.8.5.3.7 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.8.5.3.8 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Ocean Springs area to elevation 20, 24 roadway intersections would have to be accommodated. For this study it was estimated that 6 roller gate structures and 18 swing gate structures would be required.

3.3.8.5.4 Jackson County Ring Levee. Ocean Springs. Option A - Elevation 20 ft NAVD88. HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.8.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater

will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.8.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.8.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.8.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.8.7, Cost Summary. Construction costs for the various options are included in Table 3.3.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.8-2. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and

coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.8.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.8.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Ocean Springs. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.8.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.8.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.8.6.3 Jackson County Ring Levee. Ocean Springs. Option B - Elevation 30 ft NAVD88. Structural, Mechanical and Electrical

These data are the same as that presented for Option A and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

Pumping Facilities. Flow and Pump Sizes. Option B. Design hydraulic heads derived for the 14 pumping facilities included in the Ocean Springs Ring Levee system for the elevation 30 protection level varied from approximately 15 to 25 feet and the corresponding flows required varied from 70,915 to 401,703 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 290 horsepower pumps, to one having four 60-inch diameter pumps each running at 1000 horsepower

Levee and Roadway/Railway Intersections. Option B. With the installation of a ring levee around the Ocean Springs area to elevation 30, 76 roadway intersections would have to be accommodated. For this study it was estimated that 6 roller gate structures and 70 swing gate structures would be required.

3.3.8.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.8.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.8.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.8.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.8.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.8.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.8.7 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.8-1 and 3.3.8-2, below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.8-1.
Jackson Co Ocean Springs Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$152,100,000
Option B – Elevation 30 ft NAVD88	$327,000,000

Table 3.3.8-2.
Jackson Co Ocean Springs Ring Levee O & M Cost Summary

Option	O&M Cost
Option A – Elevation 20 ft NAVD88	$1,414,000
Option B – Elevation 30 ft NAVD88	$2,532,000

3.3.8.8 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

National Resource Conservation Service (NRCS). 2003. WinTR5-55 User Guide (Draft). Agricultural Research Service. 7 May 2003.

Environmental Science Services Administration. 1968. "Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico" US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968.

Weather Bureau and USACE. 1956. National Hurricane Research Project Report No. 3, "Rainfall Associated with Hurricanes (And Other Tropical Disturbances)", R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers.

3.3.9 Jackson County, Gulf Park Estates Ring Levee

3.3.9.1 General

Several high density residential and business areas in Jackson County were identified. They are : Pascagoula/Mosspoint, Gulf Park Estates, Belle Fontaine, Gulf Park Estates, and Ocean Springs. These are subject to damage from storm surges associated with hurricanes. Earthen ring levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.9.2 Location

The location of the Gulf Park Estate ring levee in Jackson County is shown below in Figure 3.3.9-1 and 3.3.9-2.

3.3.9.3 Existing Conditions

Gulf Park Estates Subdivision is located adjacent to and east of Ocean Springs. The area of study for the ring levee is bounded by Simmons Bayou on the north and the Mississippi Sound on the south. Ground elevations over most of the residential areas vary between elevation 10-20 ft NAVD88. The 4-ft(blue), 8-ft(dark green), 12-ft(light green), 16-ft(brown), and 20-ft(pink) ground contour lines and potential levee location (red) are shown below in Figure 3.3.9-3.

Drainage of the residential area is mostly to the north to Simmons Bayou. Only a small part of the area drains to Mississippi Sound.

Impacts from hurricanes are devastating to the area. Recent damage from Hurricane Katrina in August, 2005 the Gulf Park Estates area are shown below in Figures 3.3.9-4 and 3.3.9-5. Many homes are still un-repaired, pending settlement of insurance claims.

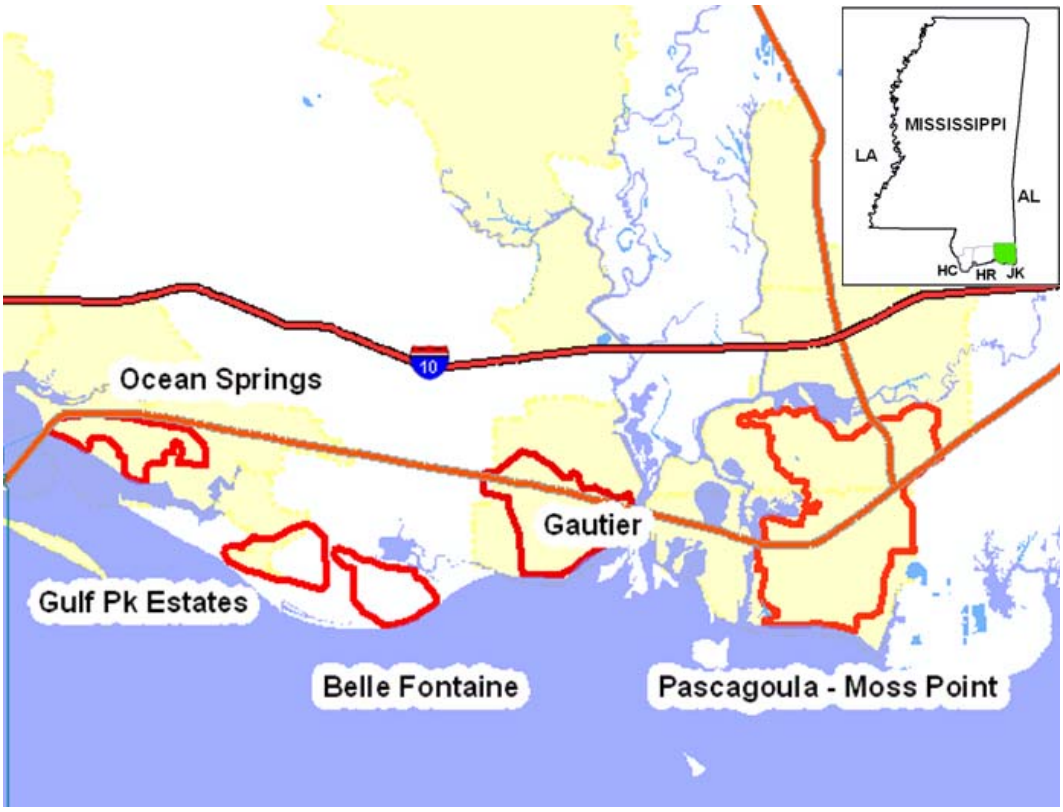


Figure 3.3.9-1. Vicinity Map Gulf Park Estates



Figure 3.3.9-2. Gulf Park Estates Ring Levee

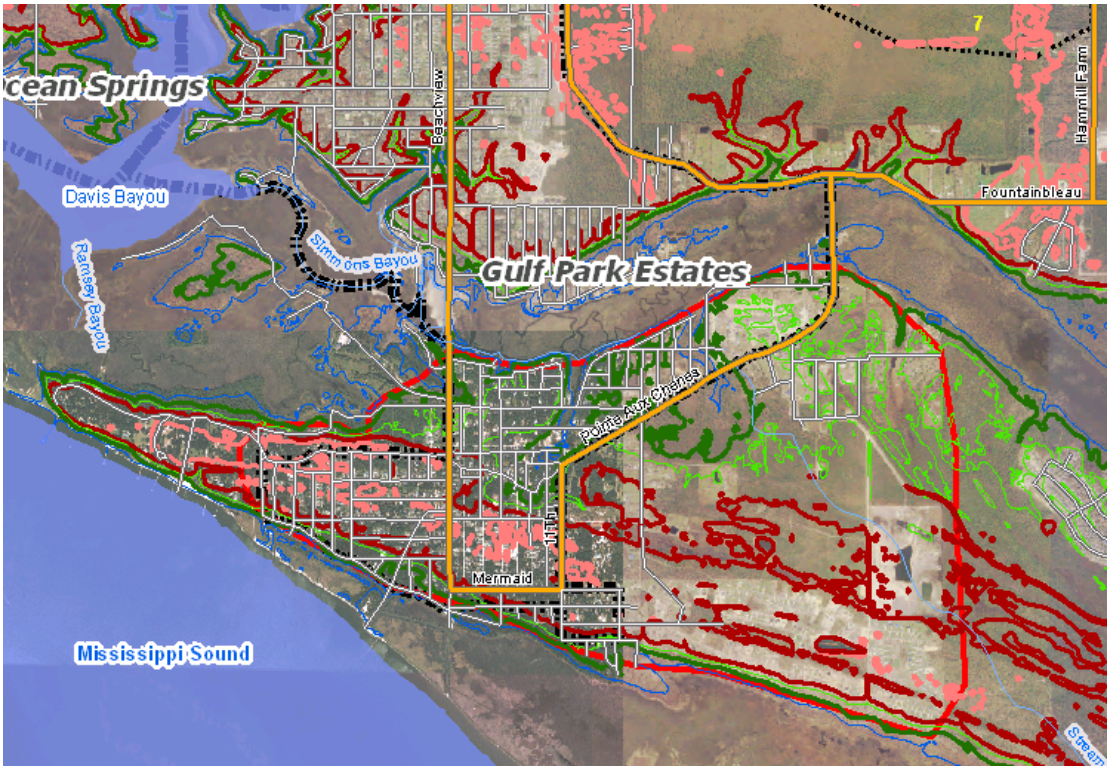


Figure 3.3.9-3. Existing Conditions Gulf Park Estates



Source: http://ngs.woc.noaa.gov/storms/katrina/24333182.jpg

Figure 3.3.9-4. Hurricane Katrina Damage Gulf Park Estates



SourceSpartan1's Photos: http://www.flickr.com/photo_zoom.gne?id=362158993&size=m&context=photostream

Figure 3.3.9-5. Hurricane Katrina Damage Gulf Park Estates, MS

3.3.8.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines major streets are shown below in Figure 3.3.9-6. The data indicates the Katrina high water was as high as 21 ft NAVD88 at the Mississippi Sound.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Gulf Park Estates at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.9-7.

Existing Condition Stage –Frequency data for Save Point 1, just off the coast of Gulf Park Estates, is shown below in Figure 3.3.9-8. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

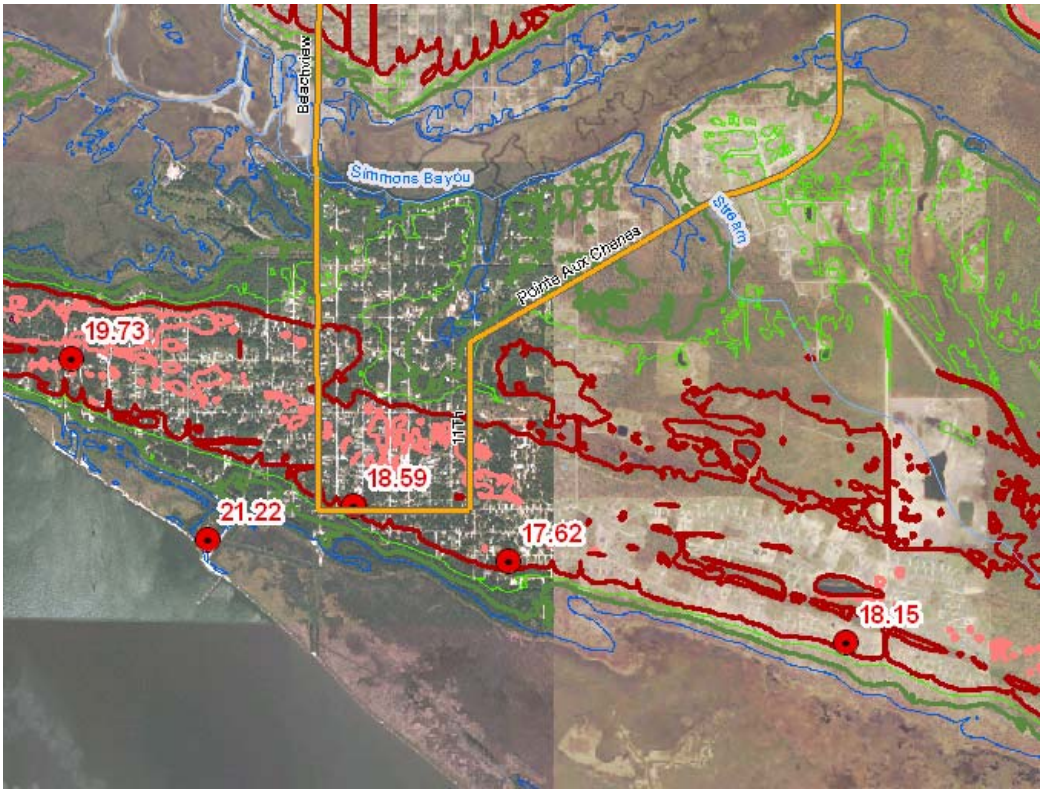


Figure 3.3.9-6. Ground Contours and Katrina High Water

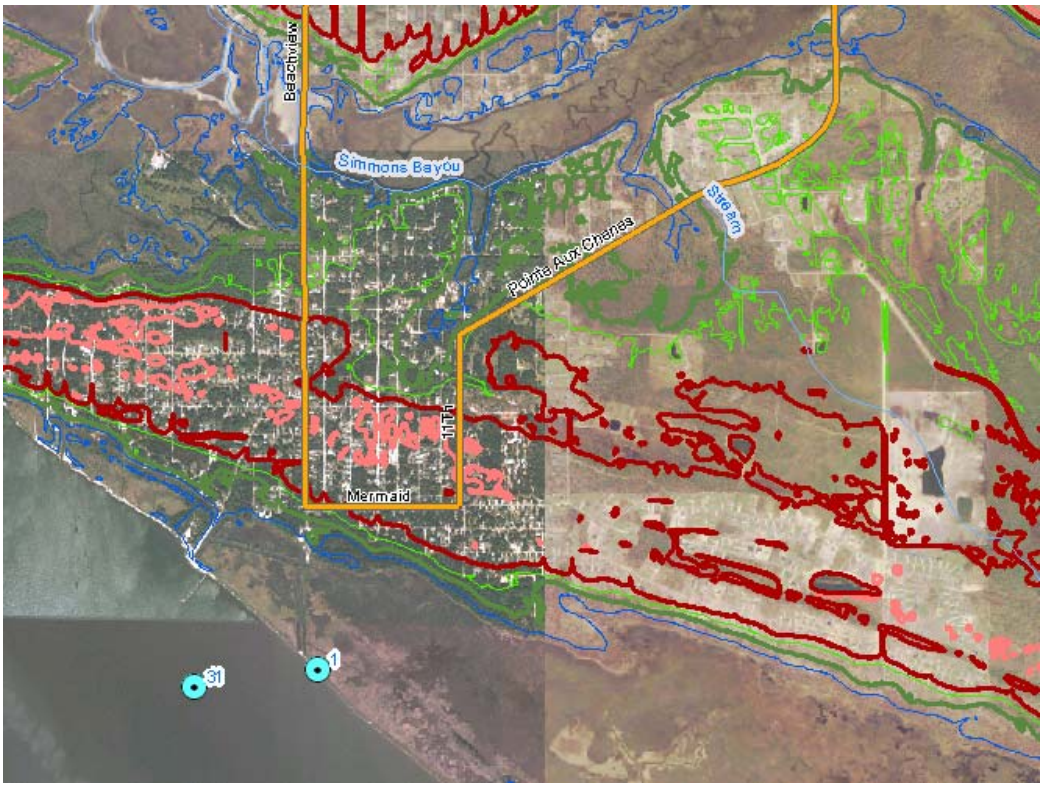


Figure 3.3.9-7. Hydrodynamic Modeling Save Points near Gulf Park Estates

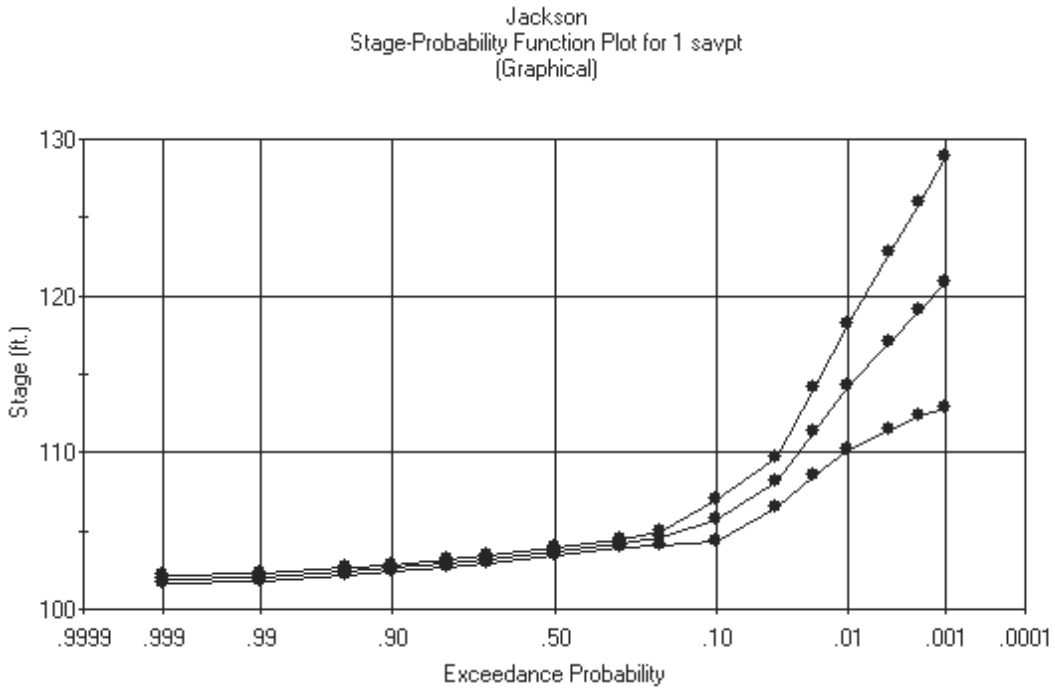


Figure 3.3.9-8. Existing Conditions at Save Point 1, near Gulf Park Estates

3.3.9.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 1473 acres around the most densely populated areas of Gulf Park Estates as shown on the following Figure 3.3.9-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

Damage and failure by overtopping of levees could be caused by storm surges greater than the levee crest as shown on Figure 3.3.9-10.

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.9-11 was caused by approximately 1-2 ft of overtopping crest depth.



Figure 3.3.9-9. Pump/Culvert/Sub-basin Locations



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.9-10. North Sea, Germany, March 1976



Source: ERDC, Steven Hughes

Figure 3.3.9-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.9-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

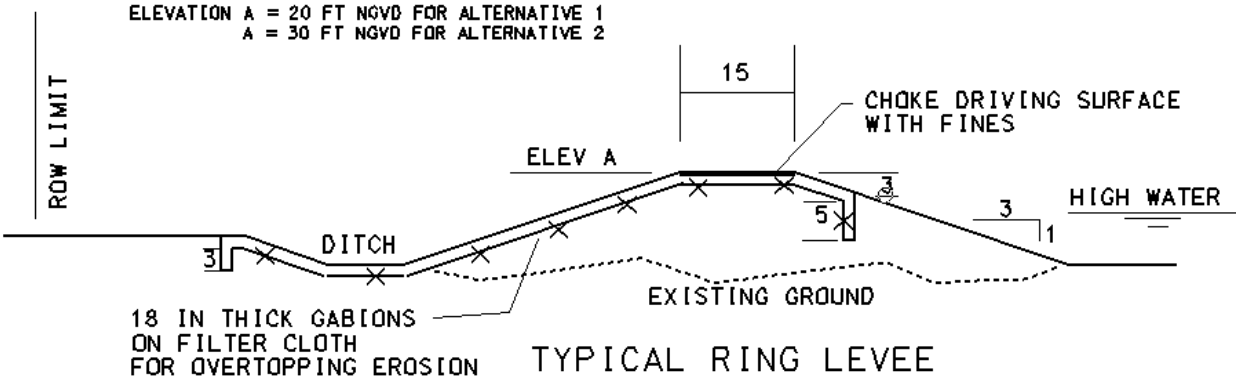


Figure 3.3.9-12. Typical Section at Ring Levee

3.3.9.5.1 Interior Drainage

Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee at the locations shown above in Figure 3.3.9-9. The culverts would have tidal gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at the upstream end at every culvert in the levee for manual control in the event the tidal gate malfunctions. A typical section is shown is shown below in Figure 3.3.9-13.

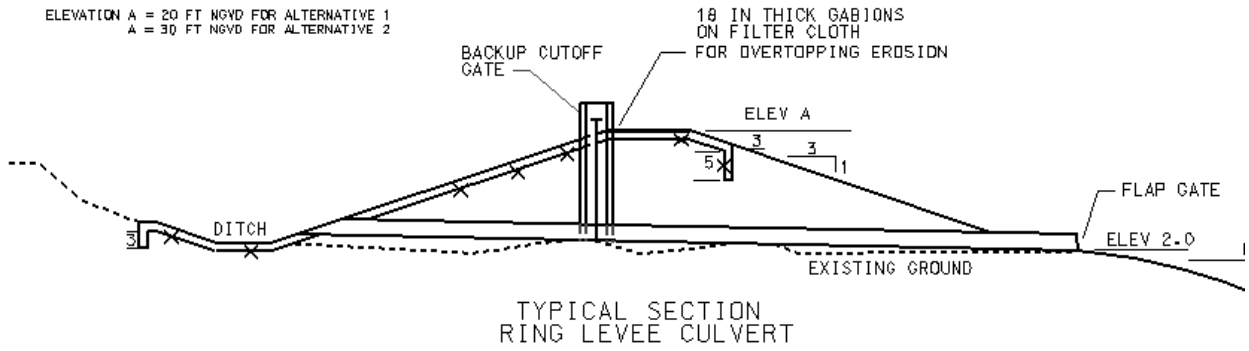


Figure 3.3.9-13. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the ring levee into major sub-basins as shown in Figure 3.3.9-9 and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number. The variation in soil types, hydrologic soil groups, and sub-basins is shown in Figure 3.3.9-14.

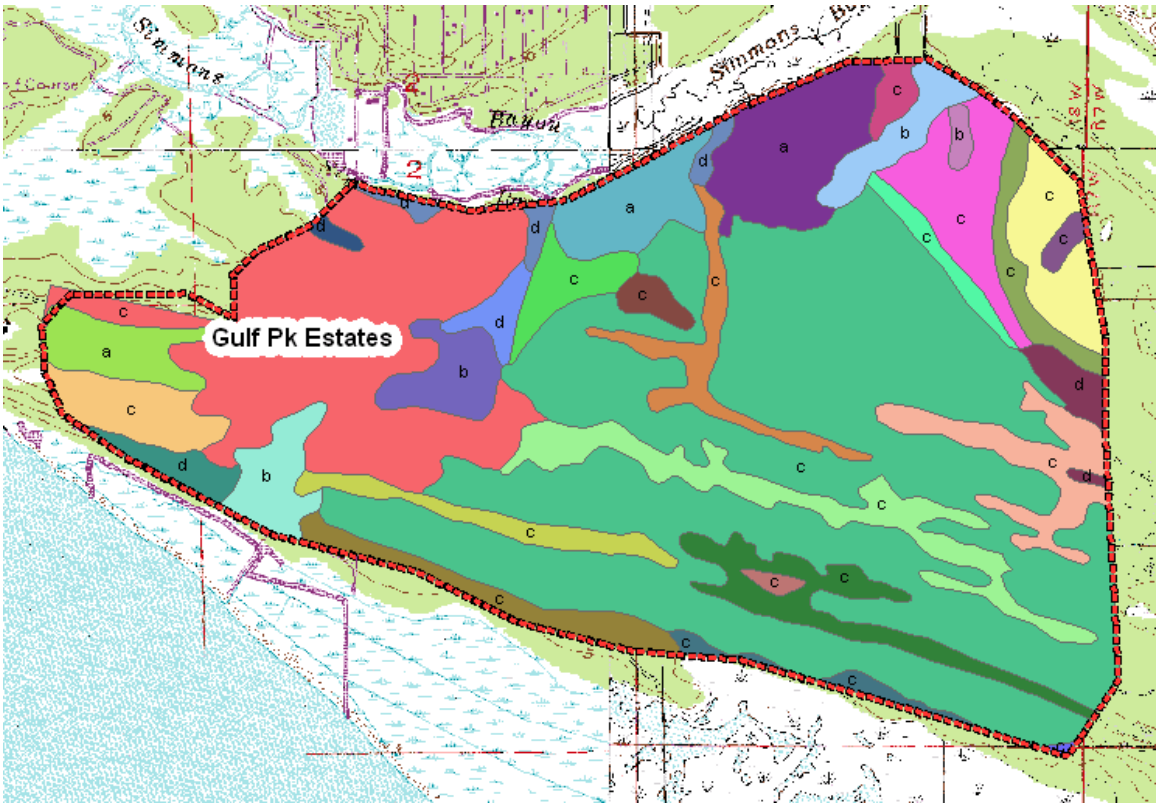


Figure 3.3.9-14. Gulf Park Estates Hydrologic Soil Groups

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission.

Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is “National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report, therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.9.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value

as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.9.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts and pumping facilities. The sites are shown above in Figure 3.3.9-9.

3.3.9.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.9.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses

for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.9.5.3.3 Pumping Stations Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.9.5.3.4 Pumping Stations Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.9.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 8 pumping facilities included in the Gulf Park Estates Ring Levee system for the elevation 20 protection level varied from approximately 10 to 15 feet and the corresponding flows required varied from 32,316 to 333,481 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 154 horsepower pump, to one having four 60-inch diameter pumps each running at 560 horsepower.

3.3.9.5.3.6 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was

assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.9.5.3.7 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.9.5.3.8 Levee and Roadway/Railway Intersections

With the installation of a ring levee around Gulf Park Estates to elevation 20, 20 roadway intersections would have to be accommodated. For this study it was estimated that 2 roller gate structures and 18 swing gate structures would be required.

3.3.9.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.9.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.9.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.9.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.9.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.9.10., Cost Summary. Construction costs for the various options are included in Table 3.3.9-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.9-2. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.9.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.9.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Gulf Park Estates. The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.9.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.9.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.9.6.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

3.3.9.6.3.1 Pumping Facilities. Flow and Pump Sizes

Design hydraulic heads derived for the 8 pumping facilities included in the Gulf Park Estates Ring Levee system for the elevation 30 protection level varied from approximately 20 to 25 feet and the corresponding flows required varied from 32,315 to 333,482 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 300 horsepower pump, to one having four 60-inch diameter pumps each running at 1000 horsepower.

3.3.9.6.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around Gulf Park Estates to elevation 30, 13 roadway intersections would have to be accommodated. For this study it was estimated that all 13 would require swing gate structures.

3.3.9.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.9.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.9.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.9.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.9.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.9.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.9.7 Option C – Alternate Alignment, Elevation 20 ft NAVD88

This option consists of an earthen levee at elevation 20 ft NAVD88 enclosing an area of 1355 acres around the most populated areas of Gulf Park Estates in an alignment slightly different from the alignment for Options A and B. The alignment of the levee is shown in Figure 3.3.9-15 below, which also shows the variation in the drainage sub-basins and the locations of the pumps and culverts.

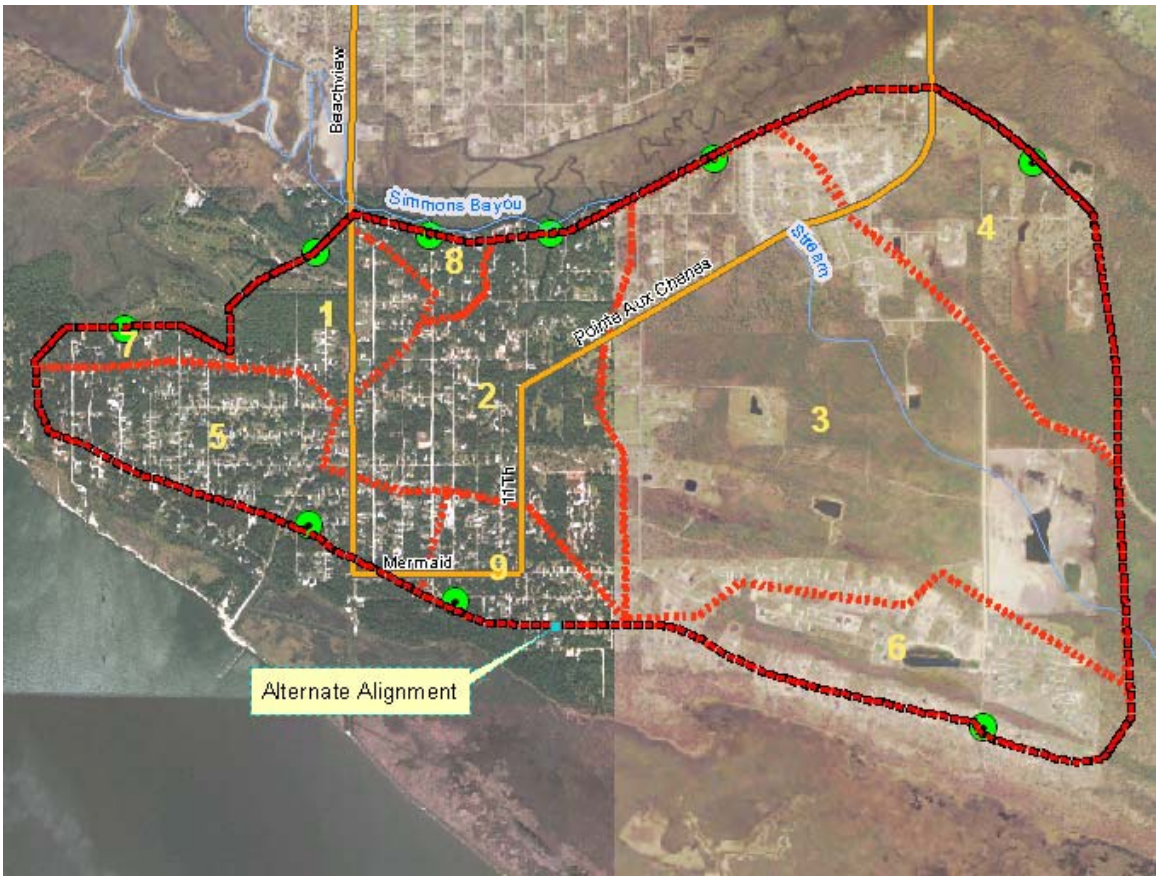


Figure 3.3.9-15. Alternative Alignment Pump/Culvert/Sub-basin Locations

3.3.9.7.1 Interior Drainage

Interior drainage flows are similar to those computed for Option A, above. However, the appropriate ditches, culverts and pumps were re-sized by either adjusting the previously computed flows by the ratio of the change in areas of the sub-basins to get the revised flows, or by computing flows by TR-55 methods.

3.3.9.7.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option C are the same as for Option A, above.

3.3.9.7.3 Structural, Mechanical and Electrical

The primary difference between the description of this option and preceding description of Option A is a slight alteration in the routing of the levee resulting in slight alteration to the required pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option C is presented below.

3.3.9.7.3.1 Pumping Facilities Flow and Pump Sizes

Design hydraulic heads derived for the 9 pumping facilities included in the Gulf Park Estates Ring Levee system for the optional alignment at elevation 20 protection level varied from approximately 5 to 20 feet and the corresponding flows required varied from 31,544 to 333,387 gallons per minute. The plants thus derived varied in size from a plant having two 26-inch diameter, 150 horsepower pumps, to one having eight 42-inch diameter pumps each running at 300 horsepower.

3.3.9.7.3.2 Levee and Roadway/Railway Intersections.

With the installation of a ring levee around Gulf Park Estates to elevation 20, 18 roadway gates for intersections would have to be accommodated. For this study it was estimated that 14 would require swing gate structures with the remaining 4 requiring roller gates of varying heights.

3.3.9.7.4 HTRW

The HTRW paragraphs for Option C are the same as for Option A, above.

3.3.9.7.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option C are the same as for Option A, above.

3.3.9.7.6 Project Security

The Project Security paragraphs for Option C are the same as for Option A, above.

3.3.9.7.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option C are the same as for Option A, above.

3.3.9.7.8 Cost Estimate

The Cost Estimate paragraphs for Option C are the same as for Option A, above.

3.3.9.7.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option C are the same as for Option A, above.

3.3.9.8 Option D – Alternate Alignment, Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Gulf Park Estates. The alignment of the levee is the same as Option C, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.9.8.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option C, above, except that the culvert lengths through the levees would be longer.

3.3.9.8.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option D are the same as for Option A, above.

3.3.9.8.3 Structural, Mechanical and Electrical

The primary difference between the description of this option and preceding description of Option A, besides the height of the levee, is a slight variation in the levee alignment, resulting in changes to the pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option D is presented below.

3.3.9.8.3.1 Pumping Facilities. Flow and Pump Sizes.

Design hydraulic heads derived for the 8 pumping facilities included in the Gulf Park Estates Ring Levee system for the elevation 30 protection level varied from approximately 15 to 30 feet and the corresponding flows required varied from 31,544 to 333,387 gallons per minute. The plants thus derived varied in size from a plant having two 26-inch diameter, 200 horsepower pump, to one having eight 42-inch diameter pumps each running at 500 horsepower.

3.3.9.8.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around Gulf Park Estates to elevation 30, 15 roadway intersections would have to be accommodated. For this study it was estimated that all 15 would require 30 swing gate structures.

3.3.9.8.4 HTRW

The HTRW paragraphs for Option D are the same as for Option A, above.

3.3.9.8.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option D are the same as for Option A, above.

3.3.9.8.6 Project Security

The Project Security paragraphs for Option D are the same as for Option A, above.

3.3.9.8.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option D are the same as for Option A, above.

3.3.9.8.8 Cost Estimate

The Cost Estimate paragraphs for Option D are the same as for Option A, above.

3.3.9.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option D are the same as for Option A, above.

3.3.9.10 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.9-1 and 3.3.9-2, below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.9-1.
Jackson Co Gulf Park Estates Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$149,200,000
Option B – Elevation 30 ft NAVD88	$220,600,000
Option C – Elevation 20 ft NAVD88	$158,900,000
Option D – Elevation 30 ft NAVD88	$208,700,000

Table 3.3.9-2.
Jackson Co Gulf Park Estates Ring Levee O & M Cost Summary

Option	O&M Cost
Option A – Elevation 20 ft NAVD88	$1,499,000
Option B – Elevation 30 ft NAVD88	$2,404,000
Option C – Elevation 20 ft NAVD88	$1,295,000
Option D – Elevation 30 ft NAVD88	$1,906,000

3.3.9.11 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

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Environmental Science Services Administration. 1968. “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968.

Weather Bureau and USACE. 1956. National Hurricane Research Project Report No. 3, “Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers.

3.3.10 Jackson County, Belle Fontaine Ring Levee

3.3.10.1 General

Several high density residential and business areas in Jackson County were identified. They are : Pascagoula/Mosspoint, Gautier, Belle Fontaine, Gulf Park Estates, and Ocean Springs. These are subject to damage from storm surges associated with hurricanes. Earthen ring levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center’s (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.10.2 Location

The location of the Belle Fontaine ring levee in Jackson County is shown below in Figures 3.3.10-1 and 3.3.10-2. Two alignments are shown on Figure 3.3.10-2. These are evaluated separately.

3.3.10.3 Existing Conditions

The subdivision of Belle Fontaine is located just west of Gautier along the gulf coast on Mississippi Sound. The northeastern part of the subdivision is near elevation 10-14 ft NAVD88 and very flat. Ground elevations over the southwestern part of the area vary between elevation 16-20 ft NAVD88. The 4-ft(blue), 8-ft (dark green), 12-ft(light green), 16-ft(brown), and 20-ft(pink) ground contour lines and levee limits (red) are shown below in Figure 3.3.10-3.

The area is drained by very small natural and some improved channels. These channels drain to the north to Graveline Bayou, and to Mississippi Sound.

Drainage from ordinary rainfall is hindered on occasions when the gulf is high, but impacts from hurricanes are devastating. Damage from Hurricane Katrina in August, 2005 in the Belle Fontaine area are shown below in Figures 3.3.10-4 and Figure 3.3.10-5. Many homes are still un-repaired, pending settlement of insurance claims.



Figure 3.3.10-1. Vicinity Map, Jackson County

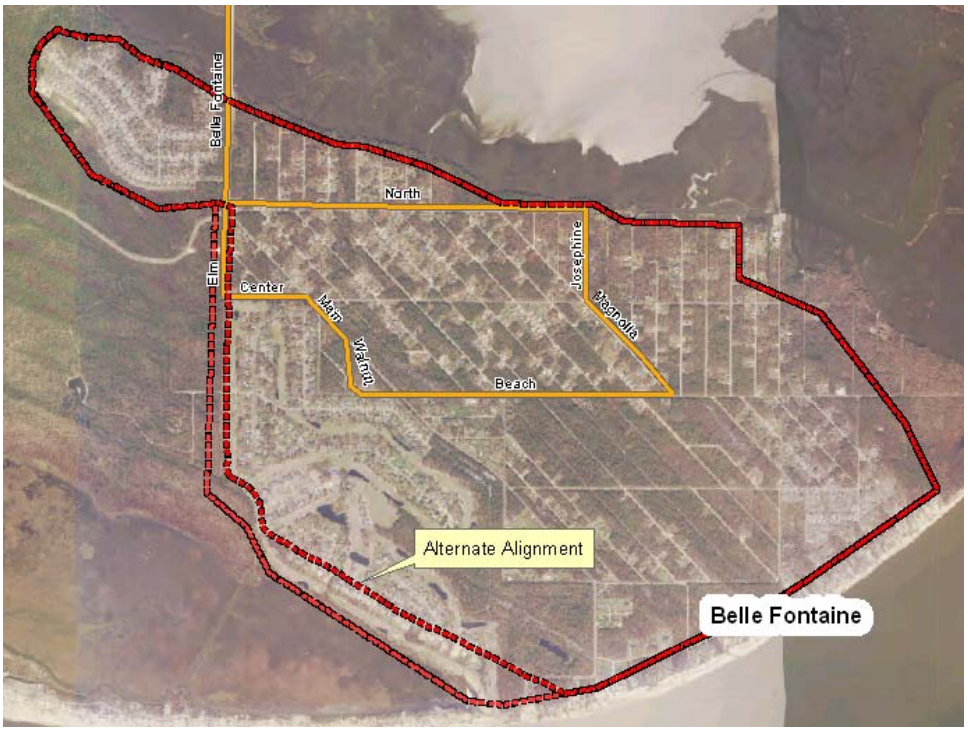


Figure 3.3.10-2. Belle Fontaine Ring Levee

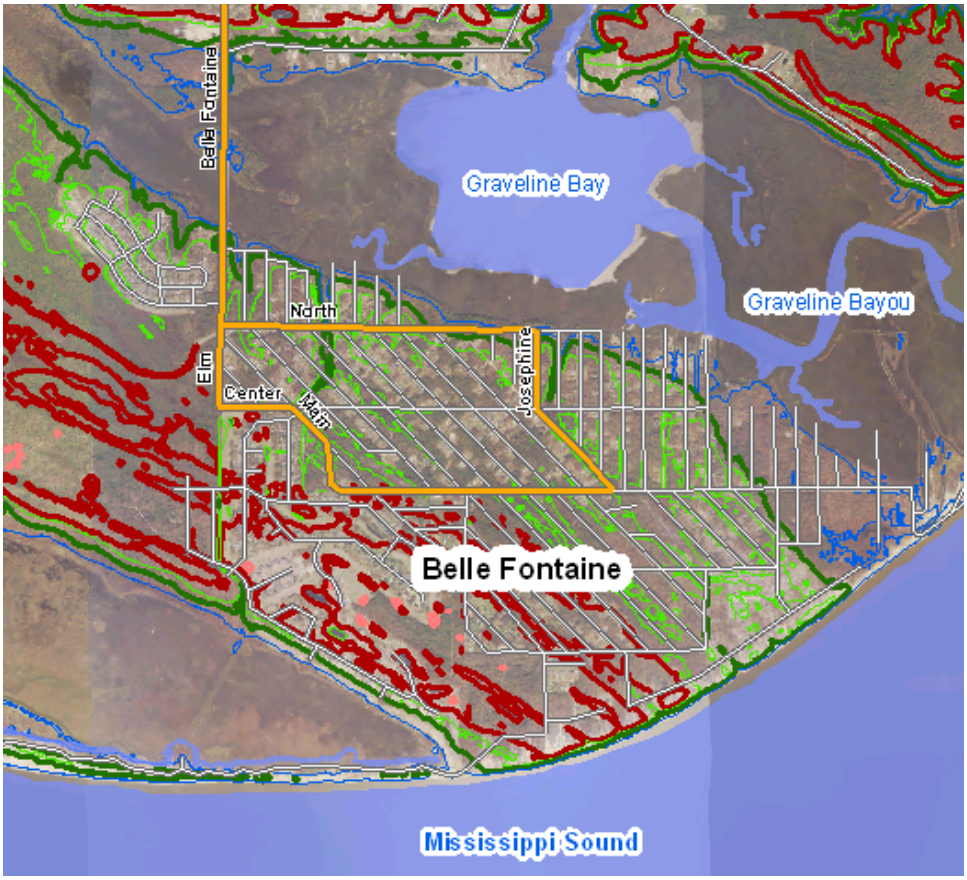


Figure 3.3.10-3. Existing Condition, Belle Fontaine



Source : http://ngs.woc.noaa.gov/storms/katrina/24330547.jpg

Figure 3.3.10-4. Hurricane Katrina Damage in Belle Fontaine



Source: http://ngs.woc.noaa.gov/storms/katrina/24330558.jpg

Figure 3.3.10-5. Hurricane Katrina Damage, Belle Fontaine

3.3.10.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8ft(dark green), 12-ft(light green), 16-ft(brown), and 20-ft(pink) ground contour lines and levee limits are shown below in Figure 3.3.10-6. The data indicates the Katrina high water was as high as 21 ft NAVD88 near the Mississippi Sound, totally inundating the area.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Belle Fontaine at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.10-7.

Existing Condition Stage –Frequency data for Save Point 30, just off the coast of Belle Fontaine, is shown below in Figure 3.3.10-8. The 95% and 5% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

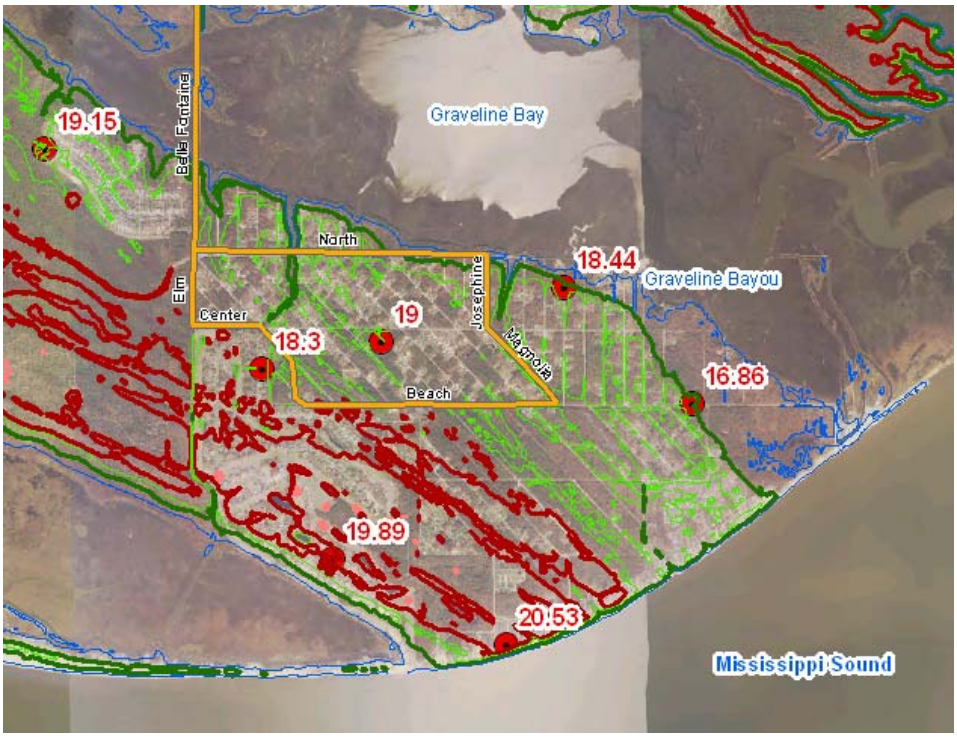


Figure 3.3.10-6. Ground Contours and Katrina High Water Elevations, Belle Fontaine



Figure 3.3.10-7. Hydrodynamic Modeling Save Points near Belle Fontaine

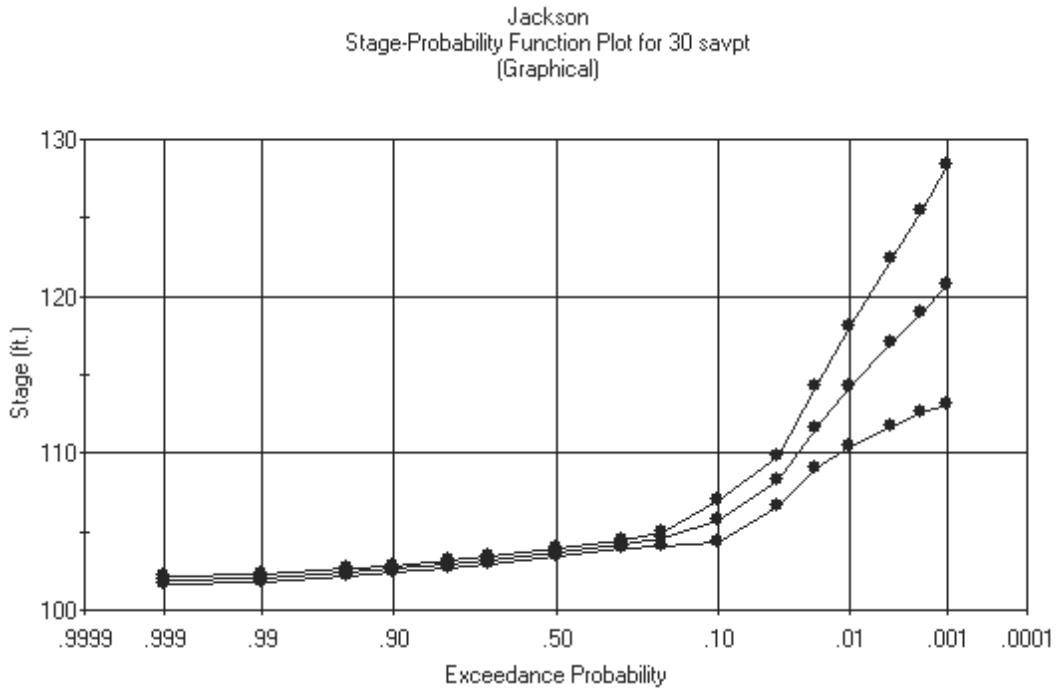


Figure 3.3.10-8. Existing Conditions at Save Point 30, near Belle Fontaine, MS

3.3.10.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 1440 acres around the subdivision of Belle Fontaine as shown on the following Figure 3.3.10-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in Figure 3.3.10-10.

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown in Figure 3.3.10-11 was caused by approximately 1-2 ft of overtopping crest depth.



Figure 3.3.10-9. Pump/Culvert/Sub-basin Locations



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.10-10. North Sea, Germany, March 1976



Source: ERDC, Steven Hughes

Figure 3.3.10-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.10-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

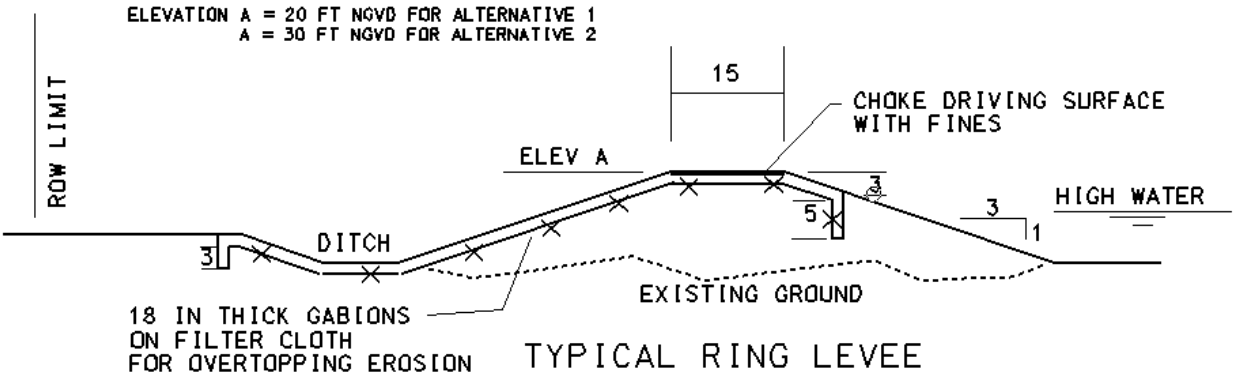


Figure 3.3.10-12. Typical Section at Ring Levee

3.3.10.5.1 Interior Drainage

Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee at the locations shown above. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.10-13.

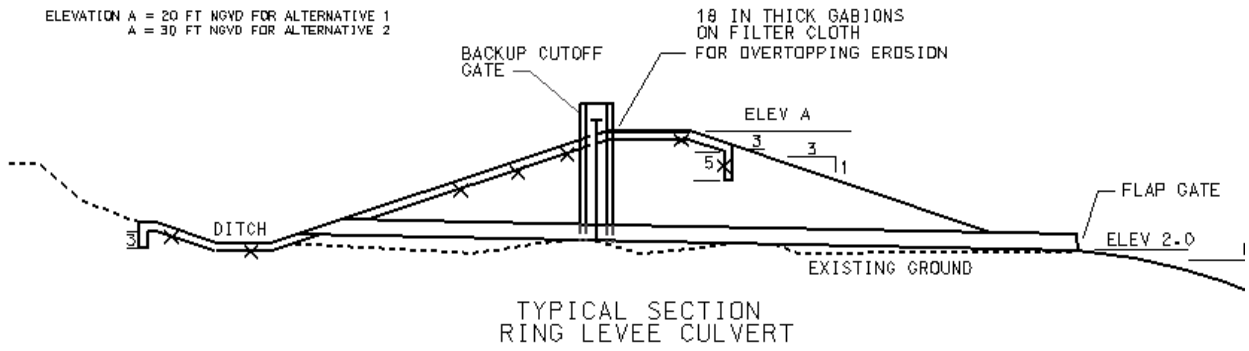


Figure 3.3.10-13. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the ring levee into major sub-basins and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number. The variation in soil types, hydrologic soil groups, and major sub-basins are shown below in Figure 3.3.10-14.

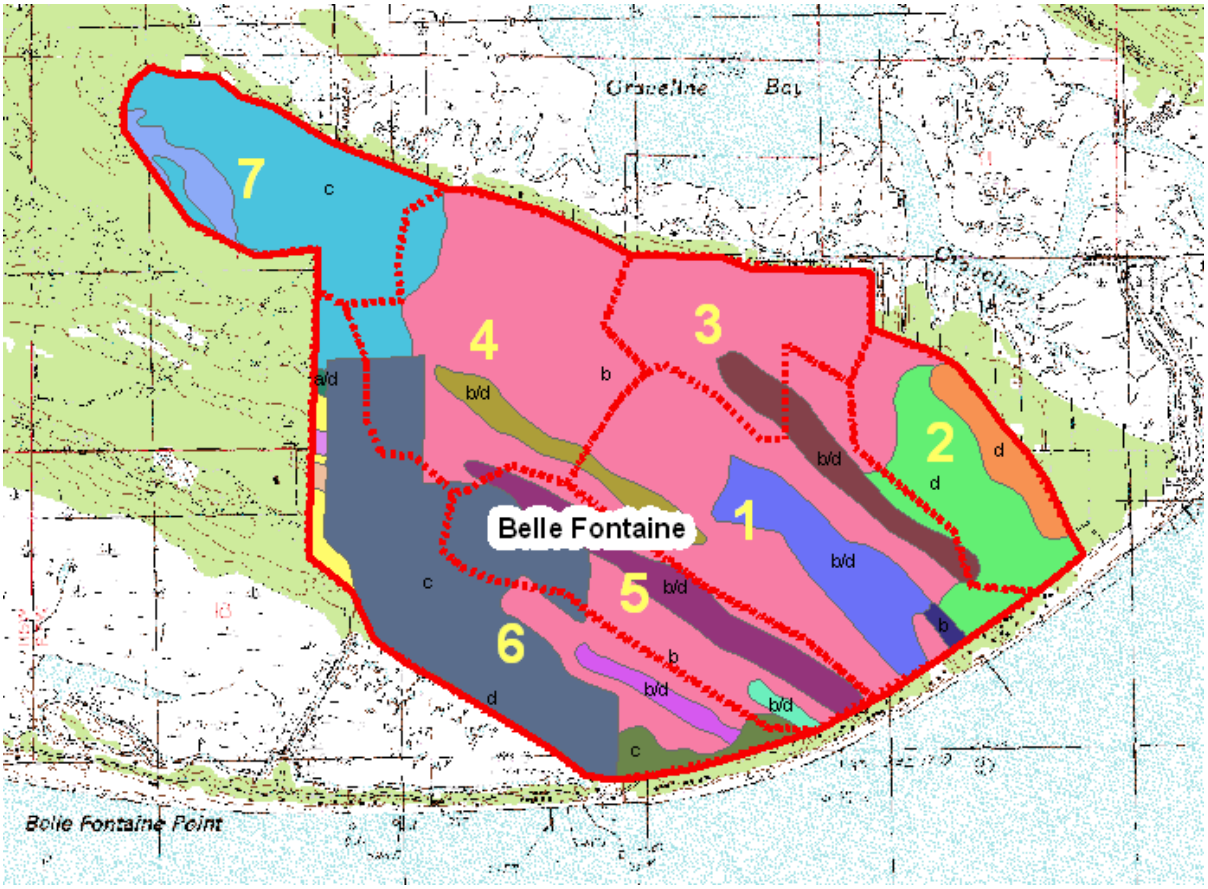


Figure 3.3.10-14. Belle Fontaine Hydrologic Soil Groups

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico" US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is "National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)", R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report, therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.10.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation

consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.10.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts and pumping facilities. The sites are shown above.

3.3.10.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.10.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In

every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.10.5.3.3 Pumping Stations Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.10.5.3.4 Pumping Stations Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.10.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 7 pumping facilities included in the Bellfontaine Ring Levee system for the elevation 20 protection level varied from approximately 10 to 15 feet and the corresponding flows required varied from 99,191 to 273,787 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 290 horsepower pumps, to one having four 60-inch diameter pumps each running at 560 horsepower.

3.3.10.5.3.6 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the

protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.10.5.3.7 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.10.5.3.8 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bellefontaine area to elevation 20, 10 roadway intersections would have to be accommodated. For this study it was estimated that 5 roller gate structures and 5 swing gate structures would be required.

3.3.10.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.10.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater

will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.10.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.10.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.10.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.10.9, Cost Summary. Construction costs for the various options are included in Table 3.3.10-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.10-2. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and

coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.10.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.10.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Belle Fontaine. The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.10.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.10.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.10.6.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

3.3.10.6.3.1 Flow and Pump Sizes

Design hydraulic heads derived for the 7 pumping facilities included in the Bellefontaine Ring Levee system for the elevation 30 protection level varied from approximately 20 to 25 feet and the corresponding flows required varied from 99,191 to 273,787 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 475 horsepower pumps, to one having four 54-inch diameter pumps each running at 775 horsepower.

3.3.10.6.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bellefontaine area to elevation 30, 13 roadway intersections would have to be accommodated. For this study it was estimated that all 13 would require swing gate structures.

3.3.10.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.10.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.10.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.10.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.10.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.10.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.10.7 Option C – Alternate Alignment, Elevation 20 ft NAVD88

This option consists of an earthen levee at elevation 20 ft NAVD88 enclosing an area of 1341 acres around the most populated areas of Belle Fontaine in an alignment slightly different from the alignment for Options A and B. The alignment of the levee is shown in Figure 3.3.10-15 below, which also shows the variation in the drainage sub-basins and the locations of the pumps and culverts.



Figure 3.3.10-15. Alternative Alignment Pump/Culvert/Sub-basin Locations

3.3.10.7.1 Interior Drainage

Interior drainage flows are similar to those computed for Option A, above. However, ditches, culverts and pumps were re-sized by adjusting the previously computed flows by the ratio of the change in areas of the sub-basins to get the revised flows.

3.3.10.7.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option C are the same as for Option A, above.

3.3.10.7.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option C is presented below.

3.3.10.7.3.1 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 7 pumping facilities included in the Bellefontaine Ring Levee system for the elevation 20 protection level varied from approximately 10 to 20 feet and the corresponding flows required varied from 99,453 to 274,644 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 290 horsepower pumps, to one having five 42-inch diameter pumps each running at 475 horsepower.

3.3.10.7.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bellefontaine area to elevation 20, 13 roadway intersections would have to be accommodated. For this study it was estimated that 5 of these would require 10 swing gate structures with the remaining 8 requiring roller gates of varying heights.

3.3.10.7.4 HTRW

The HTRW paragraphs for Option C are the same as for Option A, above.

3.3.10.7.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option C are the same as for Option A, above.

3.3.10.7.6 Project Security

The Project Security paragraphs for Option C are the same as for Option A, above.

3.3.10.7.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option C are the same as for Option A, above.

3.3.10.7.8 Cost Estimate

The Cost Estimate paragraphs for Option C are the same as for Option A, above.

3.3.10.7.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option C are the same as for Option A, above.

3.3.10.8 Option D – Alternate Alignment, Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Belle Fontaine. The alignment of the levee is the same as Option C, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option C is the height

of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.10.8.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option C, above, except that the culvert lengths through the levees would be longer.

3.3.10.8.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option D are the same as for Option A, above.

3.3.10.8.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option D is presented below.

3.3.10.8.3.1 Pumping Stations. Flow and Pump Sizes.

Design hydraulic heads derived for the 7 pumping facilities included in the Bellefontaine Ring Levee system for the elevation 30 protection level varied from approximately 20 to 30 feet and the corresponding flows required varied from 99,453 to 274,644 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 475 horsepower pumps, to one having three 60-inch diameter pumps each running at 1150 horsepower.

3.3.10.8.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bellefontaine area to elevation 30, 11 roadway intersections would have to be accommodated. For this study it was estimated that all 11 would require 22 swing gate structures.

3.3.10.8.4 HTRW

The HTRW paragraphs for Option D are the same as for Option A, above.

3.3.10.8.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option D are the same as for Option A, above.

3.3.10.8.6 Project Security

The Project Security paragraphs for Option D are the same as for Option A, above.

3.3.10.8.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option D are the same as for Option A, above.

3.3.10.8.8 Cost Estimate

The Cost Estimate paragraphs for Option D are the same as for Option A, above.

3.3.10.8.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option D are the same as for Option A, above.

3.3.10.9 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.10-1 and 3.3.10-2, below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.10-1.
Jackson Co Belle Fontaine Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$137,600,000
Option B – Elevation 30 ft NAVD88	$191,900,000
Option C – Elevation 30 ft NAVD88	$103,900,000
Option D – Elevation 30 ft NAVD88	$142,900,000

Table 3.3.10-2.
Jackson Co Belle Fontaine Ring Levee O & M Cost Summary

Option	O&M Cost
Option A – Elevation 20 ft NAVD88	$1,371,000
Option B – Elevation 30 ft NAVD88	$1,939,000
Option C – Elevation 30 ft NAVD88	$989,000
Option D – Elevation 30 ft NAVD88	$1,414,000

3.3.10.10 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

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Environmental Science Services Administration. 1968. “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968.

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3.3.11 Jackson County, Gautier Ring Levee

3.3.11.1 General

Several high density residential and business areas in Jackson County were identified. They are: Pascagoula/Mosspoint, Gautier, Belle Fontaine, Gulf Park Estates, and Ocean Springs. These are subject to damage from storm surges associated with hurricanes. Earthen ring levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center’s (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.11.2 Location

The location of the Gautier ring levee in Jackson County is shown below in Figures 3.3.11-1 and 3.3.11-2.

3.3.11.3 Existing Conditions

Gautier is located on the west side of the Pascagoula River delta at the mouth of the West Pascagoula River at the Mississippi Sound. Ground elevations over most of the residential and business areas vary between elevation 10-20 ft NAVD88. The southern-most part of the area is drained by drowned natural drainage ways. The 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and city limits are shown below in Figure 3.3.11-3.

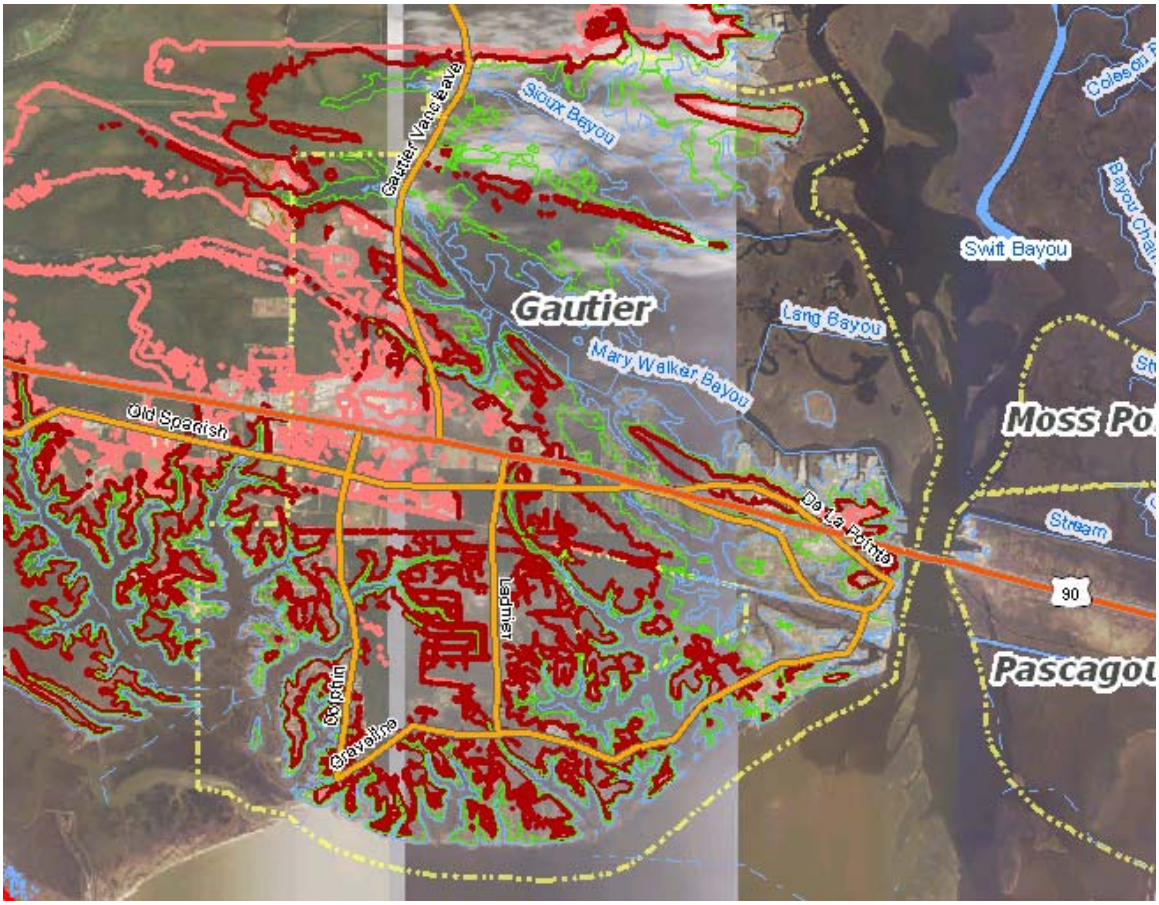


Figure 3.3.11-1 Vicinity Map, Gautier, MS

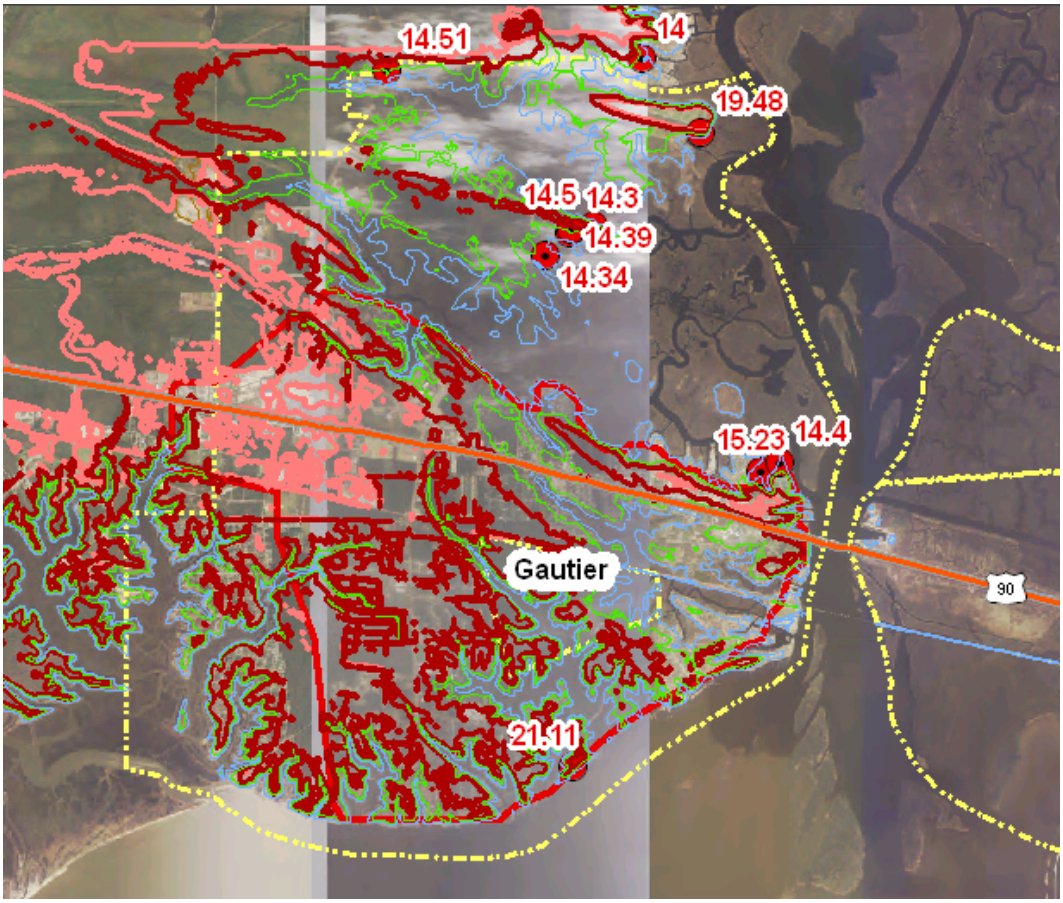


Figure 3.3.11-2 Gautier Ring Levee

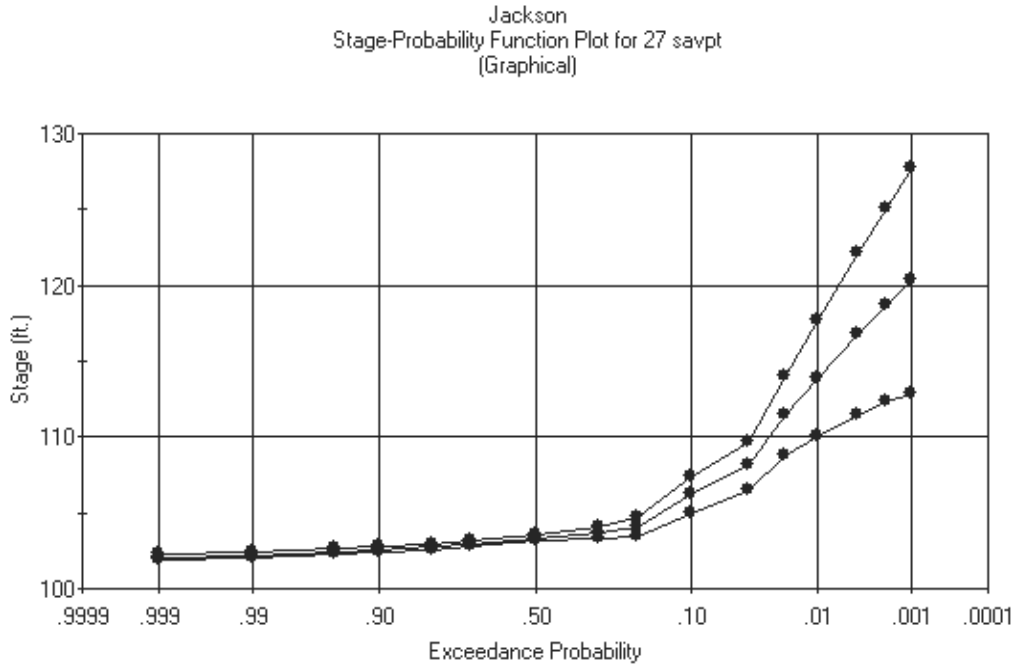


Figure 3.3.11-3. Existing Conditions

Drainage in the southern part of the city is through drowned streams that empty into Mississippi Sound. These are therefore unusually wider at the mouth and have productive environmental and recreational benefits.

Drainage from ordinary rainfall is hindered on occasions when either of the rivers or the gulf is high, but impacts from hurricanes are devastating.

Recent damage from Hurricane Katrina in August, 2005 the Gautier area are shown below in Figure 3.3.11-4 and 3.3.11-5. Many homes are still un-repaired, pending settlement of insurance claims.



Source: http://coastal.er.usgs.gov/hurricanes/katrina/quickphotos/gautier/

Figure 3.3.11-4. Hurricane Katrina Damage in Gautier, MS



Figure 3.3.11-5. Hurricane Katrina Damage in Gautier, MS

3.3.11.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4, of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and city limits are shown below in Figure 3.3.10-6. The data indicates the Katrina high water was as high as 21 ft NAVD88 at the Mississippi Sound and 15 ft NAVD88 north of Hwy 90.

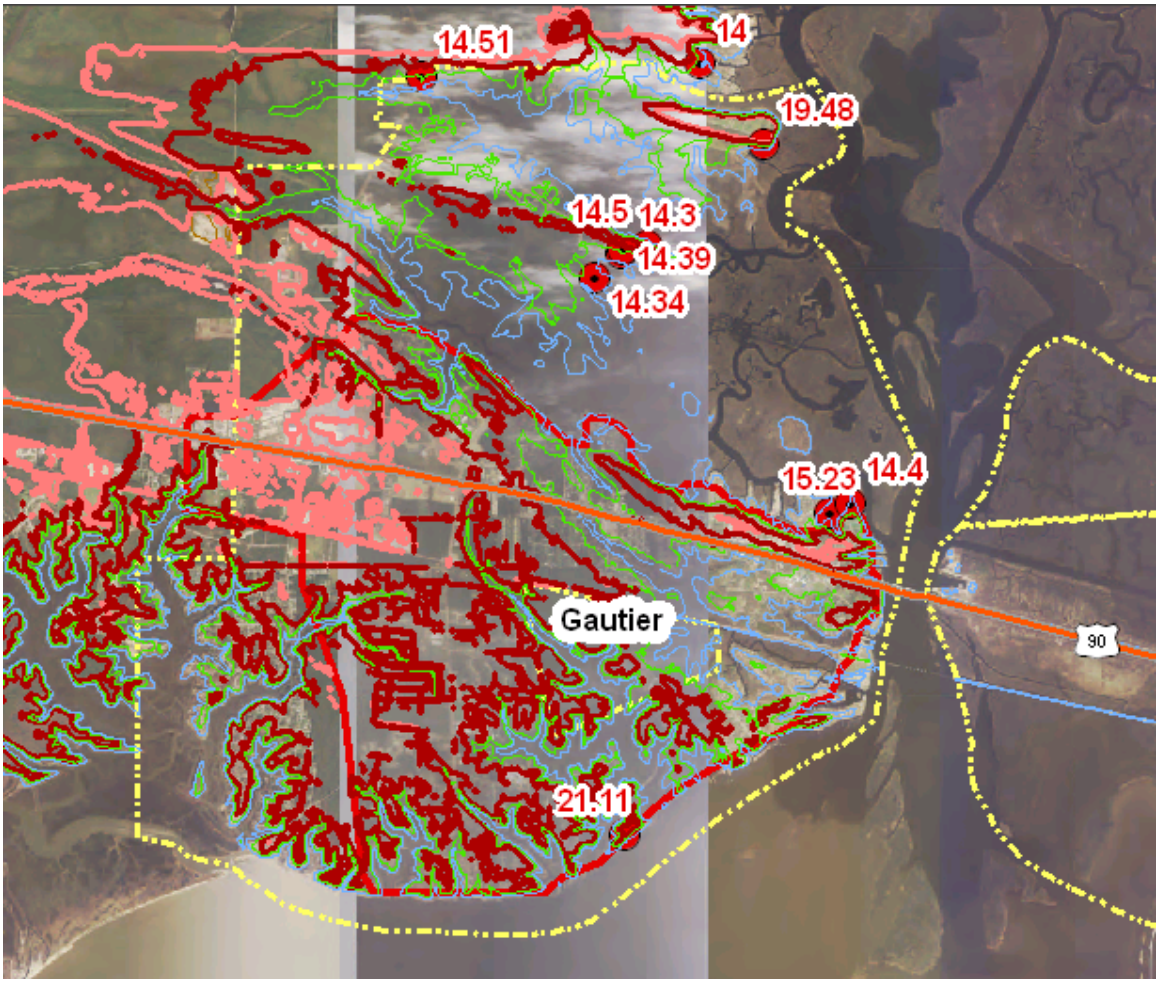


Figure 3.3.11-6. Ground Contours and Katrina High Water Elevations

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix 3.3.11.2. Points near Gautier at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.11-7.

Existing Condition Stage –Frequency data for Save Point 27, just off the coast of Gautier, is shown below in Figure 3.3.11-8. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.



Figure 3.3.11-7. Hydrodynamic Modeling Save Points near Gautier

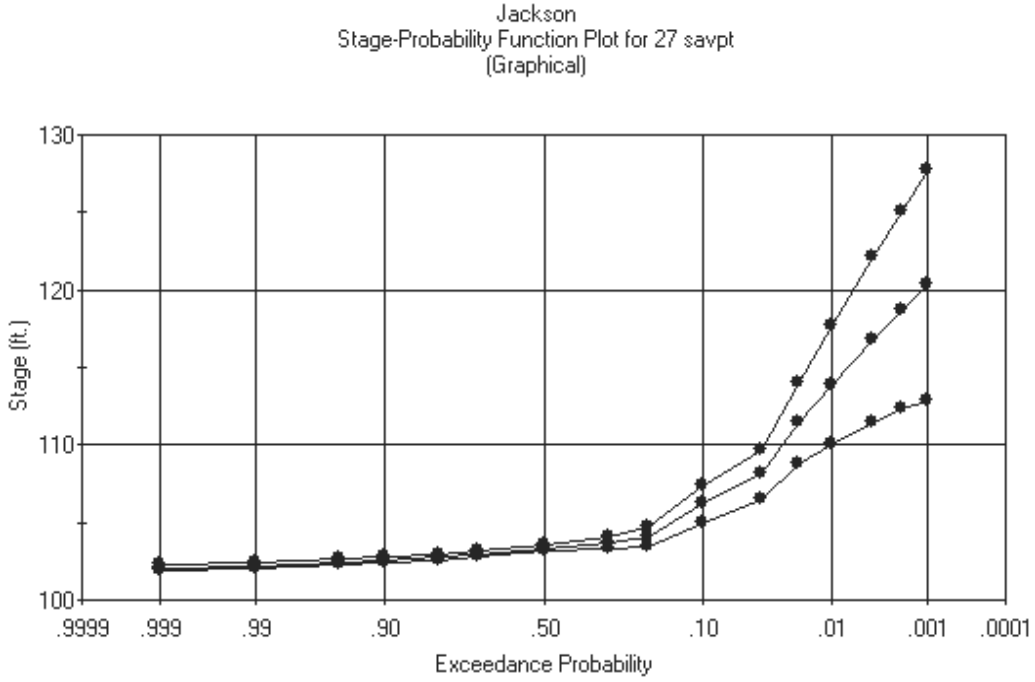


Figure 3.3.11-8. Existing Conditions at Save Point 27, near Gautier, MS

3.3.11.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 4833 acres around the most densely populated areas of Gautier as shown on the following Figure 3.3.11-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal. A small boat access structure is also shown at the mouth of several basins. Rising sector gates will be provided at these sites allowing shallow draft traffic most of the time. The gates will be closed prior to hurricane storm surge. Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown below in Figure 3.3.11-10.

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.11-11 was caused by approximately 1-2 ft of overtopping crest depth.

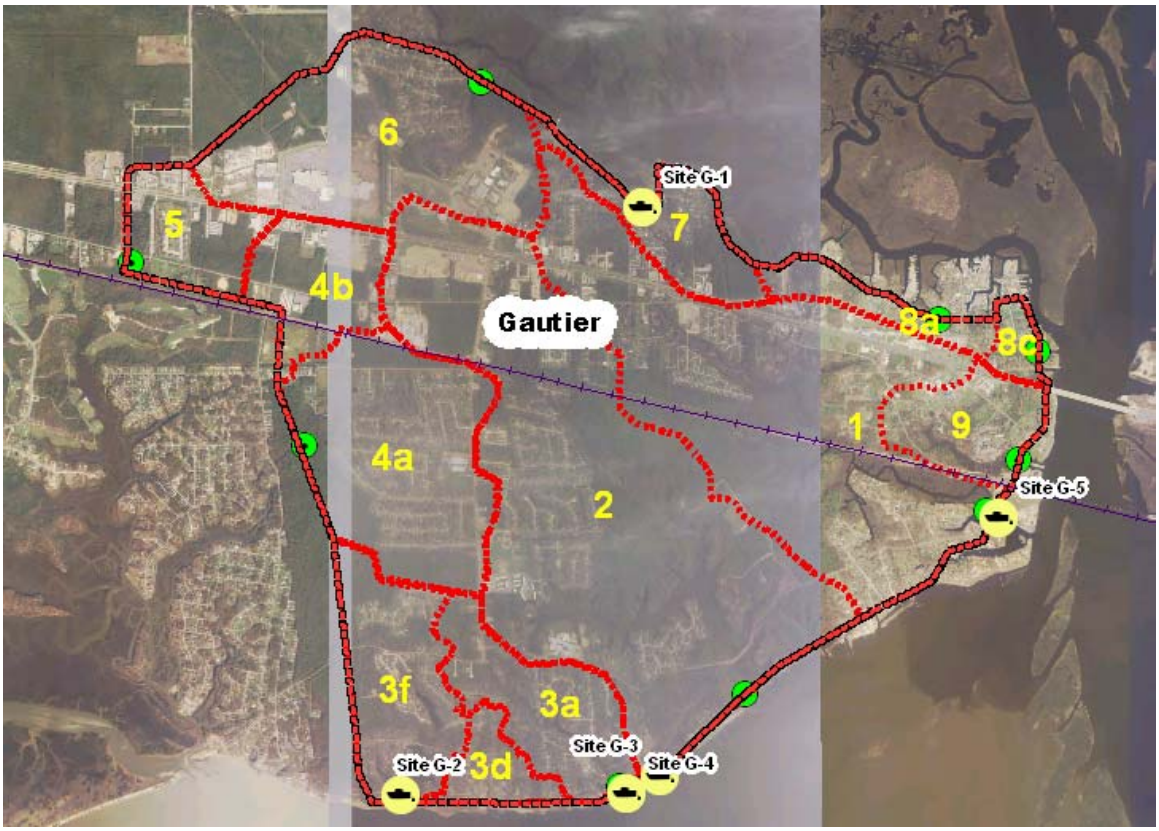


Figure 3.3.11-9. Pump/Culvert/Sub-basin/Boat Access Site Locations



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.11-10. North Sea, Germany, March 1976



Source: ERDC, Steven Hughes

Figure 3.3.11-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.11-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

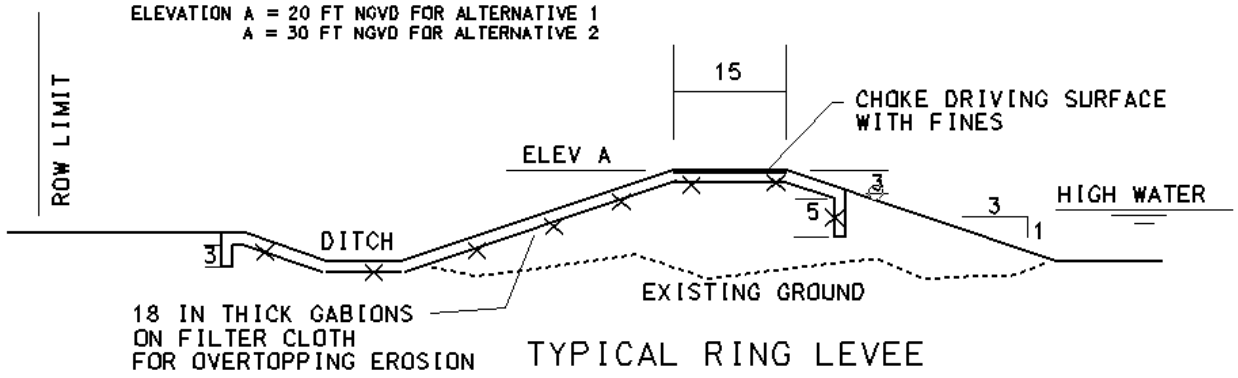


Figure 3.3.11-12. Typical Section at Ring Levee

3.3.11.5.1 Interior Drainage

Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee at the locations shown above in Figure 3.3.11-9. The culverts would have tidal gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at the upstream end at every culvert in the levee for manual control in the event the tidal gate malfunctions. A typical section is shown is shown below in Figure 3.3.11-13.

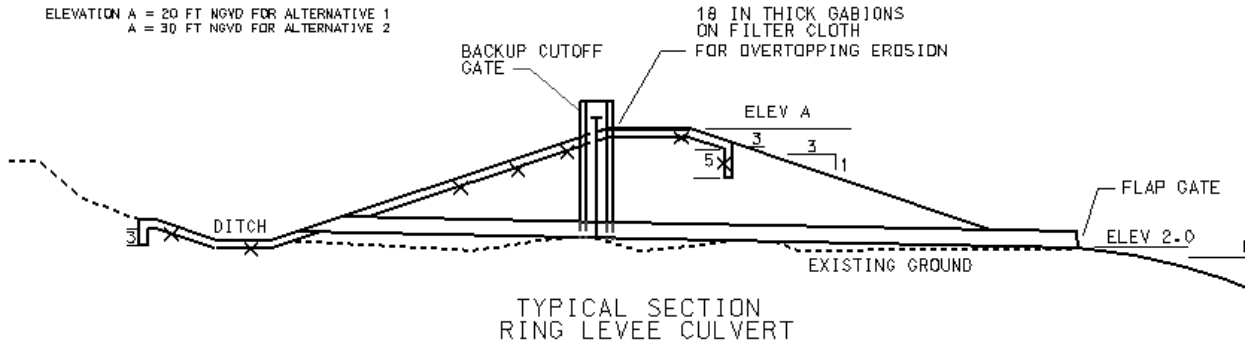


Figure 3.3.11-13. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the ring levee into major sub-basins as shown above in Figure 3.3.11-9 and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type shown below in Figure 3.3.11-14 and land use to determine a run-off curve number. The variation in soil type, hydrologic soil groups, and sub-basins is shown below in Figure 3.3.11-14.

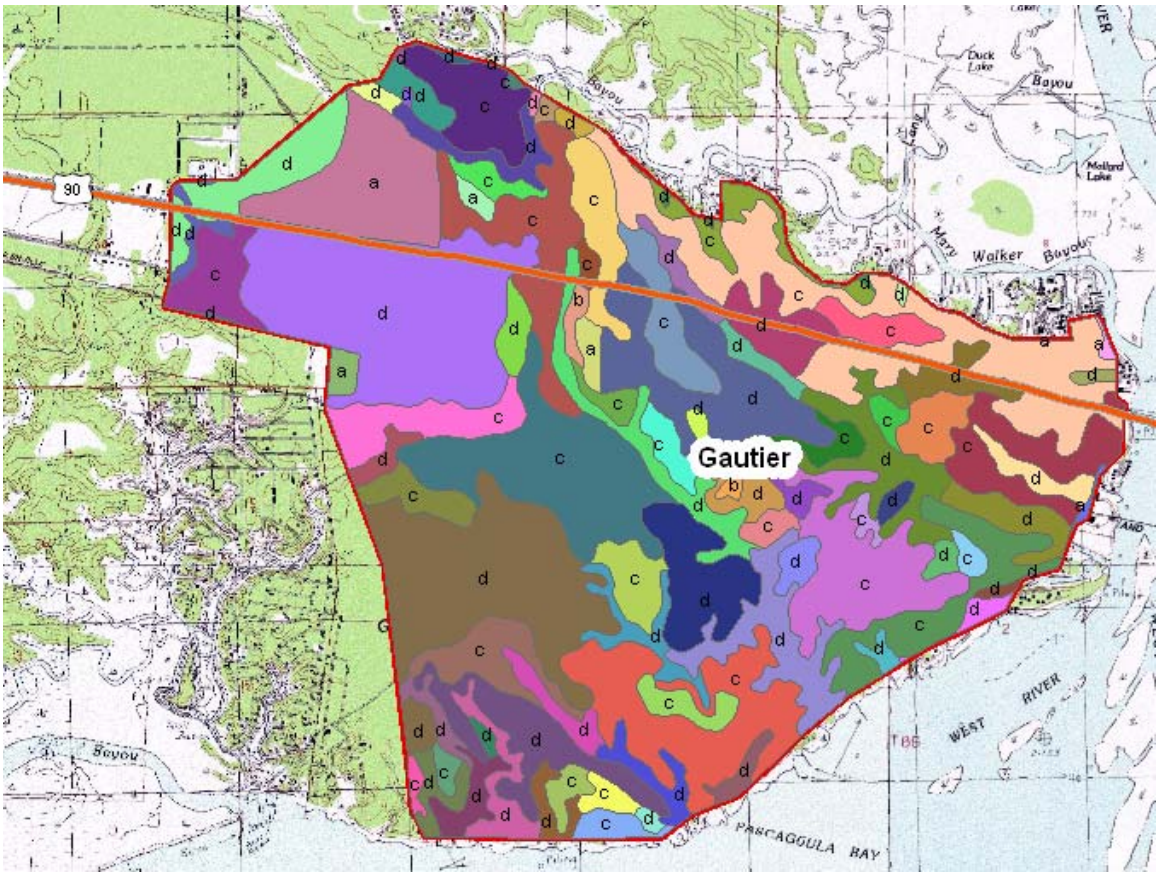


Figure 3.3.11-14. Gautier Hydrologic Soil Groups

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Aerial Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico" US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is "National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes

(And Other Tropical Disturbances)", R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report, therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.11.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of

clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.11.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts, pumping facilities and for boat access sites. The sites are shown above in Figure 3.3.11-9.

3.3.11.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.11.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.11.5.3.3 Pumping Facilities Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary

purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.11.5.3.4 Pumping Facilities Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.11.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 11 facilities included in the Gautier Ring Levee system for the elevation 20 protection level varied from approximately 15 to 20 feet and the corresponding flows required varied from 65,081 to 558,795 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 300 horsepower pumps, to one having six 60-inch diameter pumps each running at 560 horsepower.

3.3.11.5.3.6 Boat Access Structure

At five sites the Gautier ring levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. (See Figure 3.3.11-9 above). To allow continued free boat access to the areas behind the levee this site was fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay Saint Louis. This structure would, for the most part, be much smaller and lighter than those used in the bays, however it would be substantial. The operation would be similarly critical in time of storm and they would require the same attention from an Operations and Maintenance standpoint as their larger, heavier counterparts. The structure is shown below in Figure 3.3.11-15 and in Table 3.3.11-1.

Table 3.3.11-1.
Boat Access Structure Dimensional Data by Site

Site Designation	Protection Elevation, ft NAVD88	L1 ft	PW ft	H ft
G-1	20.0	50	18	29.5
	30.0	50	18	42.0
G-2	20.0	70	18	29.5
	30.0	70	18	42.0
G-3	20.0	32	18	29.5
	30.0	32	18	42.0
G-4	20.0	132	18	29.5
	30.0	132	18	42.0
G-5	20.0	104	18	29.5
	30.0	104	18	42.0

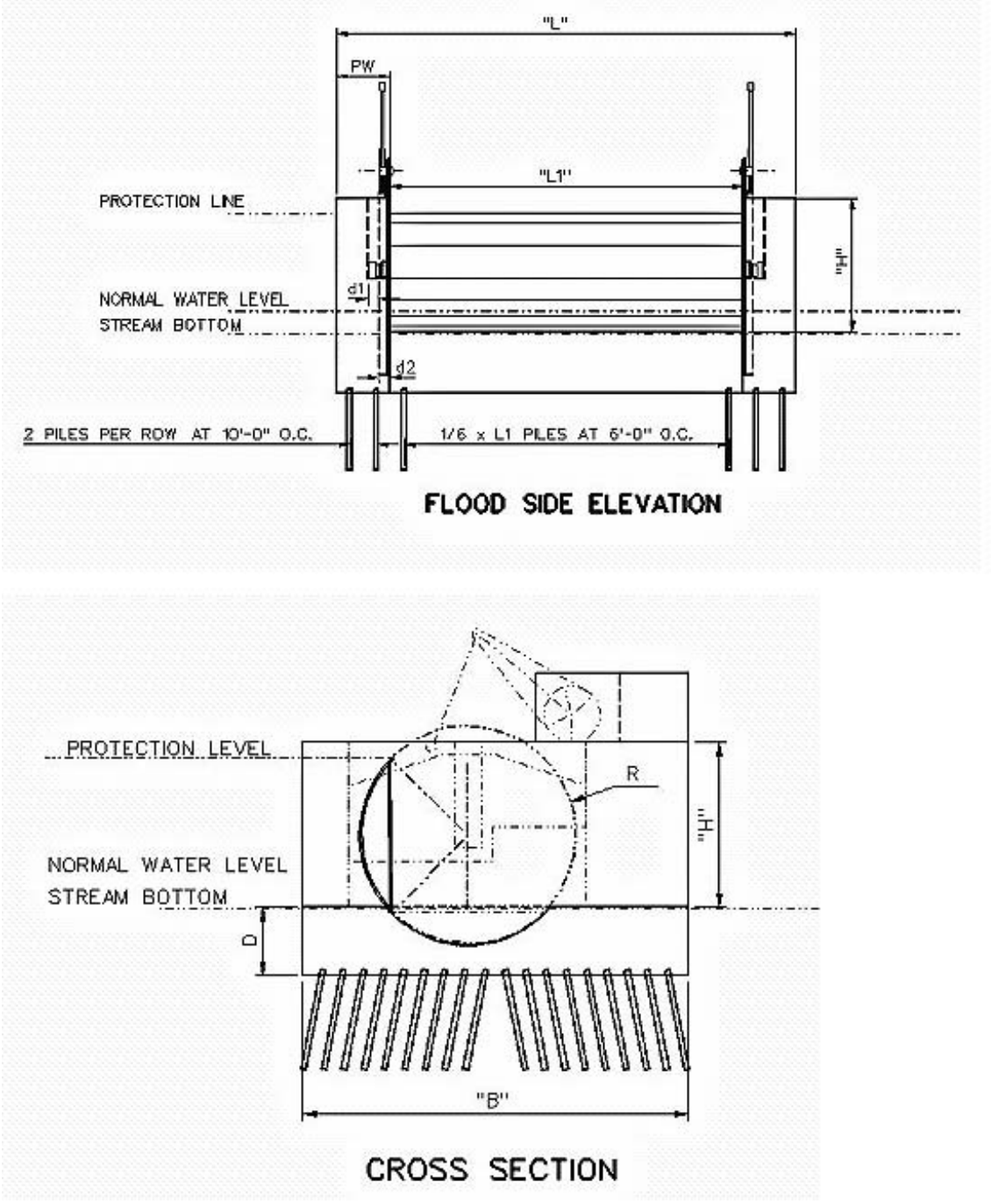


Figure 3.3.11-15. Typical Small Boat Access Structure

3.3.11.5.3.7 Boat Access Structure. Mechanical

The mechanical equipment and operating system for these structures would be similar to those used for the bay barriers, and would include steel gate linkages and hydraulic rams and pivot pins for operation of the gates. Each gate would rotate on large bearings and pivot hubs at the ends of the gate. Various operating hydraulic and lubrication oil systems would also be required. It is estimated that each gate would have a maximum opening/closing time of 15 minutes.

3.3.11.5.3.8 Boat Access Structure. Electrical

Primary electrical power for operating these gates would be provided using dedicated, standard transformers with emergency back-up generators. The electrical load demand at these facilities would be low by comparison to the bay barrier structures. The supplemental generation aspect was considered to be a vital component of the design because of the very high cost of commercial standby power and because commercial electric power would almost certainly be unavailable during and immediately following a storm event.

3.3.11.5.3.9 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.11.5.3.10 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.11.5.3.11 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Gautier area to elevation 20, 20 roadway intersections would have to be accommodated. For this study it was estimated that 11 roller gate structures and 11 swing gate structures would be required.

3.3.11.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.11.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.11.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Boat access gates and power plants would require this level of security.

3.3.11.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.11.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.11.7, Cost Summary. Construction costs for the various options are included in Table 3.3.11-2 and costs for the

annualized Operation and Maintenance of the options are included in Table 3.3.11-3. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.11.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.11.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Gautier The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.11.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.11.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.11.6.3 Structural, Mechanical and Electrical

These data are the same as that presented for Option A and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B are presented below.

3.3.11.6.3.1 Pumping Stations Flow and Pump Sizes

Design hydraulic heads derived for the 11 facilities included in the Gautier Ring Levee system for the elevation 20 protection level were steady at approximately 25 feet and the corresponding flows required varied from 65,081 to 558,795 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 500 horsepower pumps, to one having six 60-inch diameter pumps each running at 1000 horsepower.

3.3.11.6.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Gautier area to elevation 30, 23 roadway intersections would have to be accommodated. For this study it was estimated that all 23 would require swing gate structures.

3.3.11.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.11.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.11.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.11.6.7 Operation and Maintenance.

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.11.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.11.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.11.7 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are in Tables 3.3.11-2 and 3.3.11-3, shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.11-2.
Jackson Co Gautier Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$348,300,000
Option B – Elevation 30 ft NAVD88	$450,100,000

Table 3.3.11-3.
Jackson Co Gautier Ring Levee O & M Cost Summary

Option	Cost for O&M
Option A – Elevation 20 ft NAVD88	$3,744,000
Option B – Elevation 30 ft NAVD88	$4,904,000

3.3.11.8 References

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Weather Bureau and USACE. 1956. National Hurricane Research Project Report No. 3, “Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers.

3.3.12 Jackson County, Pascagoula/Moss Point Ring Levee

3.3.12.1 General

Several high density residential and business areas in Jackson County were identified. They are: Pascagoula/Mosspoint, Gautier, Belle Fontaine, Gulf Park Estates, and Ocean Springs. These are subject to damage from storm surges associated with hurricanes. Earthen ring levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center’s (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.12.2 Location

The general location of the Pascagoula/Moss Point ring levee in Jackson County is shown below in Figure 3.3.12-1. Four optional alignments are presented. Each has two levee height options. Each one is presented separately. The optional alignments are shown in Figure 3.3.12-2.

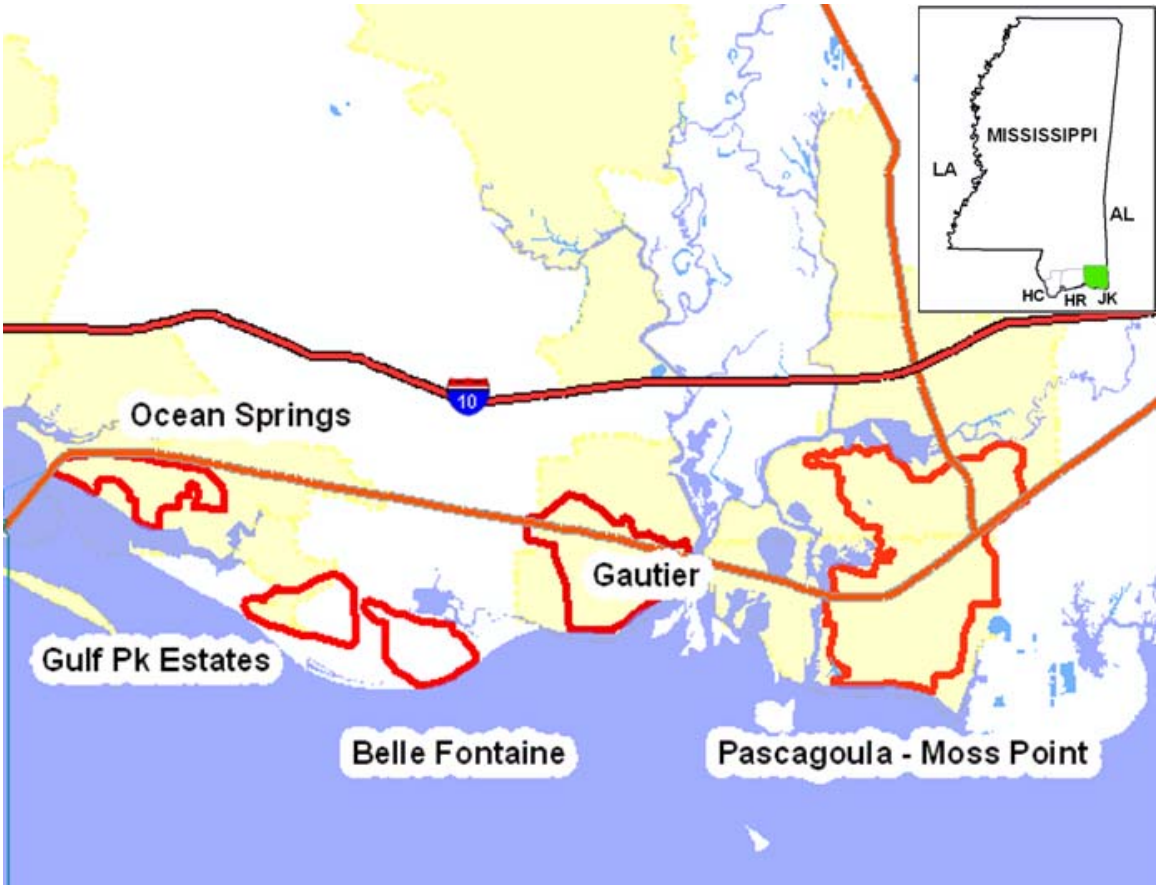


Figure 3.3.12-1. Vicinity Map Pascagoula, MS

The basic alignment is the most extensive and covers the main residential area in Pascagoula and Moss Point.

The Washington Ave. Alternate Alignment is the same as the basic alignment except that the alignment follows Washington Ave. on the southernmost leg of the levee.

The Moss Point Alternate Alignment is the same as the basic alignment except that the alignment follows higher ground on the northernmost part of the levee.

The Combined Washington Ave. and Moss Point Alternate Alignment is the same as the basic alignment except that in includes both the Washington Ave. and the Moss Point modifications on the north and south.

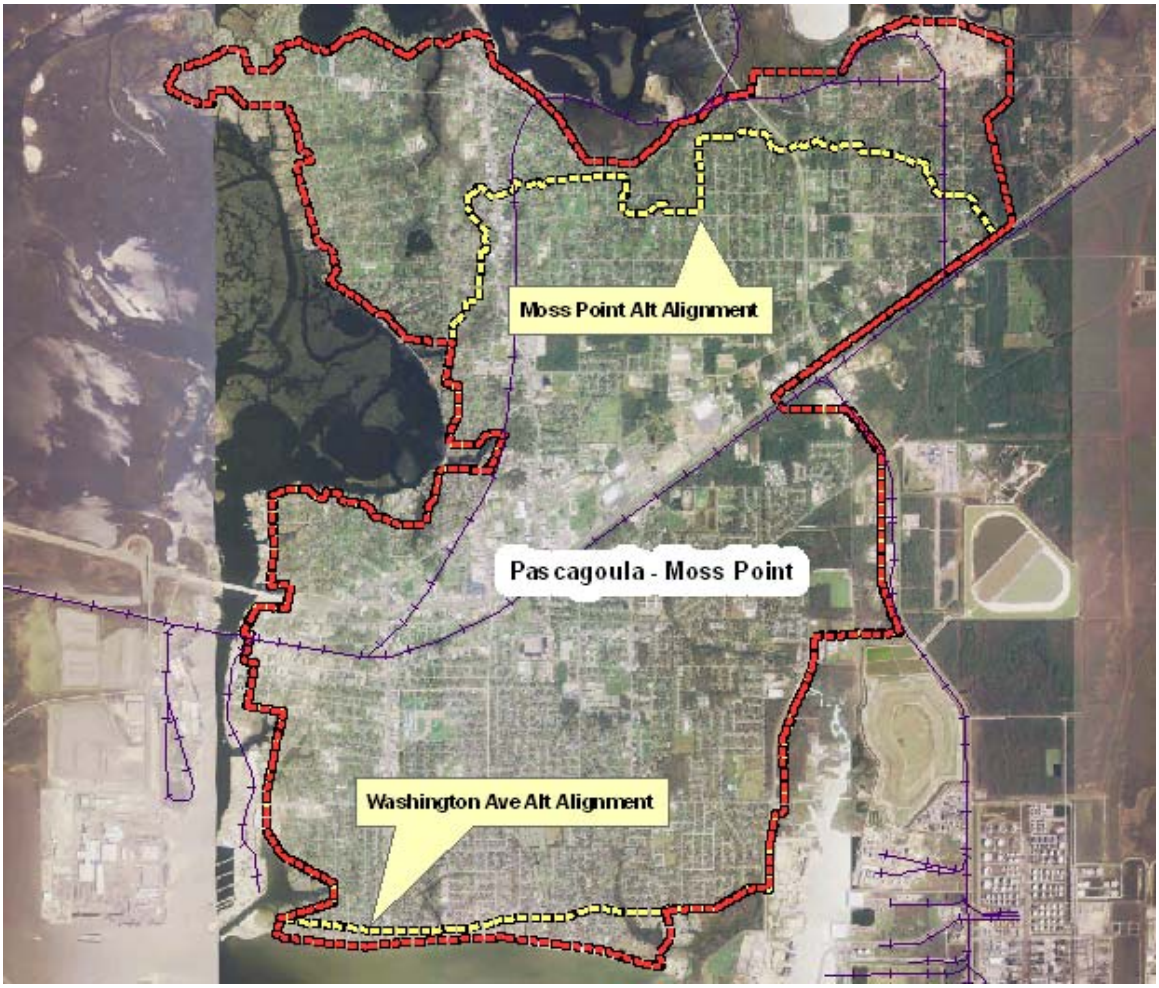


Figure 3.3.12-2. Pascagoula/Moss Point Ring Levees

3.3.12.3 Existing Conditions

The cities of Moss Point and Pascagoula lie at the confluence of the Escatawpa and Pascagoula Rivers along the gulf coast on Mississippi Sound. Both the northern part of Moss Point and the southern part of Pascagoula are very flat. Ground elevations over most of the residential and business areas vary between elevation 10-12 ft NAVD88 in the southern part of the area (Pascagoula) and 14-20 ft NAVD88 in the northern part (Moss Point). The 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and city limits are shown below in Figure 3.3.12-3.

The cities are drained by natural and some improved channels. These channels drain to the north to the Escatawpa River, the west to the Pascagoula River, to the south to the gulf, and to the east to Grand Bay Swamp, thence to the gulf. All are obviously subject to tidal influence.

Drainage from ordinary rainfall is hindered on occasions when either of the rivers or the gulf is high, but impacts from hurricanes are devastating.

Damage from Hurricane Katrina in August, 2005 in the Pascagoula area are shown below in Figures 3.3.12-4 and 3.3.12-5. Many homes are still un-repaired, pending settlement of insurance claims.

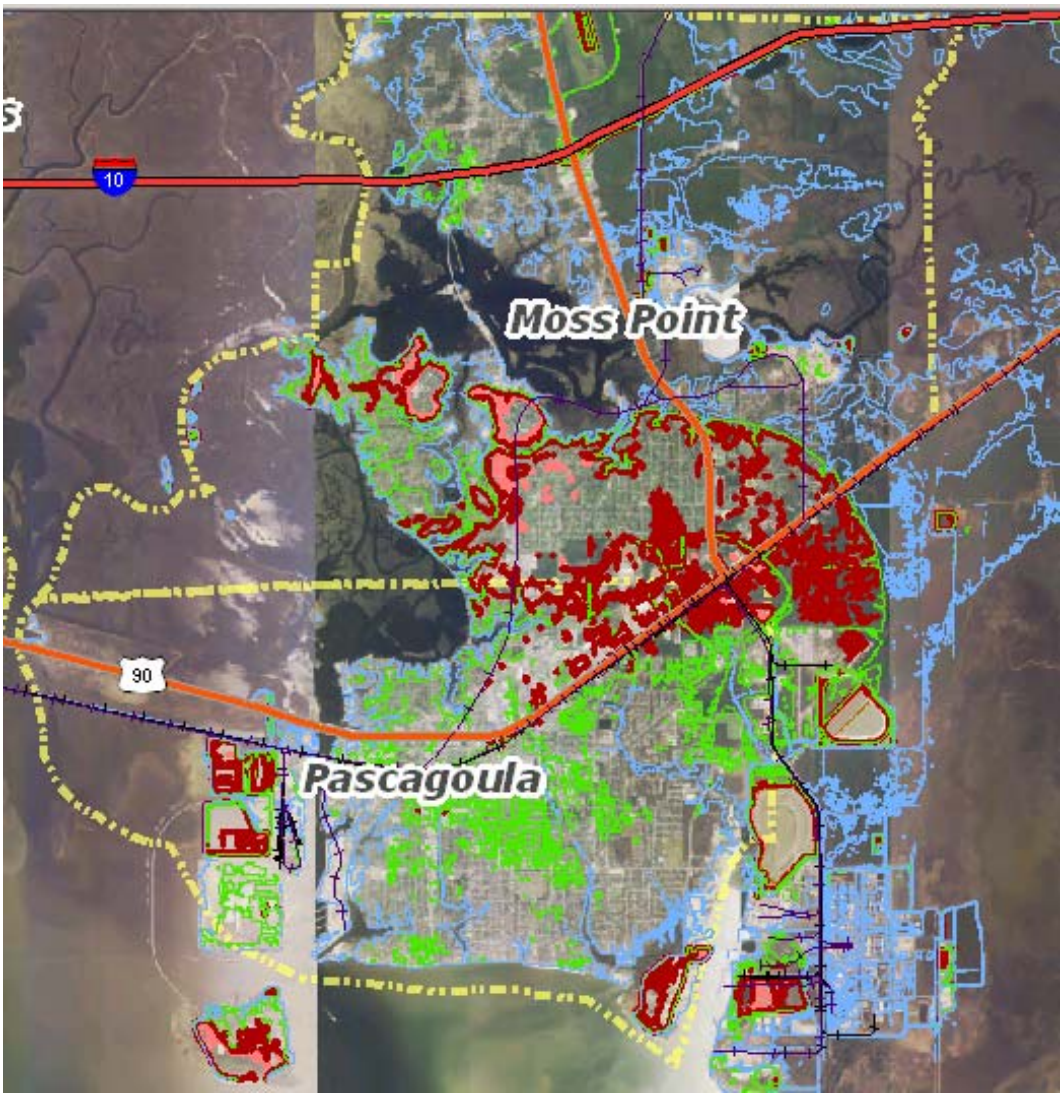


Figure 3.3.12-3. Existing Conditions Pascagoula, MS



Source : http://ngs.woc.noaa.gov/storms/katrina/24330050.jpg

Figure 3.3.12-4. Hurricane Katrina Damage Pascagoula, MS



Source: http://www.wunderground.com/hurricane/Katrinas_surge_part15.asp

Figure 3.3.12-5. Hurricane Katrina Damage Pascagoula, MS

3.3.12.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and city limits are shown below in Figure 3.3.12-6. The data indicates the Katrina high water was as high as 18-20 ft NAVD88 near the Mississippi Sound at Pascagoula and 12-15 ft NAVD88 in Moss Point.

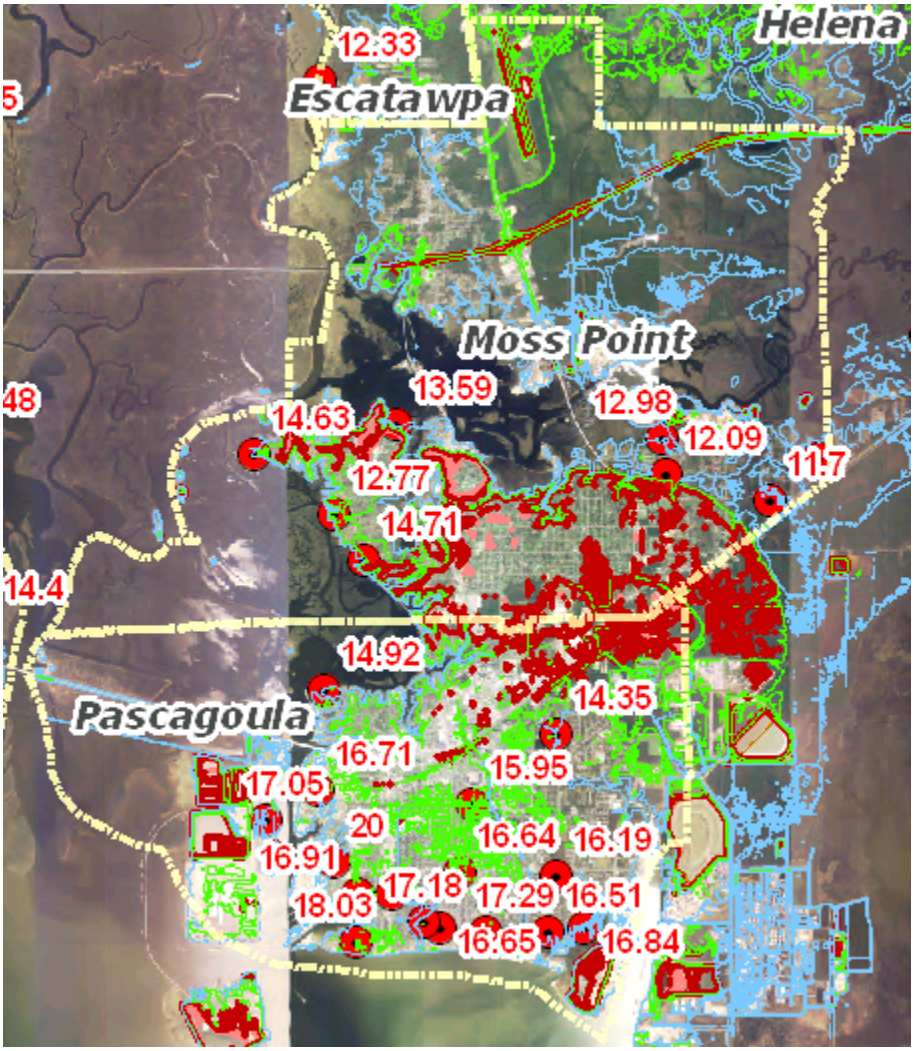


Figure 3.3.12-6. Ground Contours and Katrina High Water Elevations

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Pascagoula at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.12-7.

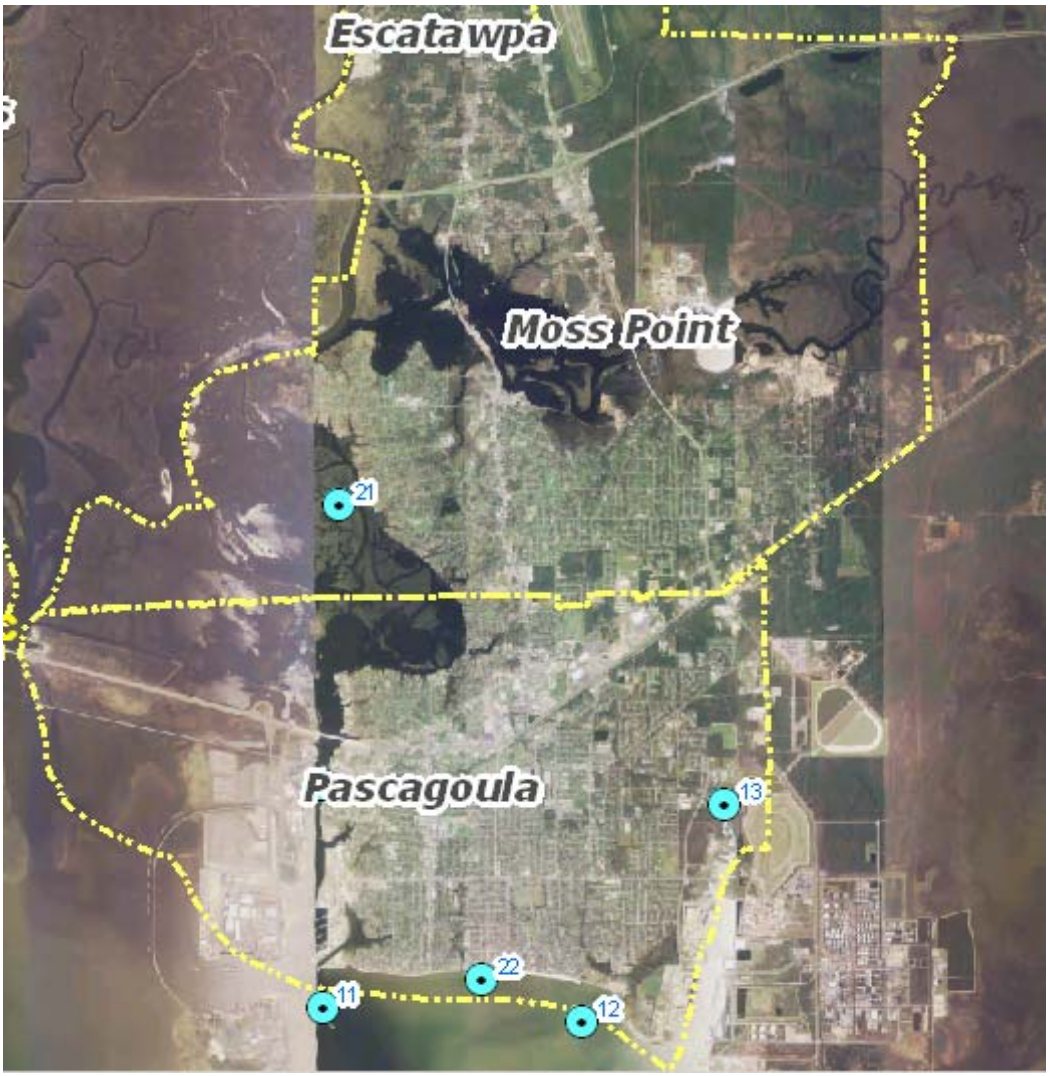


Figure 3.3.12-7. Hydrodynamic Modeling Save Points near Pascagoula

Existing Condition Stage –Frequency data for Save Point 22, just off the coast of Pascagoula, is shown below in Figure 3.3.12-8. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

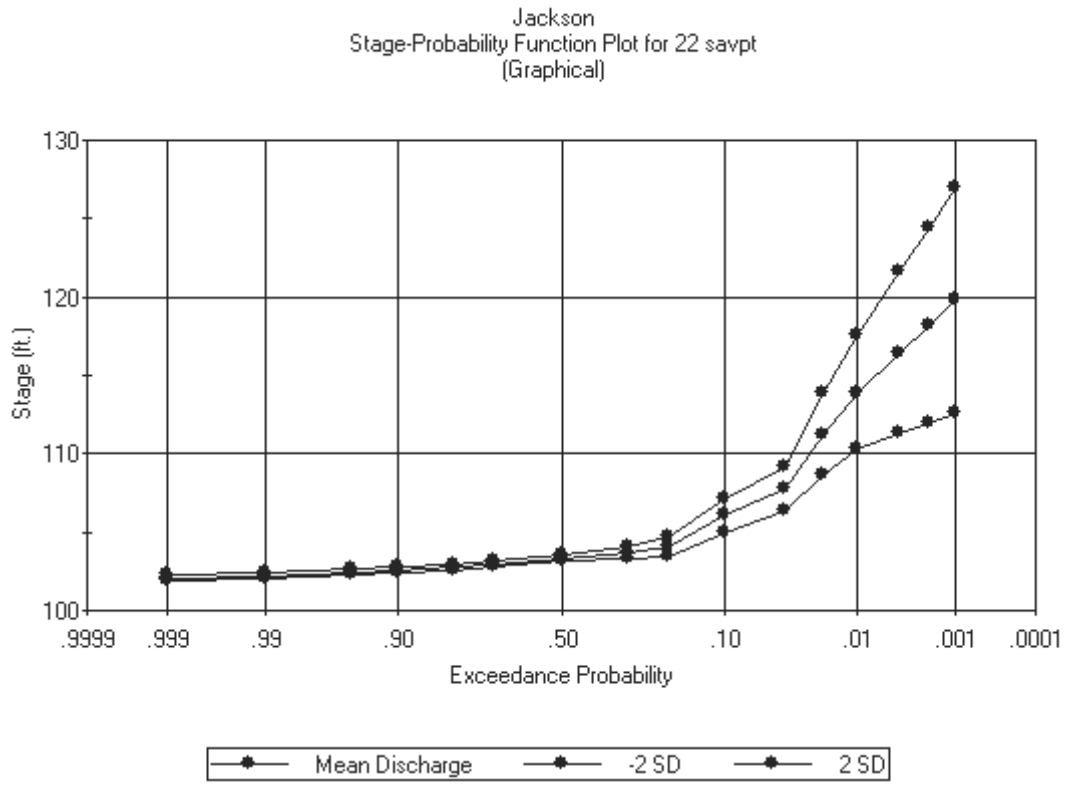


Figure 3.3.12-8. Existing Conditions at Save Point 22, near Pascagoula, MS

3.3.12.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 9523 acres around the most densely populated areas of Moss Point and Pascagoula as shown on the following Figure 3.3.12-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal. A small boat access structure is also shown at the mouth of Basin 20, PG-1 Site. Rising sector gates will be provided at this site allowing shallow draft traffic most of the time. The gates will be closed prior to hurricane storm surge. A drawing of a typical boat access gate is shown in Figure 3.3.12-15.

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in Figure 3.3.12-10.

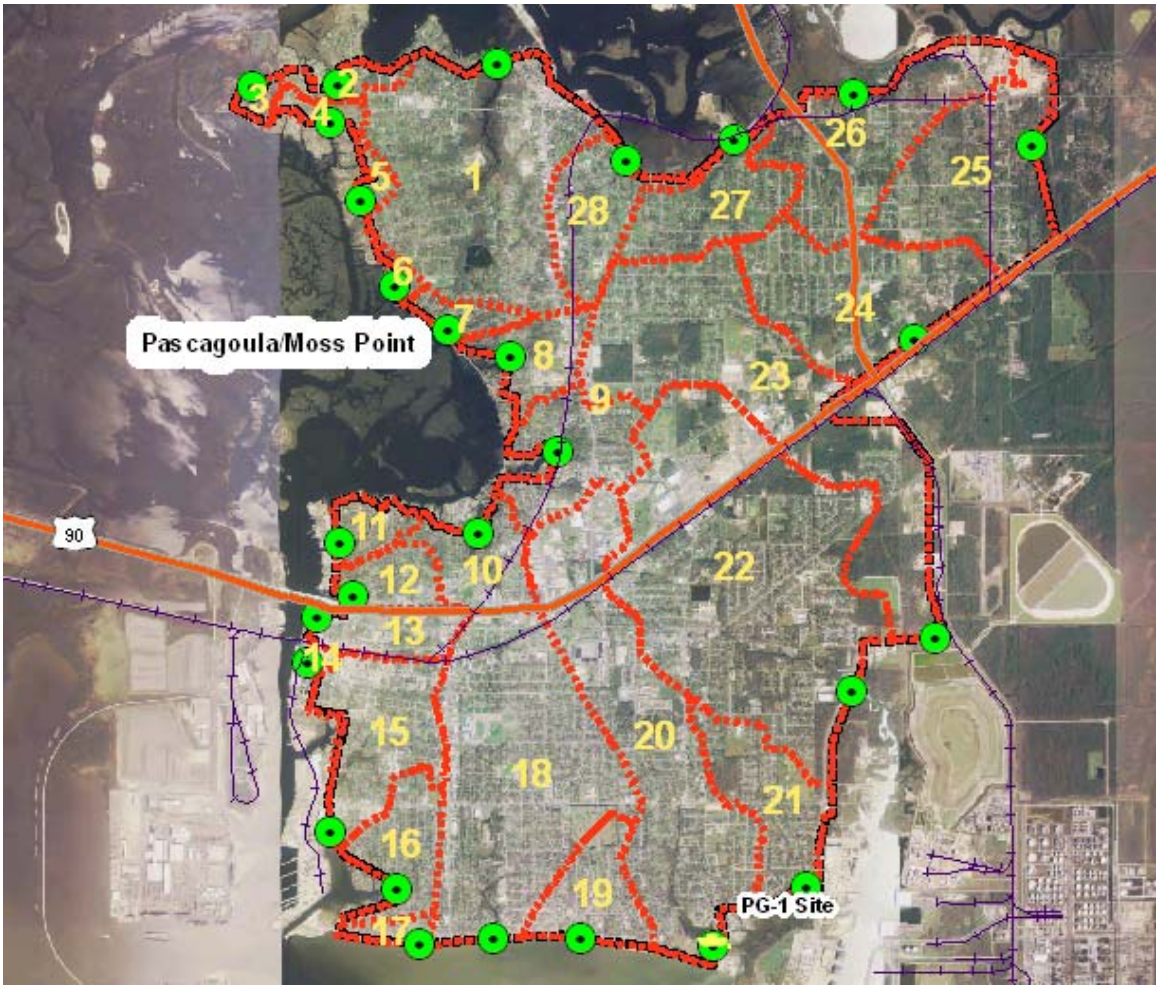


Figure 3.3.12-9. Basic Alignment Pump/Culvert/Sub-basin/Boat Access Site Locations



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.12-10. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.12-11 was caused by approximately 1-2 ft of overtopping crest depth.



Source: ERDC, Steven Hughes

Figure 3.3.12-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown on Figure 3.3.12-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

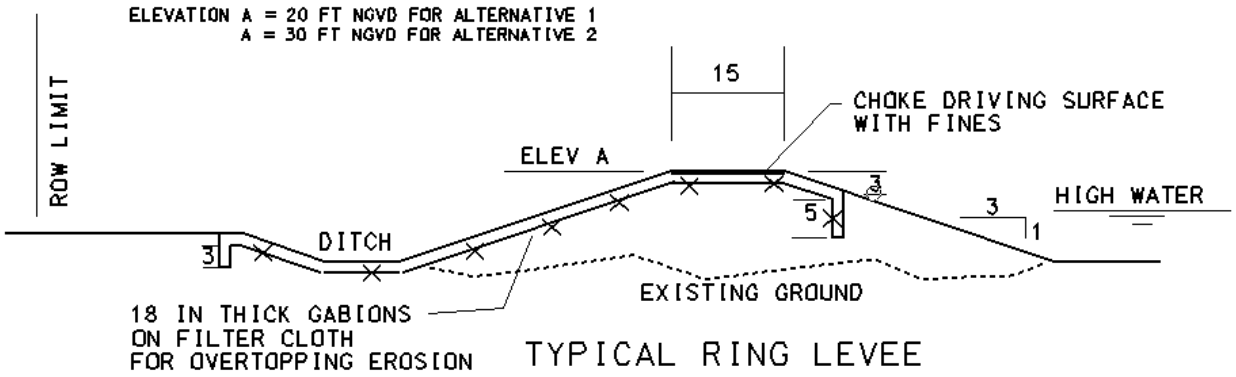


Figure 3.3.12-12. Typical Section at Ring Levee

3.3.12.5.1 Interior Drainage

Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee at the locations shown above in Figure 3.3.12-9. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An

additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.12-13.

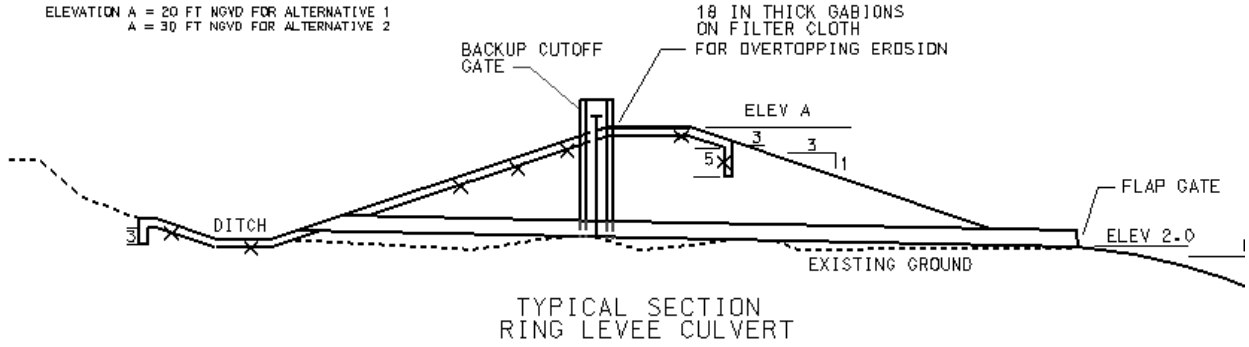


Figure 3.3.12-13. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the ring levee into major sub-basins as shown above in Figure 3.3.12-9 and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number. The variation in soil types, hydrologic soil groups, and sub-basins is shown below in Figure 3.3.12-14.

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

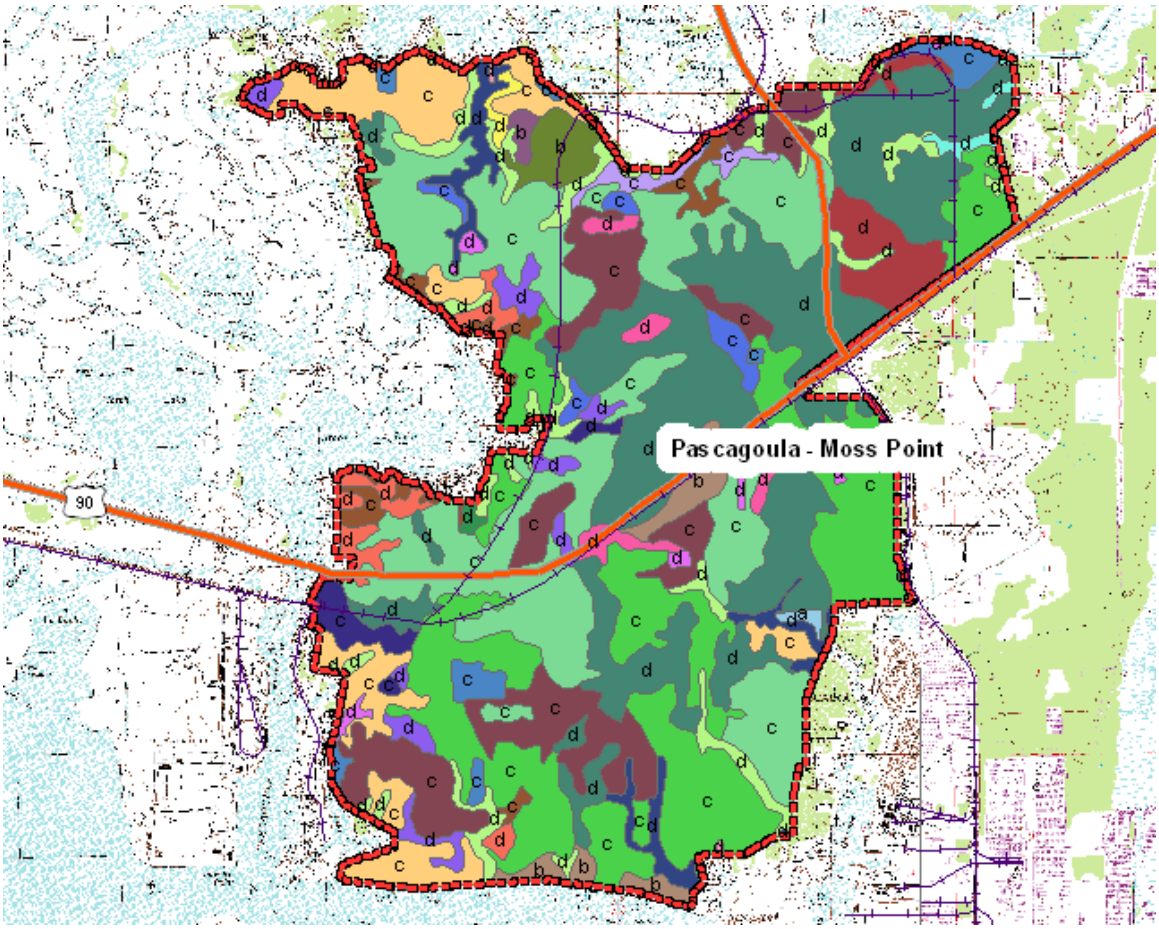


Figure 3.3.12-14. Pascagoula/Moss Point Hydrologic Soil Groups

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is “National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report, therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.12.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.12.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts, pumping facilities and for boat access sites. The sites are shown above in Figure 3.3.12-9.

3.3.12.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm

closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.12.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.12.5.3.3 Pumping Facilities Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.12.5.3.4 Pumping Facilities. Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing

and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.12.5.3.5 Pumping Stations. Flow and Pump Sizes

The design hydraulic heads derived for the 28 facilities included in the Pascagoula-Mosspoint Ring Levee system for the elevation 20 protection level varied from approximately 10 to 20 feet and the corresponding flows required varied from 24,200 to 860,900 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 290 horsepower pump, to one including 10, 54-inch diameter pumps each running at 420 horsepower.

3.3.12.5.3.6 Boat Access Structure

At Site PG-1 the ring levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. (See Figures 3.3.12-9 above and Figure 3.3.12-15 and Table 3.3.12-1, below). To allow continued free boat access to the areas behind the levee this site was fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay Saint Louis. This structure would, for the most part, be much smaller and lighter than those used in the bays, however it would be substantial. The operation would be similarly critical in time of storm and they would require the same attention from an Operations and Maintenance standpoint as their larger, heavier counterparts.

3.3.12.5.3.7 Boat Access Structure. Mechanical. Option A

The mechanical equipment and operating system for these structures would be similar to those used for the bay barriers, and would include steel gate linkages and hydraulic rams and pivot pins for operation of the gates. Each gate would rotate on large bearings and pivot hubs at the ends of the gate. Various operating hydraulic and lubrication oil systems would also be required. It is estimated that each gate would have a maximum opening/closing time of 15 minutes.

3.3.12.5.3.8 Boat Access Structure. Electrical

Primary electrical power for operating these gates would be provided using dedicated, standard transformers with emergency back-up generators. The electrical load demand at these facilities would be low by comparison to the bay barrier structures. The supplemental generation aspect was considered to be a vital component of the design because of the very high cost of commercial standby power and because commercial electric power would almost certainly be unavailable during and immediately following a storm event.

3.3.12.5.3.9 Mechanical and Electrical. Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than

ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

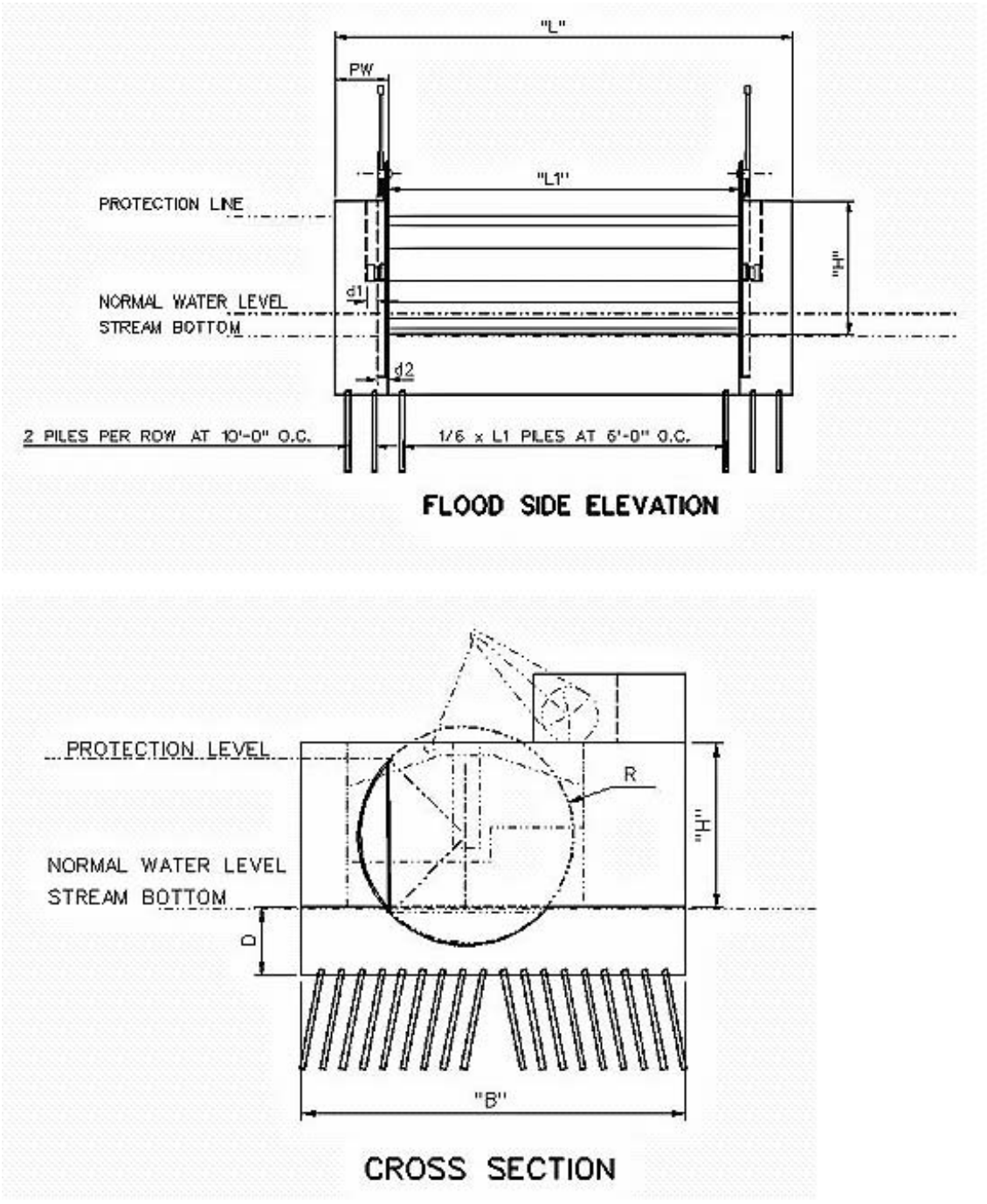


Figure 3.3.12-15. Typical Small Boat Access Structure

Table 3.3.12-1.
Boat Access Structure Dimensional Data by Site

Site Designation	Protection Elevation, ft NAVD88	L1 ft	PW ft	H ft
PG-1	20.0	75	18	29.5

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.12.5.3.10 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.12.5.3.11 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 20, 68 roadway/railway intersections would have to be accommodated. For this study it was estimated that 29 roller gate structures and 35 swing gate structures would be required at the points where roadways would cross the protection line. In addition, 8 railroad gate structures would be required.

3.3.12.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.12.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.12.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for

Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Boat access gates and power plants would require this level of security.

3.3.12.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.12.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.12.13, Cost Summary. Construction costs for the various options are included in Table 3.3.12-2 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.12-3. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.12.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications,

independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.12.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.12.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.12.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.12.6.3 Structural, Mechanical and Electrical

These data are the same as that presented for Option A and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

3.3.12.6.3.1 Pumping Stations. Flow and Pump Sizes. Option B

The design hydraulic heads derived for the 28 facilities included in the Pascagoula-Mosspoint Ring Levee system for the elevation 30 protection level varied from approximately 20 to 30 feet and the corresponding flows required varied from 24,200 to 860,900 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 475 horsepower pump, to one including 10, 54-inch diameter pumps each running at 775 horsepower.

3.3.12.6.3.2 Levee and Roadway/Railway Intersections. Option B

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 30, 79 roadway intersections would have to be accommodated. For this study it was estimated that 1 roller gate structure and 73 swing gate structures would be required at the points where roadways would cross the protection line. In addition, 5 railroad gate structures would be required.

3.3.12.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.12.6.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option B are the same as for Option A, above.

3.3.12.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.12.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.12.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.12.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.12.7 Option C – Washington Ave. Alternate Alignment, Elevation 20 ft NAVD88

This option consists of an earthen levee enclosing an area of 9350 acres around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option A, above, except that is follows Washington Avenue on the south leg of the levee. The alignment is shown below in Figure 3.3.12-16.

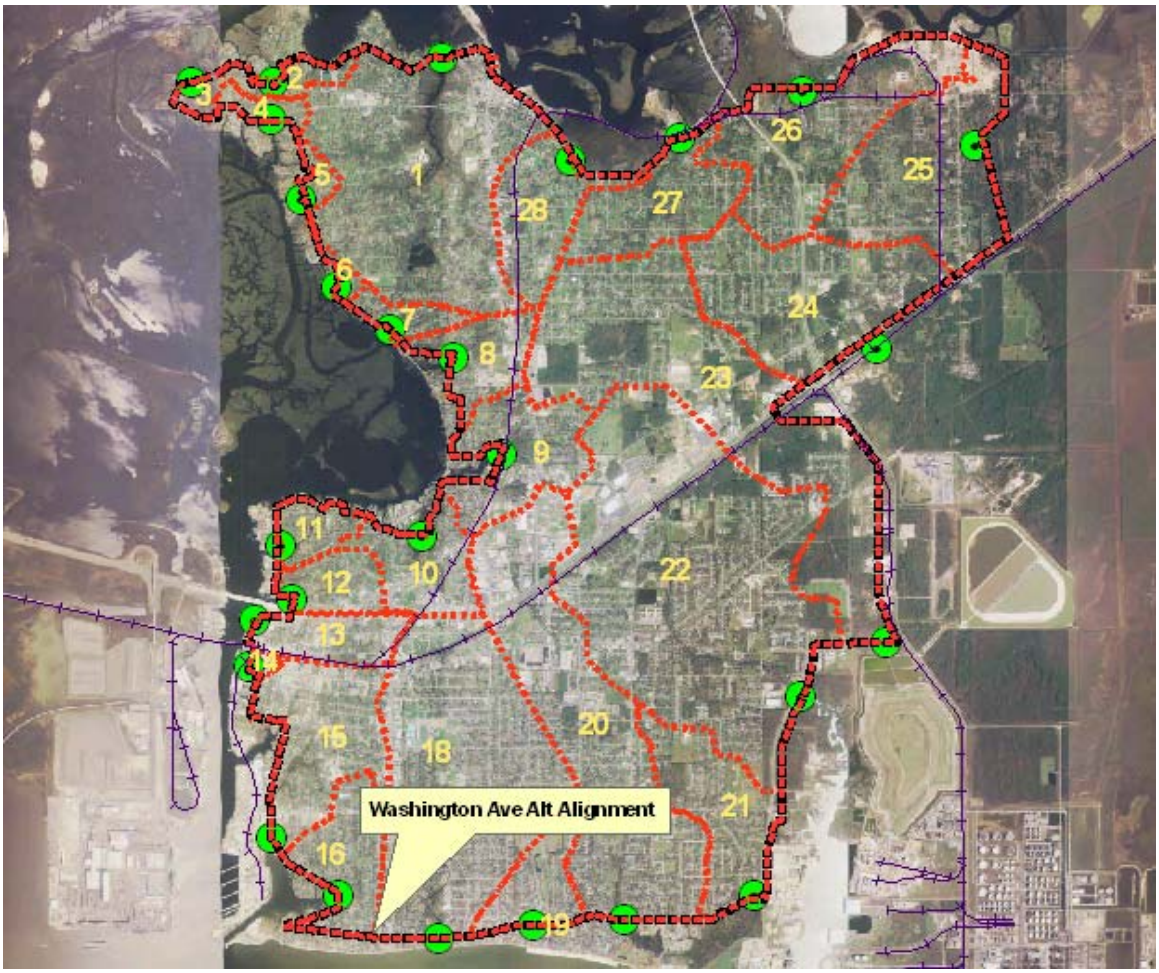


Figure 3.3.12-16. Washington Ave Alternate Alignment Pump/Culvert/Sub-basin/Boat Access Site Locations

3.3.12.7.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.12.7.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option C are the same as for Option A, above.

3.3.12.7.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the alteration of the levee alignment to roughly follow Washington Avenue. This variance occasioned changes to the pumping requirements and facilities for the sub-basins 16-20 on the south leg of the levee, and alteration of the number of roadway and railroad intersections. This changed data for Option C is presented below.

3.3.12.7.3.1 Pumping Stations. Flow and Pump Sizes. Option C

The design hydraulic heads derived for the facilities included in the Pascagoula-Mosspoint Option C Ring Levee system for the elevation 20 protection level varied from approximately 10 to 20 feet and the corresponding flows required varied from 171,578 to 490,124 gallons per minute. The plants thus derived varied in size from a plant having three 48-inch diameter, 340 horsepower pump, to one including seven 54-inch diameter pumps each running at 290 horsepower.

3.3.12.7.3.2 Levee and Roadway/Railway Intersections. Option C

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 20 and the inclusion of the Washington Avenue alignment, 76 roadway intersections would have to be accommodated. For this study it was estimated that 24 roller gate structures and 108 swing gate structures would be required at the points where roadways would cross the protection line. In addition, 14 railroad gate structures would be required.

3.3.12.7.4 HTRW

The HTRW paragraphs for Option C are the same as for Option A, above.

3.3.12.7.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option C are the same as for Option A, above.

3.3.12.7.6 Project Security

The Project Security paragraphs for Option C are the same as for Option A, above.

3.3.12.7.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option C are the same as for Option A, above.

3.3.12.7.8 Cost Estimate

The Cost Estimate paragraphs for Option C are the same as for Option A, above.

3.3.12.7.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option C are the same as for Option A, above.

3.3.12.8 Option D – Washington. Alternate Alignment, Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option C, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.12.8.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option C, above, except that the culvert lengths through the levees would be longer.

3.3.12.8.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option D are the same as for Option A, above.

3.3.12.8.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option C is the height of the levee and the resulting differences in the required pumping facilities, number of roadway and railroad intersections, the length of the levee culverts, and the exclusion of the Boat Access Structure. The changed data for Option D is presented below.

3.3.12.8.3.1 Pumping Stations. Flow and Pump Sizes. Option D

The design hydraulic heads derived for the 6 facilities included in the Pascagoula-Mosspoint Ring Levee system for the elevation 30 protection level varied from approximately 20 to 30 feet and the corresponding flows required varied from 171,578 to 490,124 gallons per minute. The plants thus derived varied in size from a plant having three 48-inch diameter, 600 horsepower pumps, to one including five 60-inch diameter pumps each running at 1150 horsepower.

3.3.12.8.3.2 Levee and Roadway/Railway Intersections. Option D

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 30, 87 roadway intersections would have to be accommodated. For this study it was estimated that 1 roller gate structure and 180 swing gate structures would be required at the points where roadways would cross the protection line. In addition, 18 railroad gate structures of varying height would be required.

3.3.12.8.4 HTRW

The HTRW paragraphs for Option D are the same as for Option A, above.

3.3.12.8.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option D are the same as for Option A, above.

3.3.12.8.6 Project Security

The Project Security paragraphs for Option D are the same as for Option A, above.

3.3.12.8.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option D are the same as for Option A, above.

3.3.12.8.8 Cost Estimate

The Cost Estimate paragraphs for Option D are the same as for Option A, above.

3.3.12.8.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option D are the same as for Option A, above.

3.3.12.9 Option E – Moss Point Alternate Alignment, Elevation 20 ft NAVD88

This option consists of an earthen levee enclosing an area of 7535 acres around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option A, above, except that is follows a modified alignment through Moss Point on the north leg of the levee. The alignment is shown below in Figure 3.3.12-17.

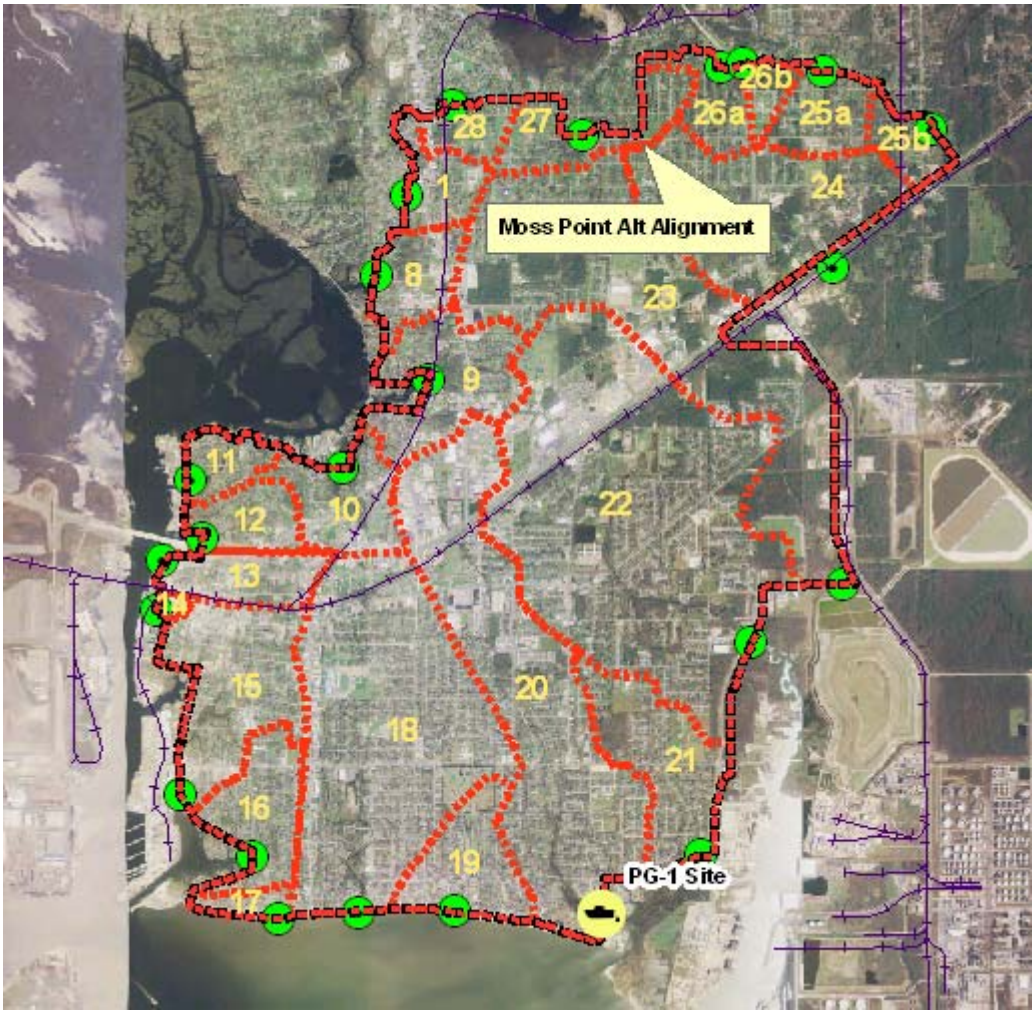


Figure 3.3.12-17. Moss Point Alignment Pump/Culvert/Sub-basin/Boat Access Site Locations

3.3.12.9.1 Interior Drainage

Interior drainage analysis and culvert design methods are the same as those for Option A, above. Culvert/Pump locations are shown in Figure 3.3.12-17, above.

3.3.12.9.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option E are the same as for Option A, above.

3.3.12.9.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the incorporation of the Moss Point Levee with that for Pascagoula and the resulting variance in the pumping requirements and facilities for the sub-basins on the north leg of the levee and the number of roadway and railroad intersections. The changed data for Option E is presented below.

3.3.12.9.3.1 Pumping Stations. Flow and Pump Sizes. Option E

The design hydraulic heads derived for the facilities included in the Pascagoula-Mosspoint Option E Ring Levee system for the elevation 20 protection level varied from approximately 5 to 20 feet and the corresponding flows required varied from 62,549 to 490,083 gallons per minute. The plants thus derived varied in size from a plant having two 36-inch diameter, 125 horsepower pumps, to one including seven 54-inch diameter pumps each running at 290 horsepower.

3.3.12.9.3.2 Levee and Roadway/Railway Intersections. Option E

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 20, 43 roadway intersections would have to be accommodated. For this study it was estimated that 15 roller gate structures and 56 swing gate structures would be required at the points where roadways would cross the protection line. In addition, 10 railroad gate structures would be required.

3.3.12.9.4 HTRW

The HTRW paragraphs for Option E are the same as for Option A, above.

3.3.12.9.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option E are the same as for Option A, above.

3.3.12.9.6 Project Security

The Project Security paragraphs for Option E are the same as for Option A, above.

3.3.12.9.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option E are the same as for Option A, above.

3.3.12.9.8 Cost Estimate

The Cost Estimate paragraphs for Option E are the same as for Option A, above.

3.3.12.9.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option E are the same as for Option A, above.

3.3.12.10 Option F – Moss Point Alternate Alignment, Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option E, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option E is the

height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.12.10.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option E, above, except that the culvert lengths through the levees would be longer.

3.3.12.10.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option F are the same as for Option A, above.

3.3.12.10.3 Structural, Mechanical and Electrical

The primary differences between the description of this option and preceding description of Option A is the incorporation of the Moss Point levee with that for Pascagoula and the increased height of the levee and the resulting changes in the pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The changed data for Option F is presented below.

3.3.12.10.3.1 Pumping Stations. Flow and Pump Sizes. Option F

The design hydraulic heads derived for the 10 facilities included in the Pascagoula-Moss Point Ring Levee system for the elevation 30 protection level varied from approximately 15 to 30 feet and the corresponding flows required varied from 62,549 to 490,083 gallons per minute. The plants thus derived varied in size from a plant having two 36-inch diameter, 250 horsepower pumps, to one including five 60-inch diameter pumps each running at 750 horsepower.

3.3.12.10.3.2 Levee and Roadway/Railway Intersections. Option F

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 30, 75 roadway intersections would have to be accommodated. For this study it was estimated that all of these structures would be swing gates. In addition, seven sites with 14 railroad gate structures would be required.

3.3.12.10.4 HTRW

The HTRW paragraphs for Option F are the same as for Option A, above.

3.3.12.10.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option F are the same as for Option A, above.

3.3.12.10.6 Project Security

The Project Security paragraphs for Option F are the same as for Option A, above.

3.3.12.10.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option F are the same as for Option A, above.

3.3.12.10.8 Cost Estimate

The Cost Estimate paragraphs for Option F are the same as for Option A, above.

3.3.12.10.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option F are the same as for Option A, above.

3.3.12.11 Option G – Combined Washington Ave and Moss Point Alternate Alignments, Elevation 20 ft NAVD88

This option consists of an earthen levee enclosing an area of 7356 acres around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option A, above, except that is follows the same modified alignment along Washington Ave as shown for Options C and D on the south, and the modified alignment in Moss Point as shown for Options E and F along the north leg of the levee. The alignment is shown below in Figure 3.3.12-18.

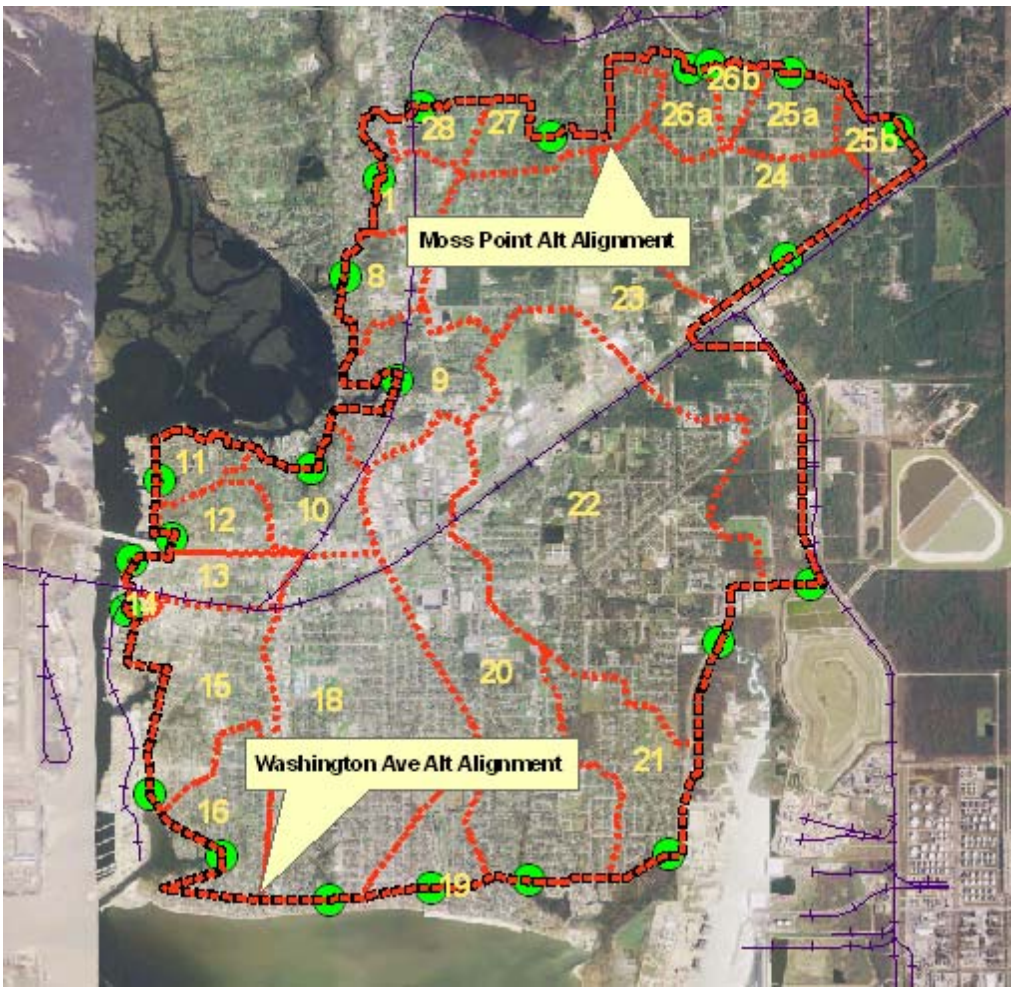


Figure 3.3.12-18. Moss Point Alignment Pump/Culvert/Sub-basin Locations

3.3.12.11.1 Interior Drainage

Interior drainage analysis and culvert design methods are the same as those for Option A, above. Culvert/Pump locations are shown in Figure 3.3.12-18, above.

3.3.12.11.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option G are the same as for Option A, above.

3.3.12.11.3 Structural, Mechanical and Electrical

The primary differences between the description of this option and preceding description of Option A would be the combination of the Pascagoula with Washington Avenue, and the Moss Point alignments resulting in an variation in the pumping requirements and facilities for the sub-basins on the north leg of the levee, number of roadway and railroad intersections, and the omission of the Boat Access Structure south of the revised alignment. The other data for Option G is presented below.

3.3.12.11.3.1 Pumping Stations. Flow and Pump Sizes. Option G

The design hydraulic heads derived for the facilities included in the Pascagoula-Mosspoint Option G Ring Levee system for the elevation 20 protection level varied from approximately 5 to 20 feet and the corresponding flows required varied from 62,388 to 490,083 gallons per minute. The plants thus derived varied in size from a plant having two 36-inch diameter, 125 horsepower pump, to one including seven 54-inch diameter pumps each running at 750 horsepower.

3.3.12.11.3.2 Levee and Roadway/Railway Intersections. Option G

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 20, 48 roadway intersections would have to be accommodated. For this study it was estimated that 15 roller gate structure and 72 swing gate structures would be required at the points where roadways would cross the protection line. In addition, five sites with 10 railroad gate structures would be required.

3.3.12.11.4 HTRW

The HTRW paragraphs for Option G are the same as for Option A, above.

3.3.12.11.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option G are the same as for Option A, above.

3.3.12.11.6 Project Security

The Project Security paragraphs for Option G are the same as for Option A, above.

3.3.12.11.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option G are the same as for Option A, above.

3.3.12.11.8 Cost Estimate

The Cost Estimate paragraphs for Option G are the same as for Option A, above.

3.3.12.11.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option G are the same as for Option A, above.

3.3.12.12 Option H – Combined Washington Ave and Moss Point Alternate Alignment, Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option G, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option G is the height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.12.12.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option G, above, except that the culvert lengths through the levees would be longer.

3.3.12.12.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option H are the same as for Option A, above.

3.3.12.12.3 Structural, Mechanical and Electrical

The primary differences between the description of this option and preceding description of Option A are the incorporation of the Pascagoula with Washington Avenue levee, with that for Moss Point, the change in the height of the levee, and the resulting changes in the pumping facilities, number of roadway and railroad intersections, the length of the levee culverts, and the omission of the Boat Access Structure. Culvert length variations are not presented but are incorporated into the cost estimate. The changed data for Option H are presented below.

3.3.12.12.3.1 Pumping Stations. Flow and Pump Sizes. Option H

The design hydraulic heads derived for the 14 facilities included in the Pascagoula-Mosspoint Ring Levee system for the elevation 30 protection level varied from approximately 15 to 30 feet and the corresponding flows required varied from 62,388 to 490,083 gallons per minute. The plants thus derived varied in size from a plant having two 36-inch diameter, 250 horsepower pumps, to one including five 60-inch diameter pumps each running at 1150 horsepower.

3.3.12.12.3.2 Levee and Roadway/Railway Intersections. Option H

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 30, 79 roadway intersections would have to be accommodated. For this study it was estimated that all of these would be swing gate structures. Fourteen railroad gate structures would be required.

3.3.12.12.4 HTRW

The HTRW paragraphs for Option H are the same as for Option A, above.

3.3.12.12.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option H are the same as for Option A, above.

3.3.12.12.6 Project Security

The Project Security paragraphs for Option H are the same as for Option A, above.

3.3.12.12.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option H are the same as for Option A, above.

3.3.12.12.8 Cost Estimate

The Cost Estimate paragraphs for Option H are the same as for Option A, above.

3.3.12.12.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option H are the same as for Option A, above.

3.3.12.13 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.12-2 and 3.3.12-3, below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.12-2.
Jackson Co Pascagoula/Moss Point Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$699,000,000
Option B – Elevation 30 ft NAVD88	$916,000,000
Option C – Elevation 20 ft NAVD88	$671,600,000
Option D – Elevation 30 ft NAVD88	$849,900,000
Option E – Elevation 20 ft NAVD88	$874,400,000
Option F – Elevation 30 ft NAVD88	$1,013,200,000
Option G – Elevation 20 ft NAVD88	$921,400,000
Option H – Elevation 30 ft NAVD88	$1,057,700,000

Table 3.3.12-3.
Jackson Co Pascagoula/Moss Point Ring Levee O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$5,719,000
Option B – Elevation 30 ft NAVD88	$8,309,000
Option C – Elevation 20 ft NAVD88	$4,658,000
Option D – Elevation 30 ft NAVD88	$6,707,000
Option E – Elevation 20 ft NAVD88	$3,761,000
Option F – Elevation 30 ft NAVD88	$5,423,000
Option G – Elevation 20 ft NAVD88	$3,537,000
Option H – Elevation 30 ft NAVD88	$5,197,000

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3.4 Line of Defense 4 – Inland Barrier and Surge Gates

3.4.1 General

To preserve the shoreline environment as much as possible, a 4th line of defense for very large storms is envisioned that would be inland from the coast. This line of defense would be the highest line and could contain a larger storm surge up to that associated with a "Maximum Possible Intensity" (MPI) hurricane. LOD-4 was be modeled as an infinitely high barrier with the screening storms defining a surge elevation against the barrier. The top elevation could then be defined based on selected protection from a selected screening storm. Storms that will be modeled against this line will vary from a Camille type storm up to the MPI. This alignment would follow the same path as the railway that crosses the state near the coast but not cross either the Pearl River to the west or the Pascagoula River to the east.

In order to protect much of the developed areas around Biloxi and St. Louis Bays, LOD-4 would have to include a structural surge barrier that would also cross the mouth of these bays. These surge barriers, when closed, would prevent storm surge from moving in through the inlets of the bays. The structural barriers across the bays could be similar to designs used in Europe for storm surge protection. While many types of barriers were reviewed, the rising sector design used on the Thames River in London, England was selected. This type of structure would allow the least restriction to natural tidal flow and with gates flush with the natural bottom, provide the least environmental concern.

During initial planning, options were discussed that would provide a LOD-4 line of defense, but not include closing off the bays with surge barriers. Due to the topography and the positions of the bays and river systems, the project team collectively decided that to be effective, LOD-4 had to include a barrier across Biloxi Bay, but that St. Louis Bay could possibly be excluded. The location of Biloxi and Gulfport on a narrow coastal ridge with the Sound to the south and the Back Bay of Biloxi to the north would not allow closure for a levee to higher elevations to the north. This would leave any type of significant defense as a high ring levee or seawall following the shorelines of the sound and the bay, something widely opposed in early public meetings. It would also leave many heavily developed

areas around the bay subject to surge from any future storms. Considering this for St. Louis Bay provides a different option. There could be an optional alignment that would extend northward from Long beach to a selected higher elevation. This northern extension would follow the general alignment of Menge Avenue north of the railroad. There are two major drainages that would cross along this alternate path that carry floodwaters from rainfall away from the town of Long Beach. These drainages are canals that extend from the headwaters of Turkey Branch southwestward to drain into St. Louis Bay. These drainages may require large pumping stations to prevent the canals from flooding upstream if they were closed off during hurricanes. This revision of LOD-4 would leave most of the area westward from Long Beach without any type of defense from storm surge including the cities of Pass Christian and Bay St. Louis. The inclusion of a ring levee around Bay St. Louis could be added should planners choose to not close off the bay.

The general alignment of line 4 is envisioned along the path of a railway that crosses the coast of Mississippi. In Harrison County, this pathway is through heavily populated and commercial zones. To the east in Jackson County, a decision was made not to cross the Pascagoula River and associated marshes. To do so would have both technical and environmental concerns. Crossing this major river system would create environmental problems as well as interior flooding. Constructing barriers or levees across the marshes will change the surface water flow, restrict tidal exchange and could alter existing salinity conditions leading to major ecosystem changes. Blocking the rivers with surge gates, even for short periods could cause extensive flooding due to water backing up behind the gates during storms as rain falls inland. This could cause more flooding than the storm surge. The Pascagoula River system is also habitat to the endangered Gulf Sturgeon and any approved construction or modifications in the river would be unlikely.

For these reasons, the first major watershed divide west of the Pascagoula River was selected to turn the barrier north and extend it to a location beyond the extent of the storm surge associated with a MPI event. Similarly to the west in Hancock County, LOD-4 follows the railway to a watershed divide that is located east of the Pearl River where it follows the divide north to the MPI line. Both of these northward extensions will cross the path of Interstate 10 and may dictate some modifications to the highway depending on the selected top elevation of the line.

LOD-4 could also be designed to have roadways, even major highways on top if desired. This line would be the highest defense, but would not protect structures seaward from the larger storms that might overtop Line 3. All facilities seaward of Line 4 would be prone to flooding in a large storm, so flood-proofing would be necessary in this zone. As described prior, this barrier would extend from high ground east of the Pearl River to high ground west of the Pascagoula River for a distance of approximately 57 miles. It would not cross either of these river systems.

Like Line 3, interior drainage behind this barrier must also be considered. The watersheds may be large and large rainfall events would require substantial structures designed to allow the water to drain or be pumped over the structure in a storm.

3.4.1.1 Surge Gates

3.4.1.1.1 Literature Research

As the requirements of the MsCIP project studies were developed it became apparent early on that several massive gate structures would be required to protect the large inlets from tidal surges during larger storm events. Initially it was thought that some adaptation of our customary tainter or vertical lift gate assemblies might serve this purpose, but as the water levels to be resisted and the required length of the structures were developed it became apparent that much more massive construction than we had heretofore experienced would be required. This was further complicated by the need to minimize the visual impact, obstruction to vessel traffic, and normal tidal flow.

Our search for a method of construction that would be efficient and effective while optimizing freedom of tide flow and minimizing visual and physical obstruction under normal conditions, led us to the Netherlands, Italy, Russia, and the River Thames in the United Kingdom, where several very massive and large scale projects of this type have been constructed or are presently in the planning stages.

Oosterscheldt Barrier, Netherlands

The Dutch have fought these coastal flooding battles for centuries and, since the major floods suffered in the middle of the 20th century, have made a concerted effort to protect their land and people from the sea's ravages. As a result of these efforts several large and innovative structures have been constructed by the Dutch, using very specialized construction techniques and involving use of conventional construction materials on a massive scale.

The Eastern Scheldt Barrier (the Oosterscheldt Barrier) completed in 1986/87 effectively enclosed the southwest coastline of Holland and Zeeland protecting some 100,000 people from flooding up to the 1:4000 year storm event. The gate structure is three kilometers long, was constructed in three segments, and consists of 65 reinforced concrete pillars ranging from 30.25 to 38.75 meters high, and weighing approximately 18,000 tons each. The gaps between the piers were filled with massive stones precisely placed to form the lower portion of the cutoff. The cutoff was completed by insertion of massive reinforced concrete upper and lower beams and moveable steel gates. The 62 massive steel gates, each 42 meters wide, are of the vertical lift type, operated by vertical overhead mounted hydraulic rams. In the open (raised) position they are suspended between the piers over the North Sea, and in the closed position they bridge vertically between the upper and lower concrete sill beams. The gates vary in height from 6 to 12 meters. The largest weighs approximately 480 tons and takes 82 minutes to close. These gates were designed for a maximum design head differential of 5 meters. The entire barrier, including the levee and gated portions, was constructed at a total cost to the Dutch Government of approximately $8.7 billion (2005 U.S. price level). The annual cost of operation is approximately 13 million dollars. See Figure 3.4.1.1-1 for a picture of these gates and their intended operation.



(Oosteschelde kering, Wikipedia, Internet Encyclopedia; The Delta Project, Ministry of Transport, Public Works, and water Management, The Netherlands)

Figure 3.4.1.1-1. Oosterscheldt Barrier, Netherlands

This type design offers several advantages. Under normal conditions the gates are high and dry leaving the structure exposed for ready access for maintenance. The construction method used included prefabricated pier sections constructed in the dry in a series of below sea level construction yards which were eventually flooded allowing the pier sections to be moved into place using specially made ships, then sunk onto previously prepared stone mattress foundations. No foundation pilings were required. The gates can be completely closed/opened in one hour. In considering application of this design for the MsCIP several disadvantages were identified. The gate and pier structures are always in view, extending above the water's surface, an undesirable feature in the locations under consideration. The design head was relatively low when compared to that which might be encountered along the Mississippi Gulf Coast. Because of the water depth at the site the gate sills were constructed to a point well above the sea floor. This has caused definite and identifiable environmental changes in the lakes and inlets inland of the barrier, one of which is marked reduction in salinity resulting in changes in the species of flora and fauna growing in these areas. These changes have adversely affected the commercial fishing industries and other commercial interests.

Maeslant Barrier, Rotterdam, Netherlands

The latest barrier constructed by the Dutch in their long fight against the North Sea tides was the Maeslant Barrier completed in 1997, near the mouth of the Nieuwe Waterweg, the main access to Rotterdam Harbor. This sea port is the second largest in the world, is surrounded by one of the largest industrial areas in Europe, and is home to approximately 1,000,000 people.

This structural marvel consists of two opposing radial sector gates. Each gate is a watertight steel chamber 22 meters high and 210 meters long mounted on two 237-meter long tubular steel space frame radial arms. These arms extend from the protected side of each gate to massive steel ball joints which are embedded in similarly massive concrete foundations in the banks of the Waterweg. These gates move radially, floating from their moorings in concrete lined pocket channels within the opposite banks of the navigation channel to their "closed" position near the canter of the channel. When the gates are within approximately 1.5 meters of each other they are flooded and sink to rest on a concrete sill in the channel bottom. The entire gate operation is controlled by computers and is linked to a highly sophisticated weather monitoring system. The gate closure operation is automatically triggered when the storm surge of 3 meters above normal sea level is predicted for Rotterdam. The entire closing operation, including ship warning and stopping of navigation traffic, takes approximately 5 hours.

The design criteria for this facility dictated that it provide maximum protection against flooding, maintain optimal channel width and depth for navigation, that its operation require a minimum of interruption to navigation traffic, and that it have no overhead obstructions. This structure and its related protection works were designed to protect against the 1:10,000 year flood event. The total construction cost of the barrier was 450-million Euros (about 500 million dollars) and it took approximately six years to build. See Figure 3.4.1.1-2 for picture of these gates in operation.



(Maeslantkering, Wikipedia, Internet Encyclopedia)

Figure 3.4.1.1-2. Maeslant Barrier, Rotterdam, Netherlands

In assessing the adaptation of this design for the MsCIP flood barrier sites the ease and simplicity of operation were noted as plusses. Also the linkage between the barrier operation and the weather monitoring system would be of great value in our area of concern. However, it was also noted that the width of the water opening at both Biloxi and Saint Louis Bays is substantially greater than that required for the Maeslant site. Also, the hydraulic head for which the structure was designed is significantly less than that which would be experienced along the Mississippi Gulf Coast. While the opening width could possibly be restricted using finger dikes and pass-through culverts to maintain the natural ebb and flow of tide water, this would drastically change the appearance of the bay inlets and might greatly restrict the seaward view from the land side. These factors coupled with the requirement that the barrier be designed to withstand considerably greater hydraulic loading than is seen at the Maeslant site, were viewed as great disadvantages to the use of this type of barrier for the MsCIP sites.

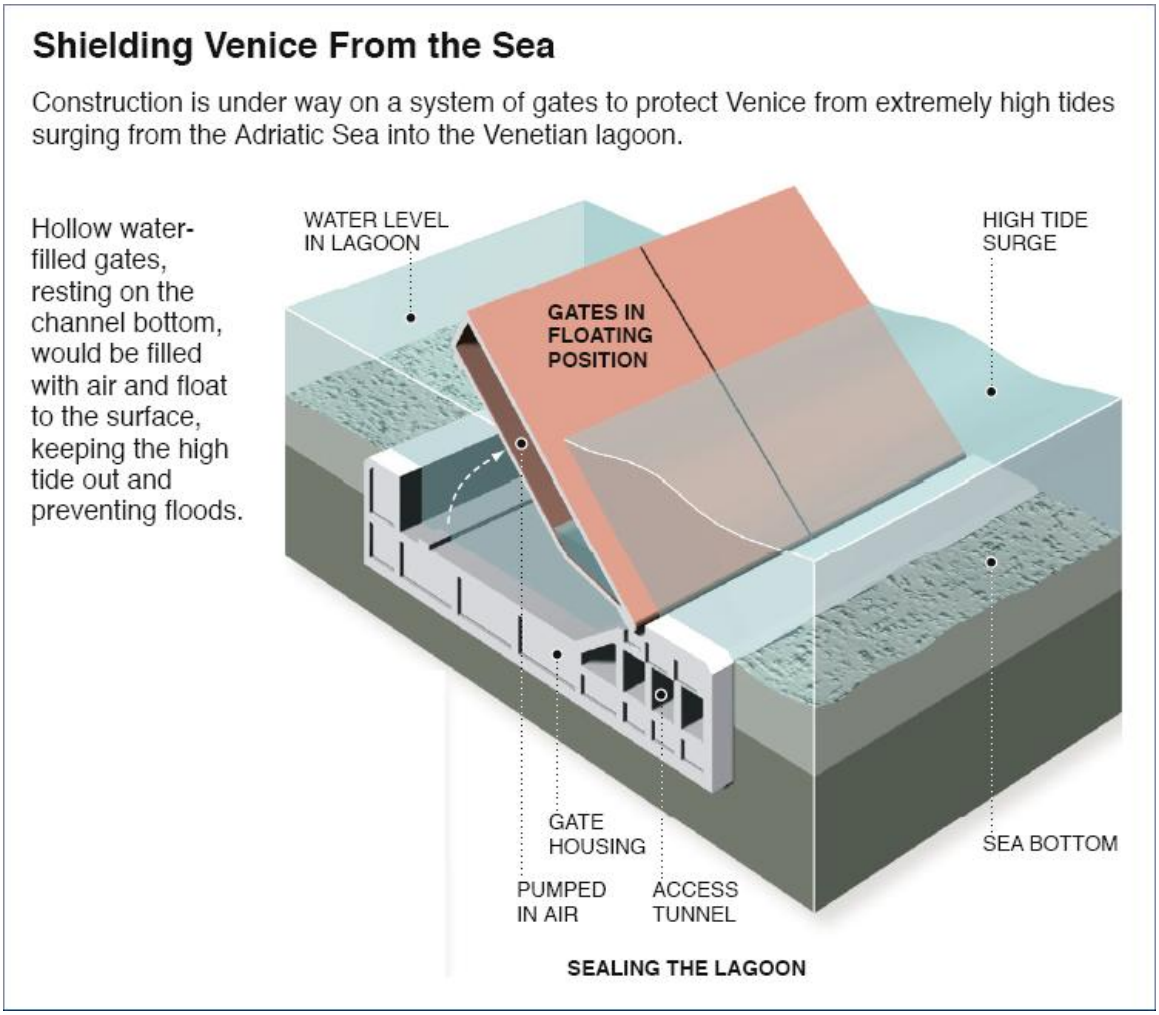
Venice Lagoons

The work done pursuant to addressing flooding problems in Venice, Italy was also cursorily investigated for possible application to the Mississippi Gulf Coast study. This work is still in the investigation and design stages, thus no actual construction details were available. This work would involve the use of “tilt-up” tide gates which would be placed across the lagoon inlets in a string as defense against higher than usual tides. As envisioned for the Venice application these gates would consist of closed hollow chamber gates attached to foundation structures along their seaward edge with hinges. These gates would normally rest filled with water in structure recesses in the sea bottom., They would be raised only when the higher tides are forecast, by injection of air into the hollow gate chambers thus causing the gates to float and hinge upward into their closed position.

The gates designed for the Venice application consisted of 79 separate gate leaves each 20 meters wide providing a total protected length of 1,580 meters configured in three separate groupings. The gates are approximately 30 meters high and were made to retain tides of up to 1.1 meters (approximately 3.6 feet) higher than normal. Further investigation revealed that, as designed, the hinge attachment is the only point of attachment of the gate leaves to the foundation or other structure. The cost estimated for the “Mobile Gates” for the Venice Lagoons in 2004 was approximately $2.7 billion. See Figure 3.4.1.1-3 for graphic depiction of these gates and their intended operation.

(NOVA, Sinking City of Venice, PBS, Internet Transcript; Venice could provide gateway to 21st century flood control method, Denise Brehm, Massachusetts Institute of Technology, 2002, Internet Article)

In order to be functional in a high head situation with gates wide enough to fulfill other project objectives, the gates and structure would have to be designed to resist high lateral loads. The gates would likely need to bear on the structure at the ends of each gate, and the foundations would have to be designed to resist the very large hydraulic loads anticipated. While this design method could possibly be developed to fulfill the needs of our structures, this would have taken considerable work and computation to ascertain the required structure configuration and requirements, much more than the scope of this effort would afford.



Source: Venice turns to the Futureto Rescue its Past, Elisabeth Rosenthal, WITS ARENA

Figure 3.4.1.1-3. Venice Lagoons Flood Barrier, Venice Italy

Thames River Barrier

The Thames River Barrier, Figure 3.4.1.1-4 and 3.4.1.1-5, was constructed during the 1980's to protect portions of historic London and the surrounding area from tidal flooding. At this site there is a naturally wide variation in the "spring tides" resulting in frequent very high tides, the maximum observed to date being +3.2 meters (i.e. 3.2 meters above the normal tide influenced water level). Also at this site storm surges of as much as +3.66 meters have been experienced. In the event that a storm surge equivalent to the maximum experienced to date and a very high spring tide were to occur at the same time, the water level could conceivably reach as much as +6.86 meters at this site. Based on this possibility, the top of the gates at the Thames River barrier was set at +6.9 meters. This elevation is sufficient to fully contain the 100-year flood event which would yield a water elevation of approximately +5.5 meters. The design flood event was estimated as being the 2000-year flood.



Figure 3.4.1.1-4. Thames River Barrier, Sea Side View



Figure 3.4.1.1-5. Thames River Barrier, Aerial Right Bank View

The Barrier constructed includes a series of reinforced concrete piers and sills, supporting massive steel gates. Each main pier is 11 meters wide and extends to a point slightly above the top of the gates, with the operating machinery and machinery housings mounted atop each pier. Protective and decorative machinery housings were constructed consisting of large curved coverings made of wood and clad with stainless steel. The lowest pier foundations were sunk some 17 meters into the chalk beneath the river bottom.

The barrier includes four main navigation openings measuring 61 meters (approximately 200 feet) in width and two 31.5 meter (approximately 103-foot) openings for passage of smaller vessels. Each of these openings is fitted with a rising sector gate. To allow for free water flow for practically the full width of the river, four more 31.5 meter openings were included each having a falling radial gate, similar to the tainter type gates common to our inland waterway control structures.

The rising sector gates are hollow stainless steel structures with the downriver side curved. Each gate is mounted at either end to large steel disks giving the entire gate structure the appearance of a cut-away cylinder. The gates are supported on trunnion shafts which rotate in bearings mounted in the piers. They are operated by means of reversible hydraulic rams and operating arms mounted on the top of the piers. Under normal conditions the gates lie flat in curved concrete sill recesses in the river bed. Each can be operated upward and stopped at four positions, partially closed (1/8 turn of the disk upward), fully closed (1/4 turn of the disk upward), underspill position (3/8 turn of the disk upward), and maintenance position (1/2 turn of the disk upward). To facilitate operation of the gate the interior of each gate chamber is evacuated of water resulting in a partially buoyant structure.

The sills were set at elevation -9.25 meters and the top of the gates in the fully closed position is +6.9 meters (mean sea level), for an overall protection height of 16.15 meters (approximately 53 feet). The design head for these structures was 6.9 meters (approximately 22.6 feet).

The facilities are operated from a Control Tower located on one bank of the river with a backup control room on the opposite bank. Two service tunnels pass through the foundation of the barrier beneath the river to connect between the two control rooms and to provide power and other utility service access to each pier. In case of extreme emergency each gate can be operated from the individual pier engine rooms. Operating power is provided by three 1.5 MW on-site power generating units, with backup connection to the local electrical grid.

Since its commissioning the Thames River Barrier has been operated 4 to 5 times per year, for a total of 276 times as of 29 April 2002. Each closing cycle takes approximately 15 minutes, though the operation time is greatly extended because of the coordination required with operation of the port facilities.

The Thames River Barrier was constructed between 1972 and 1982 and was formally opened in 1984. The total project construction cost was approximately $760 million. The annual operating and maintenance cost for the Barrier and appurtenant facilities is approximately $13 million.

(Flood London, Thames Barrier: History, Technical Specifications, Why The Barrier is Too Small, Internet articles; Thames Region – Operating the Barrier, Environmental Agency, 2007, Internet Article)

In considering the rising sector gate design for application to the MsCIP barrier structures several points of advantage were identified. Under normal conditions the gates rest out of view at river bottom level. This is appealing in that it would offer a minimum of obstruction to view, to tidal ebb and flow, and to navigation through the structure. The piers, while substantial, are placed wide enough apart that they should be no more obtrusive than the existing bridge structures. The speed of operation would minimize the time the gates would be required to be in place before and after a storm event, and the fact that the gates can be rotated to a full up position for maintenance completely in the dry without installation of unwatering devices or dismantling of the structure is a great maintenance advantage. The maintenance aspect is further enhanced by the fact that the gate surface material is all stainless steel.

Readily observable disadvantages or questionable considerations include the very high construction cost, the relatively small design head required at the Thames River installation as compared to those for the MsCIP sites, the considerably weaker foundation materials existing at the Mississippi Gulf Coast sites, and the relative lengths of the barrier structures required for the MsCIP project sites compared to the Thames River site.

3.4.1.1.2 Design Rationale

The approach to selection of a structural model upon which to base our general design for the MsCIP surge barrier structures was governed by certain basic assumptions and basic criteria:

- The structure must, as completely as possible, block the water surge resulting from the design storm;
- It must be as unobtrusive to view from the sound side or the bay side as possible;
- It must not appreciably alter the natural ebb and flow of water from the Mississippi Sound into/out of the bay areas to be protected;
- It must not appreciably alter the existing navigation of the affected waters by commercial and pleasure craft.

After studying the facilities described above and assessing the features offered by each design approach, along with the associated advantages and disadvantages, it was decided to use the Thames River Barrier model as the basis for the cursory layout and design required for the surge barriers at Biloxi and Saint Louis Bays. A structure layout was made for each bay crossing based on available sounding and water surface information. Uniformity of structure height, gate bay width, and end treatment were used so that one single design might be adapted to each bay crossing.

Preliminary gate designs were made using © STAAD computer modeling, and applying the water pressure and wave action forces based on the prescribed protection levels. Various gate heights were used for each design, as dictated by the protection level under consideration and the configuration of the bay bottom along the route of the surge barrier.

Trial designs were made based on the maximum prescribed protection level and using a 200-foot wide centerline to centerline of pier gate bay and a pier width of 28 feet. The resulting 172-foot wide gates proved to be much too massive, requiring the use of very large structural shapes, very thick covering plate elements, and very closely spaced stiffening frames within the gate proper. The required gate operating disks would have been similarly massive using the 200-foot bay width. This difference form the Thames River gates was primarily caused by the much greater design head possible at the MsCIP sites, amounting to 40 feet at the MsCIP sites, as opposed to approximately 23 feet for the Thames River Site.

The gates were reconfigured using a 160-foot center to center of pier spacing and retaining the 28-foot pier width, resulting in a gate clear width of 132 feet. These gates appeared to be much more reasonable, the framing members required being in the mid range of structural shapes available. It should be noted that these design computations were made purely to obtain rough materials weights upon which to base construction cost estimates. Deflections were not checked, and member connections were not designed. In the event that these facilities were to be designed for construction much more work would be required to bring these gate structures to final design. However, the gate structures arrived at through this effort should provide a good estimate of the materials that would be required to construct such structures.

Once the gate structures were cursorily designed, concrete pier and sill monoliths were laid out and iterative static stability analyses were made to arrive at a structure that would be stable under the applied loading. The foundation bearing pressures resulting from these analyses were above that deemed acceptable for the materials likely to be encountered at these sites. Therefore, as a final design measure, these monoliths were fitted with an array of foundation piles. These piles were battered to resist both vertical and horizontal loading. The resulting materials data are summarized in the tables below, for the various protection levels and resulting monolith configurations.

3.4.1.2 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. These features would be equipped with gates to provide for closure during

extreme storms. The shear number of these structures required throughout the area covered by this study could dictate that some automated system be incorporated whereby the gates could be operated from a series of central locations. From each control point the culverts could be monitored and the sluice gates operated to close off the culverts. Multiple flood protection districts would be set up all along each protection line, each coordinating its efforts with all others.

3.4.1.3 Pumping Stations

The stoppage of normal runoff during storm events would dictate that some means be included by which to evacuate groundwater from behind the protection line during such events. This would be done using pumping stations located at appropriate points along each protection line as described below.

Mechanical. Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve and in light of the widespread unavailability of electric power during and immediately after a major storm it was determined that the pumps should be diesel engine driven. Each engine would be battery started through activation of a float switch and the start-up of the engines would be properly timed to accommodate variations in required pumping volume.

Structural layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was included as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet.

Electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

3.4.1.4 Levee and Roadway/Railway Intersections

Roadways. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that the majority of roadways and all railways crossing the levee alignment would be retained.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required. See Figures 3.4.1.4-1 and 3.4.1.4-2 for geometric plan representations of typical types of roadway crossing structures. All gates up to and including 9 feet high would be roller gates. All above 9 feet high would be dual leaf swing gates.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

Railways. Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures or much more expensive tunnel structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee. See Figure 3.4.1.4-3 for geometric plan representation of railroad crossing structures. All railroad gates were assumed to be dual leaf swing gates extending to the full height of levee.

3.4.1.5 Dedicated Flood Barriers

At certain locations there exist properties of vital government interest, extreme historic value, or vital emergency response value in areas where the city congestion would preclude use of levee structures to protect them. As a matter of prudent design these facilities should be removed from the danger zone to a point behind the protection line and where this is possible, this option was followed. However, there are a few instances where removal to a protected area is not desired or expedient. In these instances other structural protection measures would be used as determined by the height of protection required. Generally this protection has been provided using reinforced concrete Tee Walls with sufficient pass through gates to maintain usefulness of the facilities during normal times.

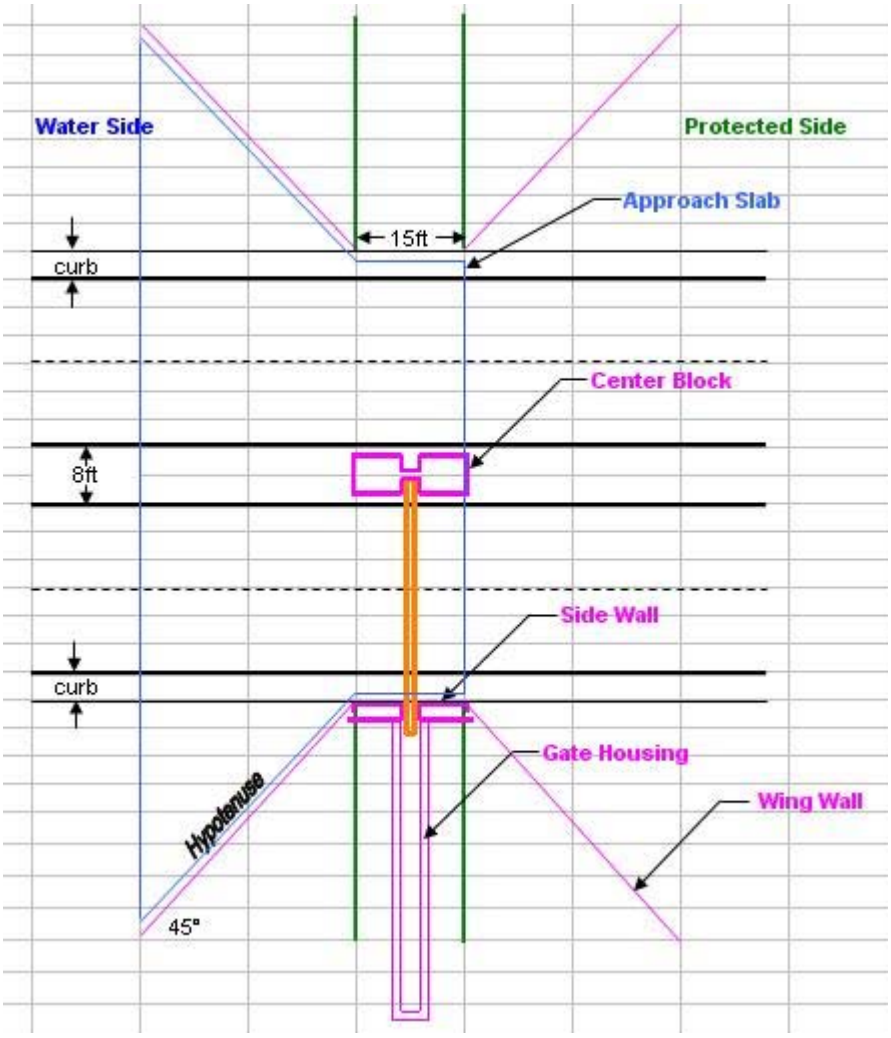


Figure 3.4.1.4-1. Crossings Under 9ft (two lane gate shown; gate and structure would be mirrored to provide for four-lane highway)

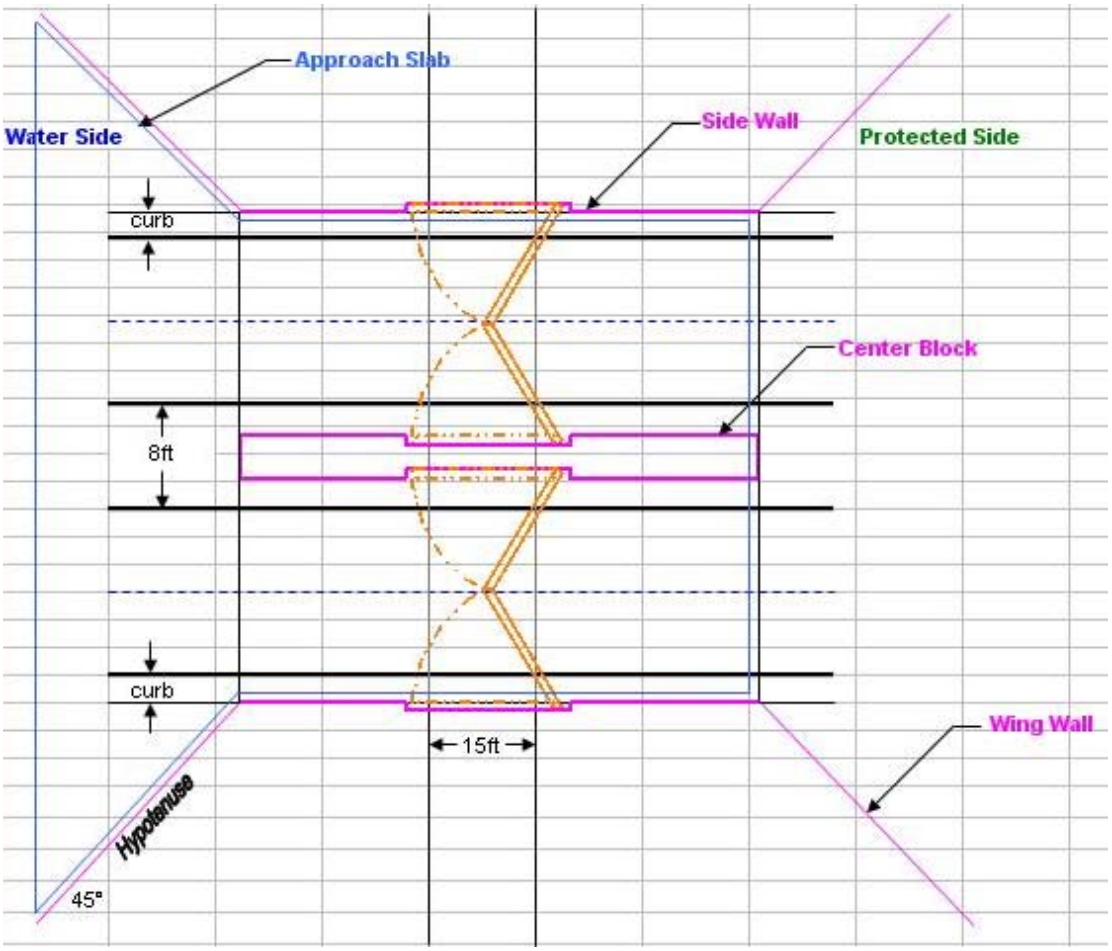


Figure 3.4.1.4-2. Crossing Over 9ft

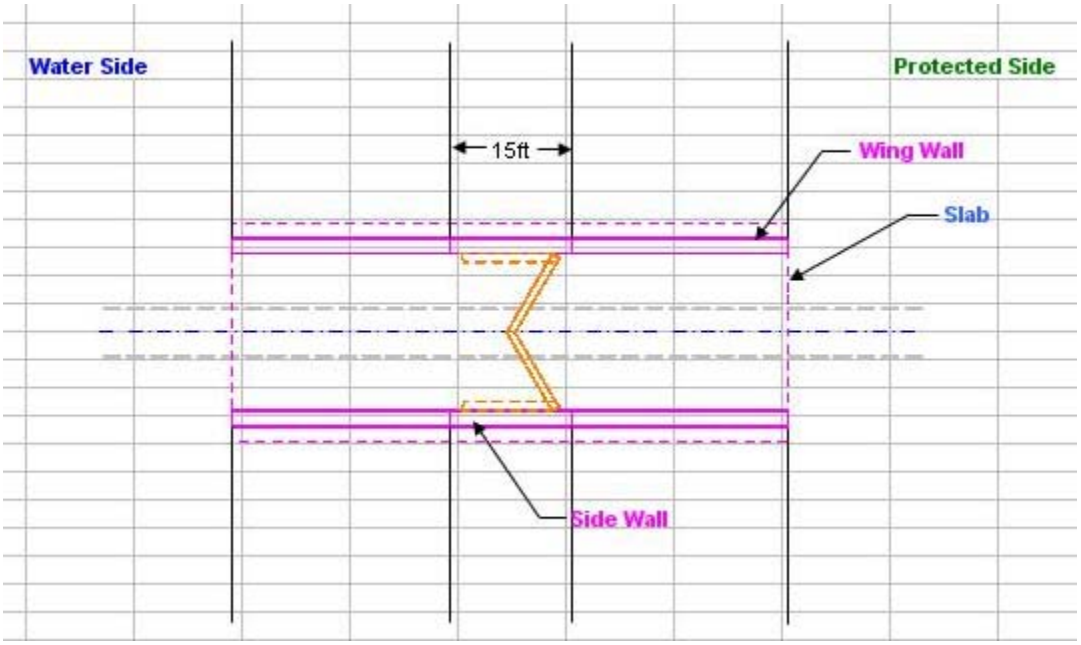


Figure 3.4.1.4-3. Railroad Crossings

3.4.1.6 Operation and Maintenance

3.4.1.6.1 Levee

All levees will require periodic maintenance efforts to include mowing of surface grasses, monitoring of any surface erosion and filling of any resulting cavities. The levees will be periodically monitored for any evidence of subsidence, slope instabilities or seepage.

3.4.1.6.2 Culverts

All culverts penetrating the levee system would have to be periodically and regularly inspected for damage, overgrowth, and sedimentation. The culvert intake and outfall areas would require periodic clearing of vegetation and debris and the surrounding levee slopes and overbanks would have to be kept free of erosion.

The gates and operating mechanisms at each culvert would also require periodic inspection and operation to assure their operability. As planned for this study, all of the culvert gates would be remotely operated. Therefore the periodic maintenance would also cover checks and fine tuning of the remote monitoring and control system. These facilities would require a staff of mechanics and technicians capable of maintaining all mechanical and electrical components in proper working order.

3.4.1.6.3 Pumping Stations

Maintenance of the pumping facilities would require all of the normal civil maintenance activities including clearing of impoundment and outfall areas and general housekeeping activities designed to maintain a workable plant. In addition, the pumps themselves would require periodic inspection and maintenance in keeping with the pump and pump driver manufacturers' warranty requirements. Such requirements would also dictate that each pumping unit be exercised for a minimum duration and a certain number of times during each year. This may pose some degree of difficulty for some of the plants since some were designed almost totally to respond to flood situations. During normal times there may be insufficient inflow to support operation of the pumps, even with the adjacent culverts closed and the normal runoffs collected at the pumps. This difficulty would be addressed in detail in any future study and design work that might be undertaken to refine this system.

3.4.1.6.4 Levee and Roadway/Railway Intersections

These features would require all of the civil maintenance required at the other structures but would in general be more accessible being located along traveled ways. A possible exception to this would be the railway crossings, however these are relatively few and would likely be maintained by railroad personnel. At each of these sites the gates would require lubrication and operation and the gate seals would require periodic inspection and renewal. The gates would be manually operated and would require close coordination with local traffic authorities when any gate movement might be planned.

3.4.1.7 Physical Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an

adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study.

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied building and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.1.8 References

(Oosteschelddekering, Wikipedia, Internet Encyclopedia; The Delta Project, Ministry of Transport, Public Works, and water Management, The Netherlands)

(Maeslantkering, Wikipedia, Internet Encyclopedia)

(NOVA, Sinking City of Venice, PBS, Internet Transcript; Venice could provide gateway to 21st century flood control method, Denise Brehm, Massachusetts Institute of Technology, 2002, Internet Article)

(Flood London, Thames Barrier: History, Technical Specifications, Why The Barrier is Too Small, Internet articles; Thames Region – Operating the Barrier, Environmental Agency, 2007, Internet Article)

EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations

3.4.2 Hancock County Inland Barrier

3.4.2.1 General

Several high density residential and business areas are located in Hancock County. These are subject to damage from storm surges associated with hurricanes. Earthen levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88 and 40 ft NAVD88. The top width was assumed 15 ft with side-slopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Storm surge gates across St Louis are also included to prevent flooding from hurricanes. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented elsewhere in this report.

3.4.2.2 Location

The location of the levee in Hancock County is shown in Figures 3.4.2-1 through 3.4.2-4 parallel to the CSX Railroad and the coast and turning northward across I-10 to tie into the corresponding elevation.

3.4.2.3 Existing Conditions

Hancock County is located on the west side of the Mississippi coast of Mississippi Sound. The main residential and business area is at Bay St Louis and Waveland. Ground elevations over the areas behind the levee vary between elevations 10-20 ft NAVD88 at low areas to as low as 5 ft NAVD88 in the Shoreline Park area. The drains to the south along the coast to Mississippi Sound, to the north and east to St Louis Bay, and on the far west to Pearl River. The 4-ft(blue), 8-ft(Dark green), 12-ft(light green), 16-ft(brown), 20-ft(pink), and 24-ft(purple) ground contour lines are shown in Figure 3.4.2-5.



Figure 3.4.2-1. Vicinity Map Hancock County, MS

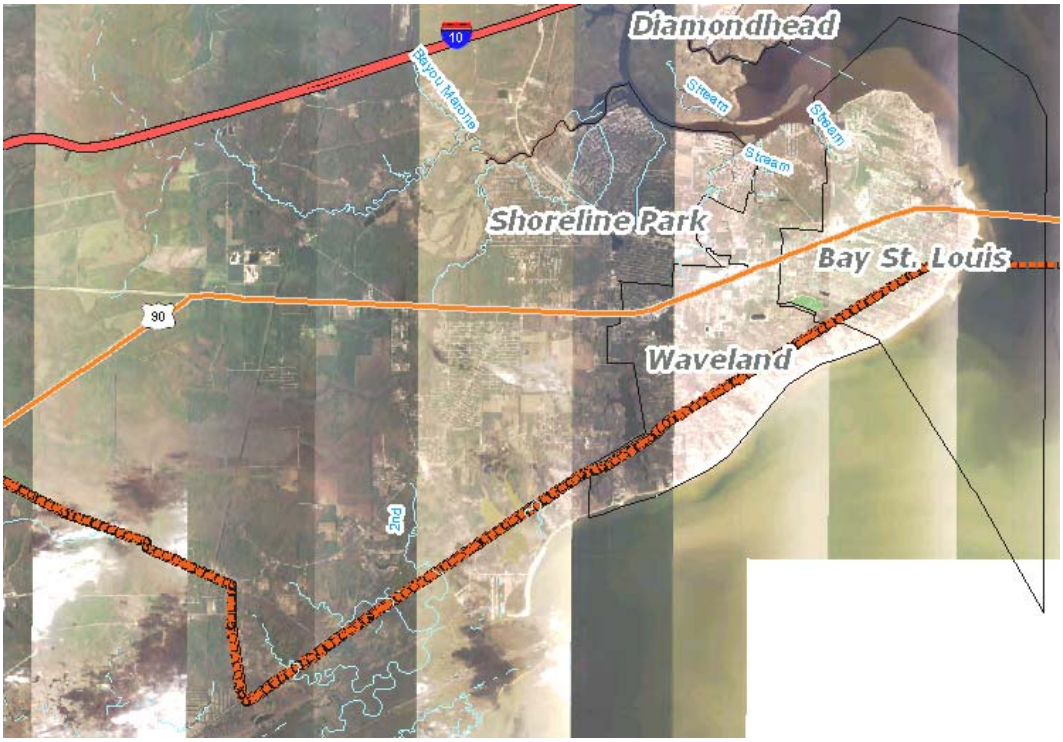


Figure 3.4.2-2. Hancock County Inland Barrier

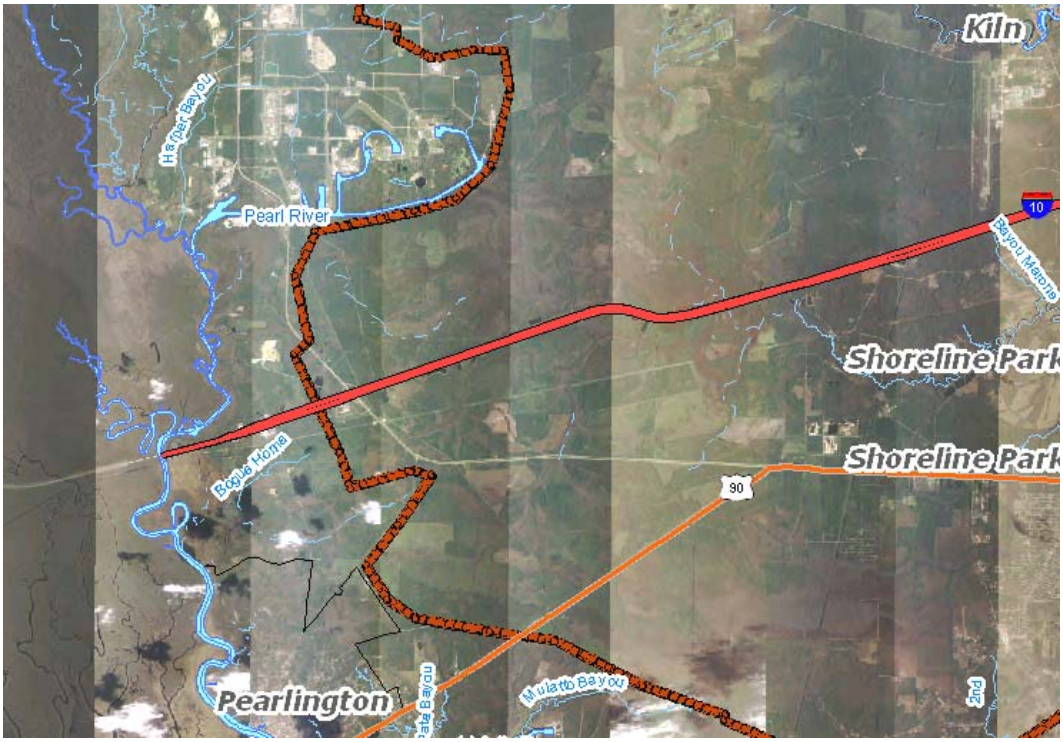


Figure 3.4.2-3. Hancock County Inland Barrier

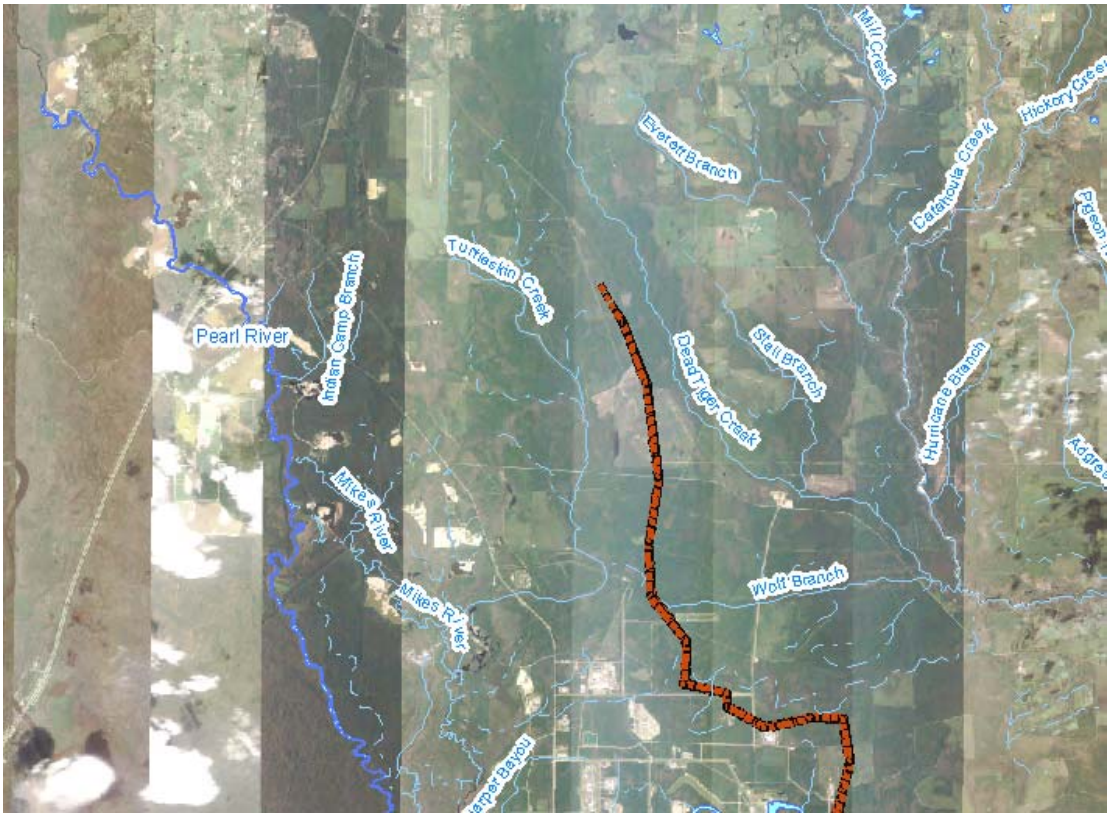


Figure 3.4.2-4. Hancock County Inland Barrier

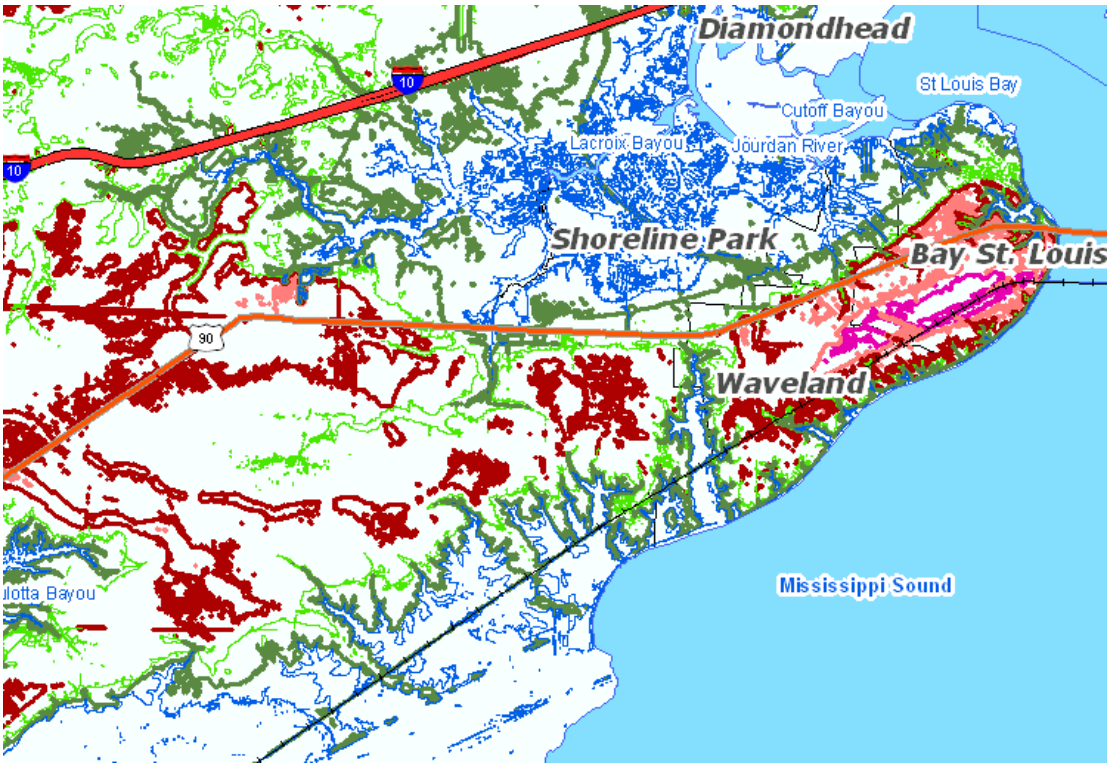


Figure 3.4.2-5. Existing Conditions Hancock County, MS

Drainage from ordinary rainfall is hindered on occasions when either of the rivers or the gulf is high, but impacts from hurricanes are devastating. Damage from Hurricane Katrina in August, 2005 in the Waveland area are shown in Figure 3.4.2-6 and 3.4.2-7.



Source: http://ngs.woc.noaa.gov/storms/katrina/24334552.jpg

Figure 3.4.2-6. Hurricane Katrina Damage Hancock Co, MS



Source: G.J. Charlet III, http://www.flickr.com/photo_zoom.gne?id=46937047&size=m

Figure 3.4.2-7. Hurricane Katrina Damage Hancock Co, MS

3.4.2.4 Coastal and Hydraulic Data

Historic coastal data is shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(Dark green), 12-ft(light green), 16-ft(brown), 20-ft(pink), and 24-ft(purple) ground contour lines are shown below in Figures 3.4.2-8 and 3.4.2-9. The data indicates the Katrina high water was as high as 26 ft NAVD88 in the Waveland/Bay St Louis area.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown elsewhere in this report. Points near Waveland/Bay St Louis at which data from hydrodynamic modeling was saved are shown in Figures 3.4.2-10 and 3.4.2-11.

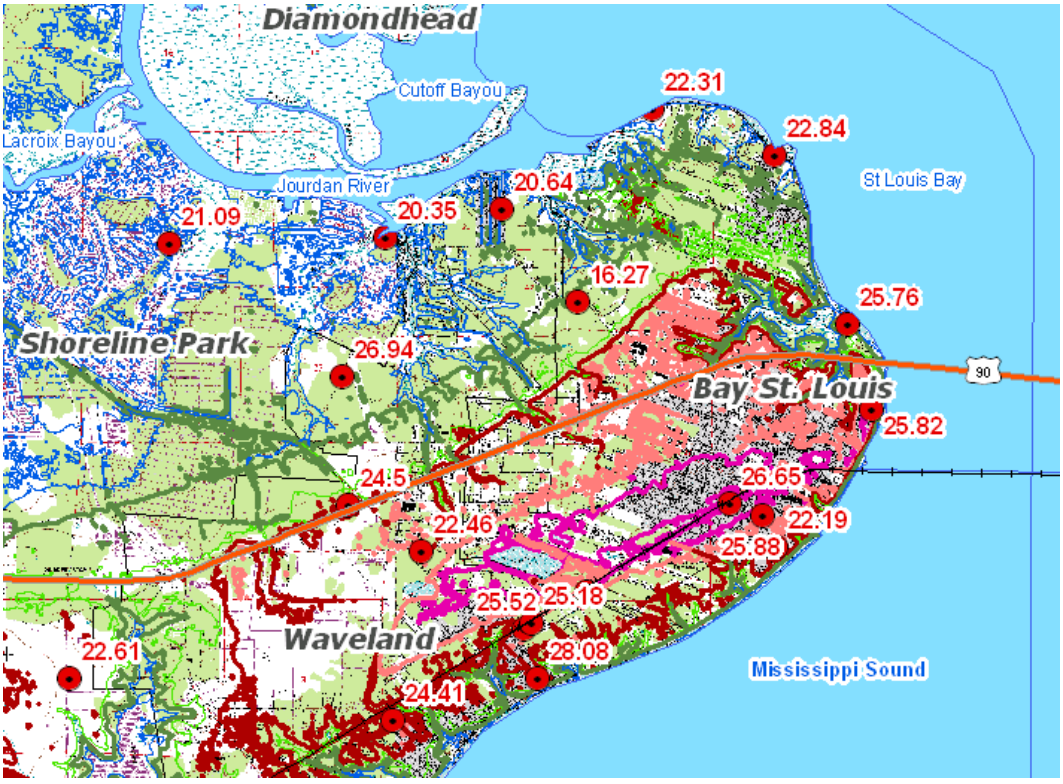


Figure 3.4.2-8. Ground Contours and Katrina High Water Elevations

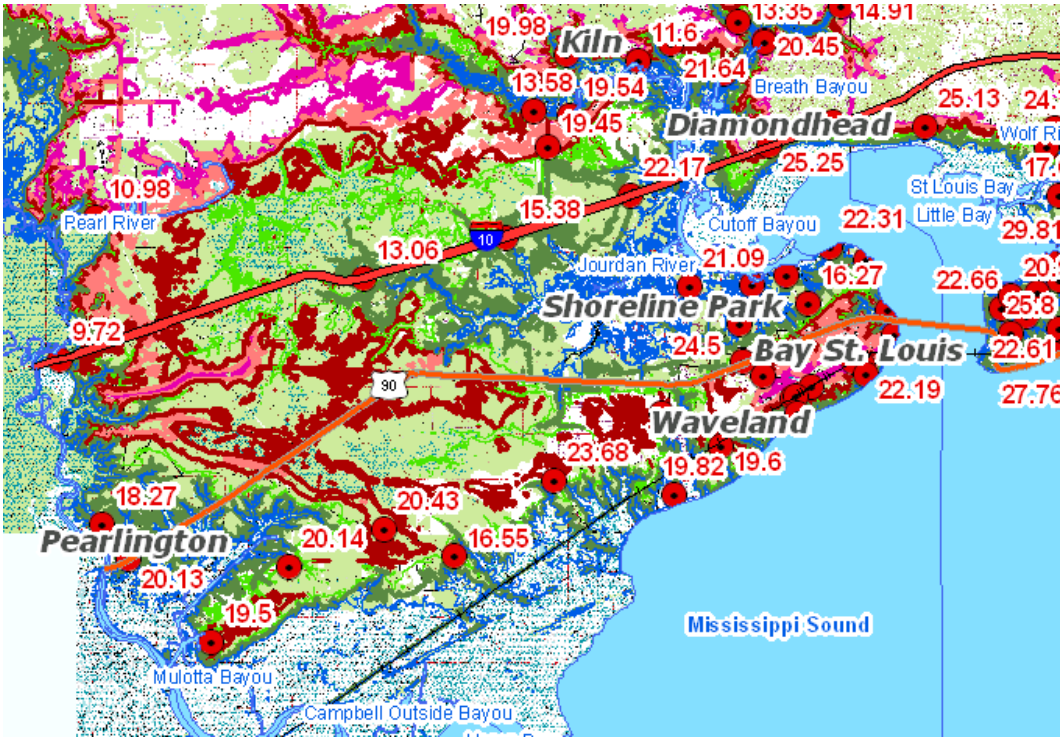


Figure 3.4.2-9. Ground Contours and Katrina High Water Elevations



Figure 3.4.2-10. Hydrodynamic Modeling Save Points near Waveland/Bay St Louis

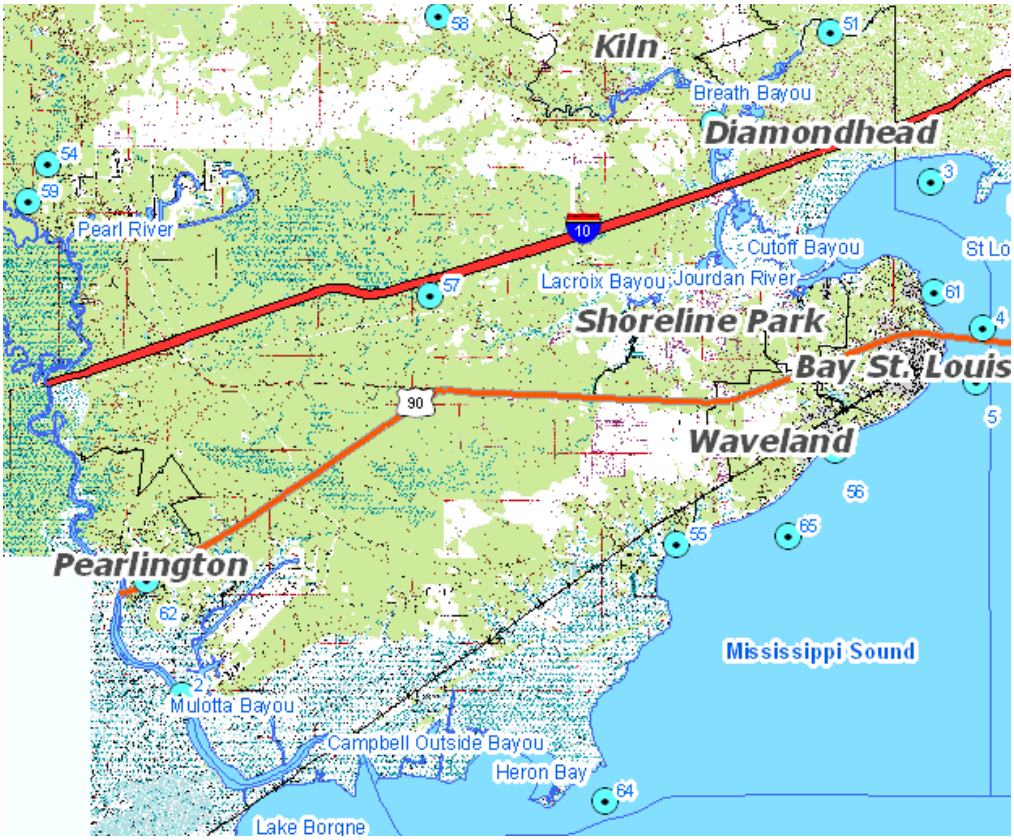


Figure 3.4.2-11. Hydrodynamic Modeling Save Points near Waveland/Bay St Louis

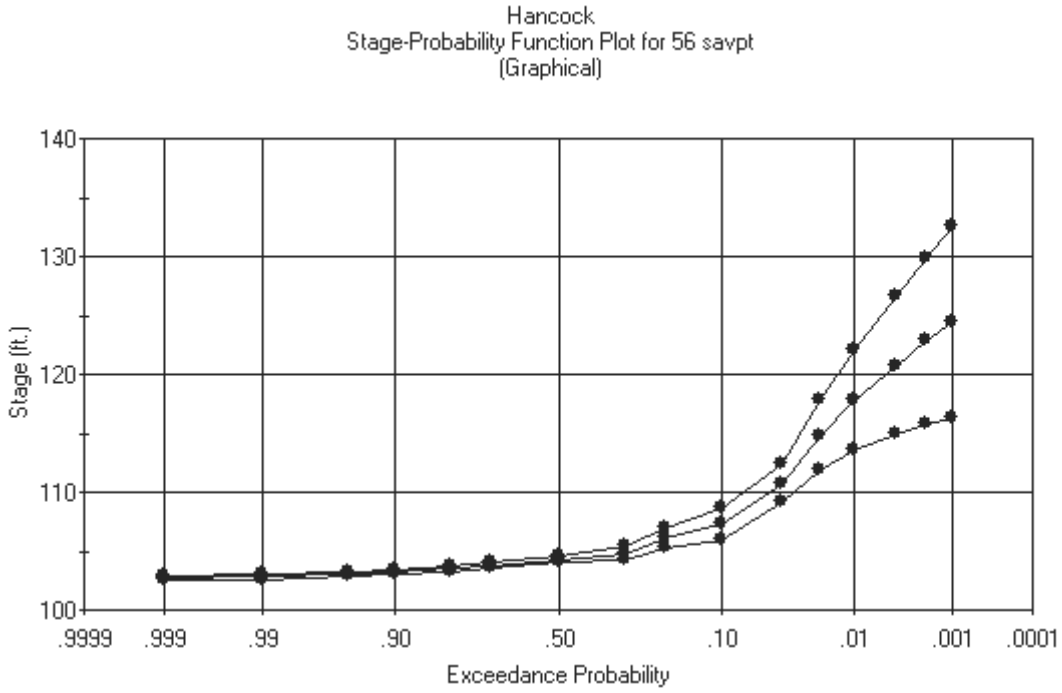


Figure 3.4.2-12. Existing Conditions at Save Point 56, near Waveland, MS

3.4.2.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike across the high ground of the county as shown on Figures 3.4.2-13 through 3.4.2-15, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal. The levee is located mostly along high ground so ponding at the levee would be minimal. Some ditching would be required on the outside of the levee which is shown in dark blue below. Small boat access structures are also shown at the basin 2. Rising sector gates will be provided at these sites allowing shallow draft traffic most of the time. The gates will be closed prior to hurricane storm surge. A drawing of a typical boat access gate is shown in Figure 3.3.12-5.



Figure 3.4.2-13. Pump/Culvert/Sub-basins/Boat Access Site Locations

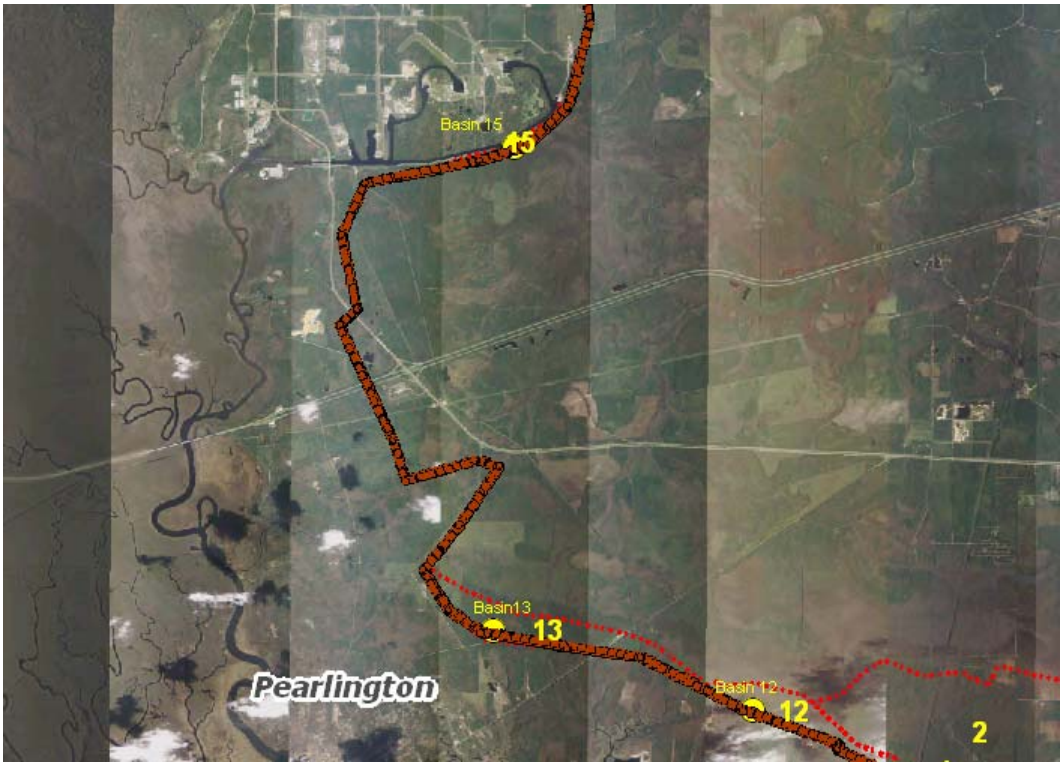


Figure 3.4.2-14. Pump/Culvert/Sub-basins/Boat Access Site Locations

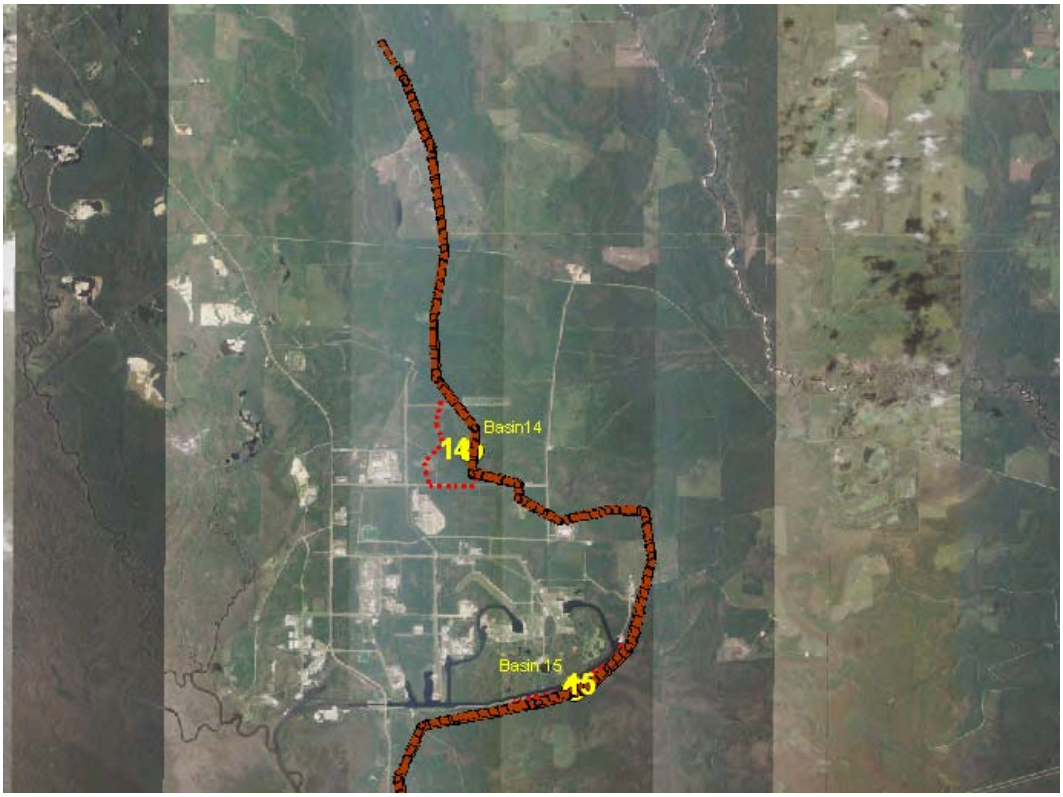


Figure 3.4.2-15. Pump/Culvert/Sub-basins/Boat Access Site Locations

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as depicted in Figure 3.4.2-16.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo: Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.4.2-16. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown in Figure 3.4.2-17 was caused by approximately 1-2 ft of overtopping crest depth.



Source: ERDC, Steven Hughes

Figure 3.4.2-17. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment will be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.4.2-18, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

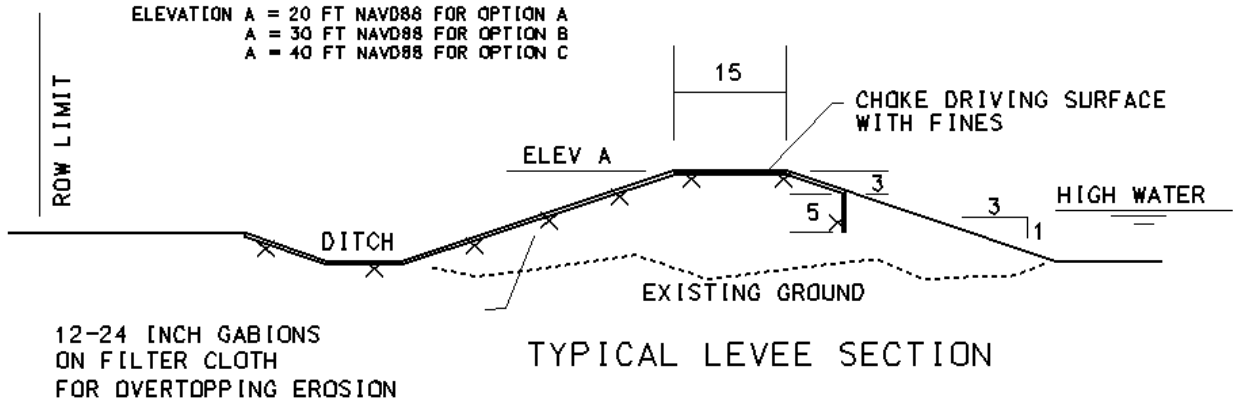


Figure 3.4.2-18. Typical Section at Inland barrier

3.4.2.5.1 Interior Drainage

For smaller drainage areas, drainage on the interior of the inland barrier would be collected at the levee and channeled to culverts placed in the levee at the locations shown in Figures 3.4.2-13 through 3.4.2-15. The culverts would have tidal gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at the upstream end at every culvert in the levee for manual control in the event the tidal gate malfunctions. A typical section is shown is shown in Figure 3.4.2-19.

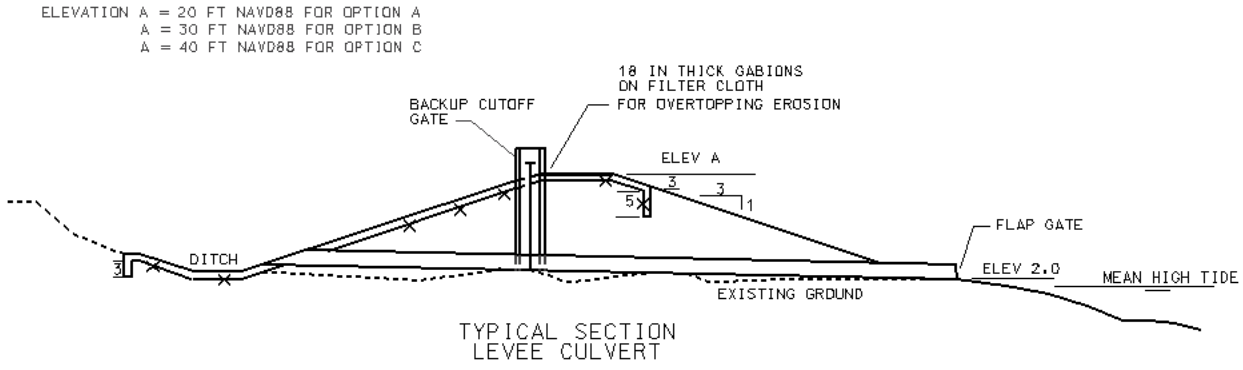


Figure 3.4.2-19. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the inland barrier into major sub-basins as shown in Figure 3.4.2-13 through 3.4.2-15 and computing flow for each sub-

basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number.

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data is considered beyond the level of detail required for this report.

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is “Frequency and Aerial Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is “National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report; therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

In addition to the local drainage outlets at the levee described above, in the event of an imminent hurricane, barrier gates across the St Louis Bay would be closed, and flow from the Jourdan and Wolf Rivers, as well as local runoff would pond behind the gates. The location of the barrier is shown in Figure 3.4.2-20.

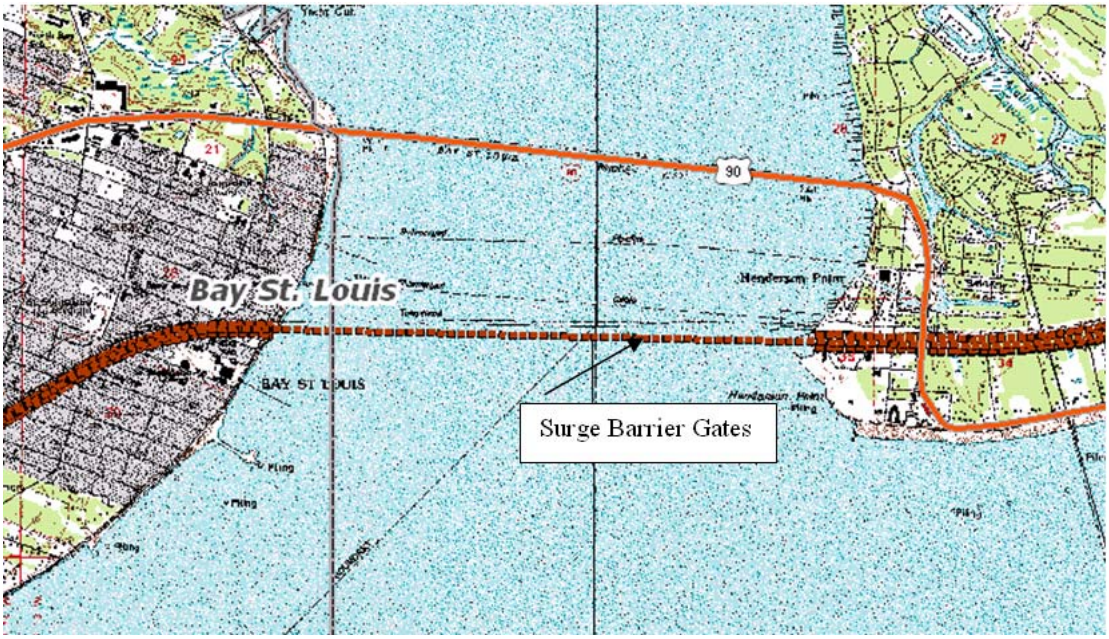


Figure 3.4.2-20. St Louis Bay Surge Barrier Location

The gates would be similar to the gates across the Thames River in London, England, shown in Figure 3.4.2-21.

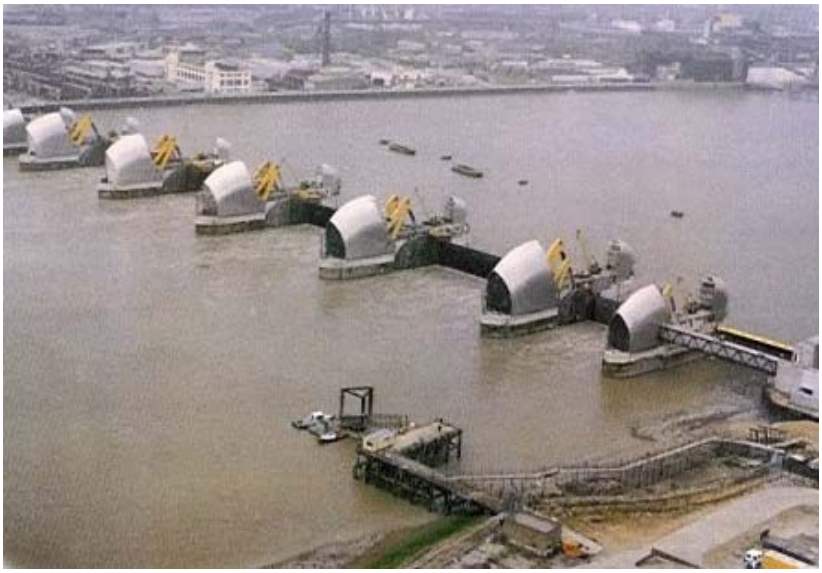


Figure 3.4.2-21. Thames River Barrier Gates

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used to model the St Louis Bay watershed in order to predict the maximum water elevation behind the gates in the bay under several different scenarios.

The St. Louis Bay watershed covers approximately 654 square miles and is comprised of six sub-basins that stretch across the Mississippi counties of Harrison, Hancock, Stone, and Pearl River. There is one United States Geological Survey (USGS) discharge stream gage (#2481510) located in the watershed along the Wolf River, near Landon, Mississippi. There are three significant National

Oceanic and Atmospheric Administration (NOAA) hourly precipitation gages located nearby to the watershed: #109617 White Sand located to the west, #87720 Purvis 2 N to the north, and #109617, 87720, and 107840 Saucier Experimental Forest to the east of the basin. Data from these gages, along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering St. Louis Bay from the St. Louis Bay watershed for the 2 year, 5 year, 10 year, 25 year, 50 year and 100 year rainfall events. The St. Louis Bay watershed is shown in Figure 3.4.2-22.

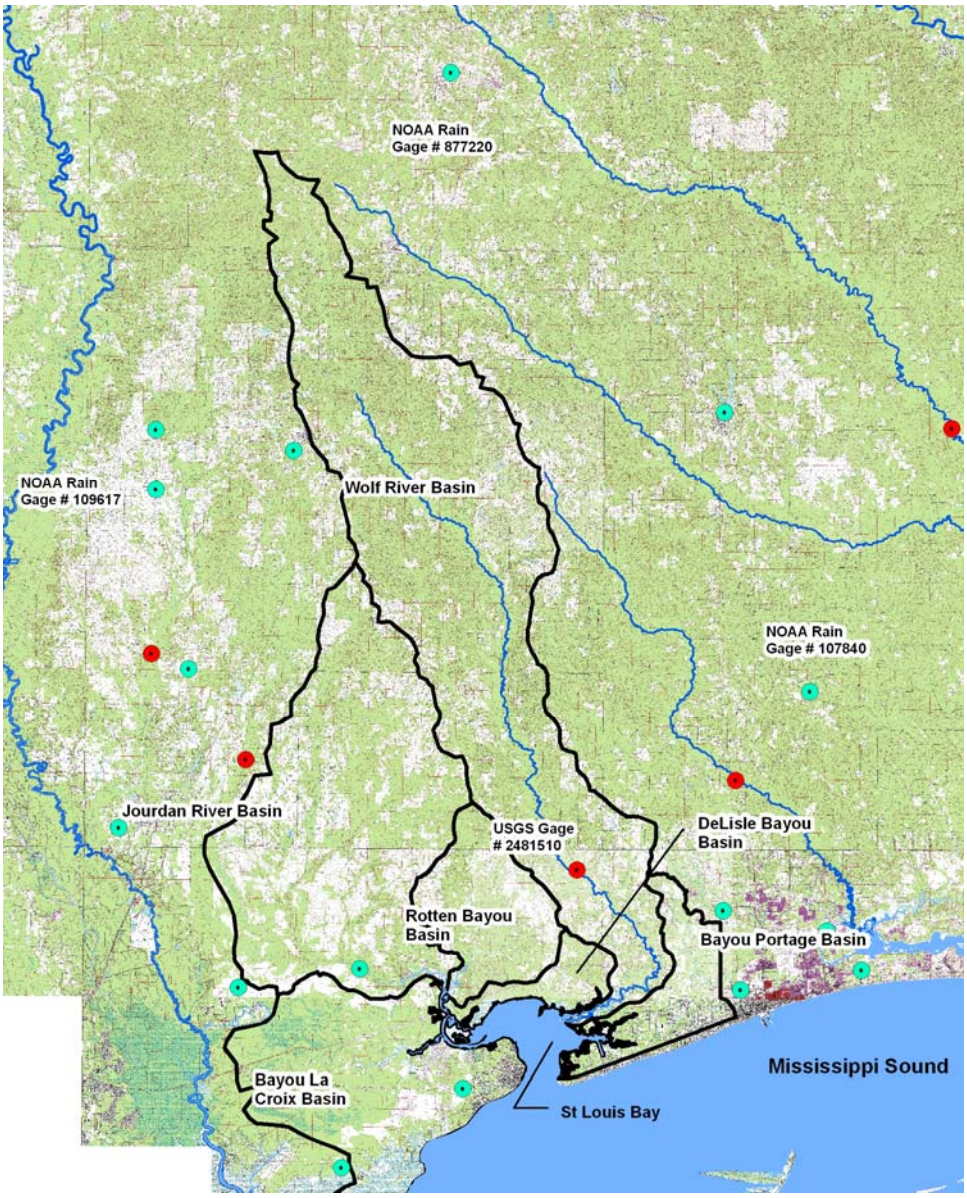


Figure 3.4.2-22. St Louis Bay Watershed

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gages 109617, 87720, and 109617, 87720, and 107840 and the 2-100 year 24-hour TP-40 rainfall events. The initial and constant loss rate method

was used for the loss model while the Snyder's unit hydrograph (UH) method was used for the direct runoff model. The model was calibrated to observed hourly discharge data for one event at USGS gage 2481510. Several other events were analyzed but not used because the observed hourly precipitation for those events did not match the TP-40 rainfall.

The HEC-HMS St. Louis Bay watershed model was calibrated to the September 24-30, 2002 storm events. The model was calibrated at the Upper Wolf River sub-basin using observed precipitation data from NOAA gages 109617, 87720, and 107840 and observed discharge data from USGS gage 2481510. This event had a total rainfall of 13.75 inches and peak discharge of 17,854 cfs. This event was chosen due to the availability of both the hourly precipitation and discharge data. The observed and computed hydrographs are shown in Figure 3.4.2-23.

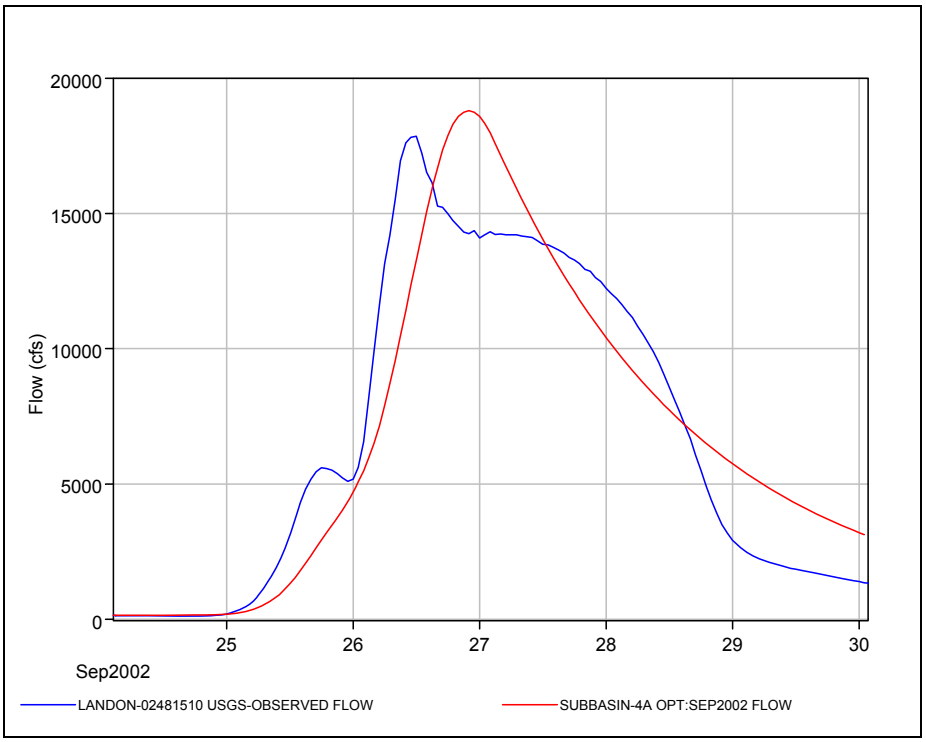


Figure 3.4.2-23. St. Louis Bay Watershed Calibration

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition, in accordance with studies cited above. The highest inflow period of the inflow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

Based on this method of analysis, the resulting elevations for the various storms are shown in Table 3.4.2-1, with the 10-yr elevation of 6.8 ft NAVD88 the design condition.

This ponded water area in Hancock County above the surge barrier gates is approximated by the 8-ft ground contour line shown in Figure 3.4.2-24.

Table 3.4.2-1.
St. Louis Bay Ponding

St. Louis Bay 4 ft. Base Elevations	
Strom Event	**Bay Elevation (ft NAVD88)**
2-year	5.5
5-year	6.3
10-year	6.8
25-year	7.5
50-year	7.9
100-year	8.4

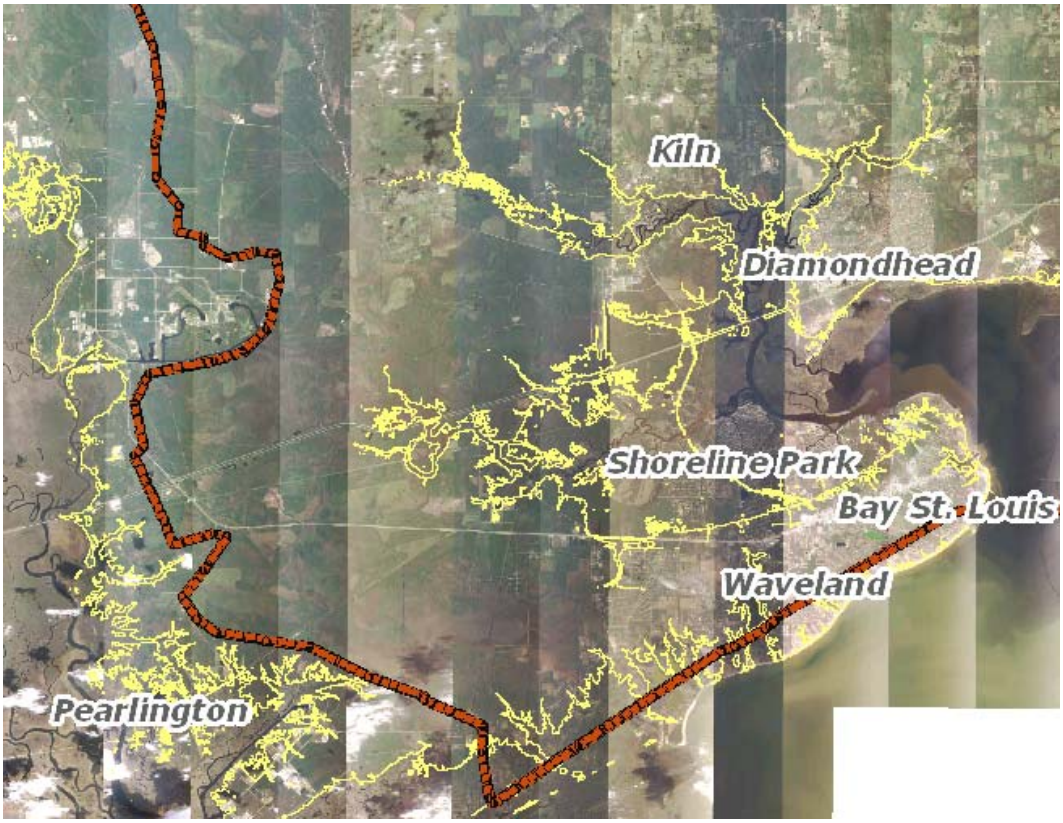


Figure 3.4.2-24. St Louis Bay 10-yr Ponding to Elev. 6.8 ft NAVD88

3.4.2.5.2 Geotechnical Data

Geology: The Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.2.5.3 Structural, Mechanical and Electrical

See sections 3.4.2.5.3.1 through 3.4.2.5.3.3.

3.4.2.5.3.1 Culverts

Drainage features would be required at 16 locations ranging from 20-inch diameter reinforced concrete pipe to reinforced concrete box culverts having 11 water passages, each measuring 12’ wide by 4’ high. Each of the culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.2.5.3.2 Pumping Stations

The design hydraulic heads derived for the three pumping facilities included in the Hancock County Inland Barrier for the elevation 20 protection level varied from 15 to 20 feet and the corresponding flows required varied from 59,694 to 390,483 gallons per minute. The facilities thus derived would vary from a plant having two, 42-inch diameter, 300 horsepower pumps, to one having four, 60-inch diameter pumps operating at 560 horsepower.

3.4.2.5.3.3 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 20, 14 roadway intersections would have to be accommodated. For this study it was estimated that 4 roller gate structures and 6 swing gate structures would be required. In addition, 4 railway closures would be required.

3.4.2.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.2.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.2.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. This level is the most applicable to this option.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would

possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.2.5.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.2.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.2.8 Cost Summary. Construction costs for the various options are included in Table 3.4.2-2 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.4.2-3 Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.2.5.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.2.6 Option B – Elevation 30.0 NAVD 88

3.4.2.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.4.2.6.2 Geotechnical Data

Geology: Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.2.6.3 Structural, Mechanical and Electrical

See sections 3.4.2.6.3.1 through 3.4.2.6.3.3.

3.4.2.6.3.1 Culverts

Drainage features would be required at 16 locations ranging from 20-inch diameter reinforced concrete pipe to reinforced concrete box culverts having 11 water passages, each measuring 12’ wide by 4’ high. Each of the culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.2.6.3.2 Pumping Stations

Design hydraulic heads derived for the three pumping facilities included in the Hancock County Inland Barrier for the elevation 30 protection level varied from 25 to 30 feet and the corresponding flows required varied from 59,694 to 390,483 gallons per minute, respectively. The facilities thus derived would consist of one plant having two, 42-inch diameter, 500 horsepower pumps to one having four, 60-inch diameter pumps operating at 1000 horsepower.

3.4.2.6.3.3 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 30, 31 roadway/railway intersections would have to be accommodated. For this study it was estimated that 9 roller gate structures and 18 swing gate structures would be required. In addition, 4 railway closure gates would be required.

3.4.2.6.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.2.6.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.2.6.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. This level of security is the most applicable to this option.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would

possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.2.6.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.2.6.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.2.8 Cost Summary. Construction costs for the various options are included in Table 3.4.2-2 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.4.2-3. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.2.6.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.2.7 Option C – Elevation 40.0 NAVD 88

3.4.2.7.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.4.2.7.2 Geotechnical Data

Geology: Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will not be armored since the elevation will not allow overtopping. All surfaces of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.2.7.3 Structural, Mechanical and Electrical

See sections 3.4.2.7.3.1 through 3.4.2.7.3.3.

3.4.2.7.3.1 Culverts

Drainage features would be required at 16 locations ranging from 20-inch diameter reinforced concrete pipe to reinforced concrete box culverts having 11 water passages, each measuring 12’ wide by 4’ high. Each of the culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.2.7.3.2 Pumping Stations

Design hydraulic heads derived for the three pumping facilities included in the Hancock County Inland Barrier for the elevation 40 protection level varied from 30 to 35 feet and the corresponding flows required varied from 59,694 to 390,483 gallons per minute, respectively. The facilities thus derived would consist of one plant having two, 42-inch diameter, 500 horsepower pumps to one having six, 54-inch diameter pumps operating at 1000 horsepower.

3.4.2.7.3.3 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 40, 40 roadway/railway intersections would have to be accommodated. For this study it was estimated that all 36 of the highway crossings would require swing gates. In addition, 4 railway closure gates would be required.

3.4.2.7.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.2.7.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.2.7.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. This level of security is the most applicable to this option.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.2.7.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.2.7.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.2.8 Cost Summary. Construction costs for the various options are included in Table 3.4.2-2 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.2-3. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and

Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.2.7.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.2.8 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.4.2-2.
Hancock Co Inland Barrier Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$379,400,000
Option B – Elevation 30 ft NAVD88	$852,200,000
Option C – Elevation 40 ft NAVD88	$790,800,000

Table 3.4.2-3.
Hancock Co Inland Barrier O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$3,390,000
Option B – Elevation 30 ft NAVD88	$8,934,000
Option C – Elevation 40 ft NAVD88	$7,562,000

3.4.2.9 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

National Resource Conservation Service (NRCS). 2003. WinTR5-55 User Guide (Draft). Agricultural Research Service. 7 May 2003.

Environmental Science Services Administration. 1968. “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968.

Weather Bureau and USACE. 1956. National Hurricane Research Project Report No. 3, “Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers.

3.4.3 St. Louis Bay Surge Barrier

3.4.3.1 General

In order to protect the properties surrounding Saint Louis Bay and along the lower portions of the various rivers and streams flowing into the bay, a barrier would be required at some point to block storm waters during major storm events. A proposed alignment for the surge barrier is shown in Figure 3.4.3.1-1. As outlined above, a search of other similar facilities constructed world wide revealed that the structure model best satisfying both the engineering and socio-ecological necessities of this site was that used for the Thames River Barrier in London, UK. The structure tentatively investigated for incorporation into this work was thus, patterned after the Thames River Barrier with certain minor modifications to adapt to the site and environment specific conditions enumerated previously.

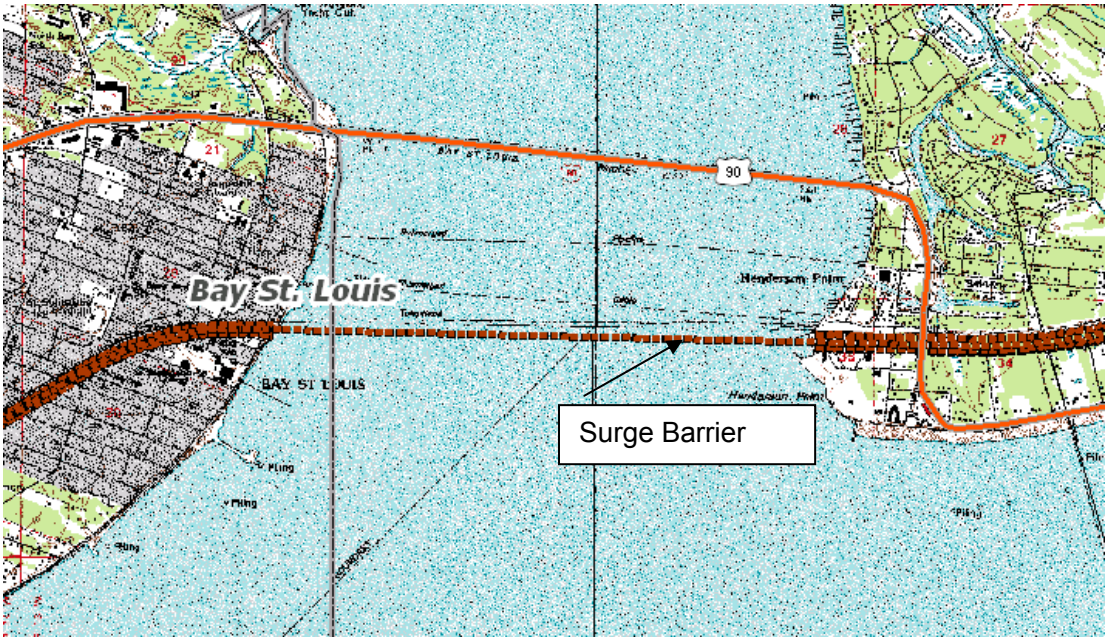


Figure 3.4.3.1-1. St. Louis Bay Surge Barrier Location

3.4.3.1.1 Interior Drainage

In the event of an imminent hurricane, the gates St Louis Bay would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates. The tentative location of the barrier chosen for this study is shown below.

The St. Louis Bay watershed, Figure 3.4.3.1-2, covers approximately 654 square miles and is comprised of six sub-basins that stretch across the Mississippi counties of Harrison, Hancock, Stone, and Pearl River. There is one United States Geological Survey (USGS) discharge stream gage (#2481510) located in the watershed along the Wolf River, near Landon, Mississippi. There are three significant National Oceanic and Atmospheric Administration (NOAA) hourly precipitation gages located nearby to the watershed: #109617 White Sand located to the west, #87720 Purvis 2 N to the north, and #109617, 87720, and 107840 Saucier Experimental Forest to the east of the basin. Data from these gages, along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering St. Louis Bay from the St. Louis Bay watershed for the 2 year, 5 year, 10 year, 25 year, 50 year and 100 year rainfall events.

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gages 109617, 87720, and 109617, 87720, and 107840 and the 2-100 year 24-hour TP-40 rainfall events. The initial and constant loss rate method was used for the loss model while the Snyder's unit hydrograph (UH) method was used for the direct runoff model. The model was calibrated to observed hourly discharge data for one event at USGS gage 2481510. Several other events were analyzed but not used because the observed hourly precipitation for those events did not match the TP-40 rainfall.

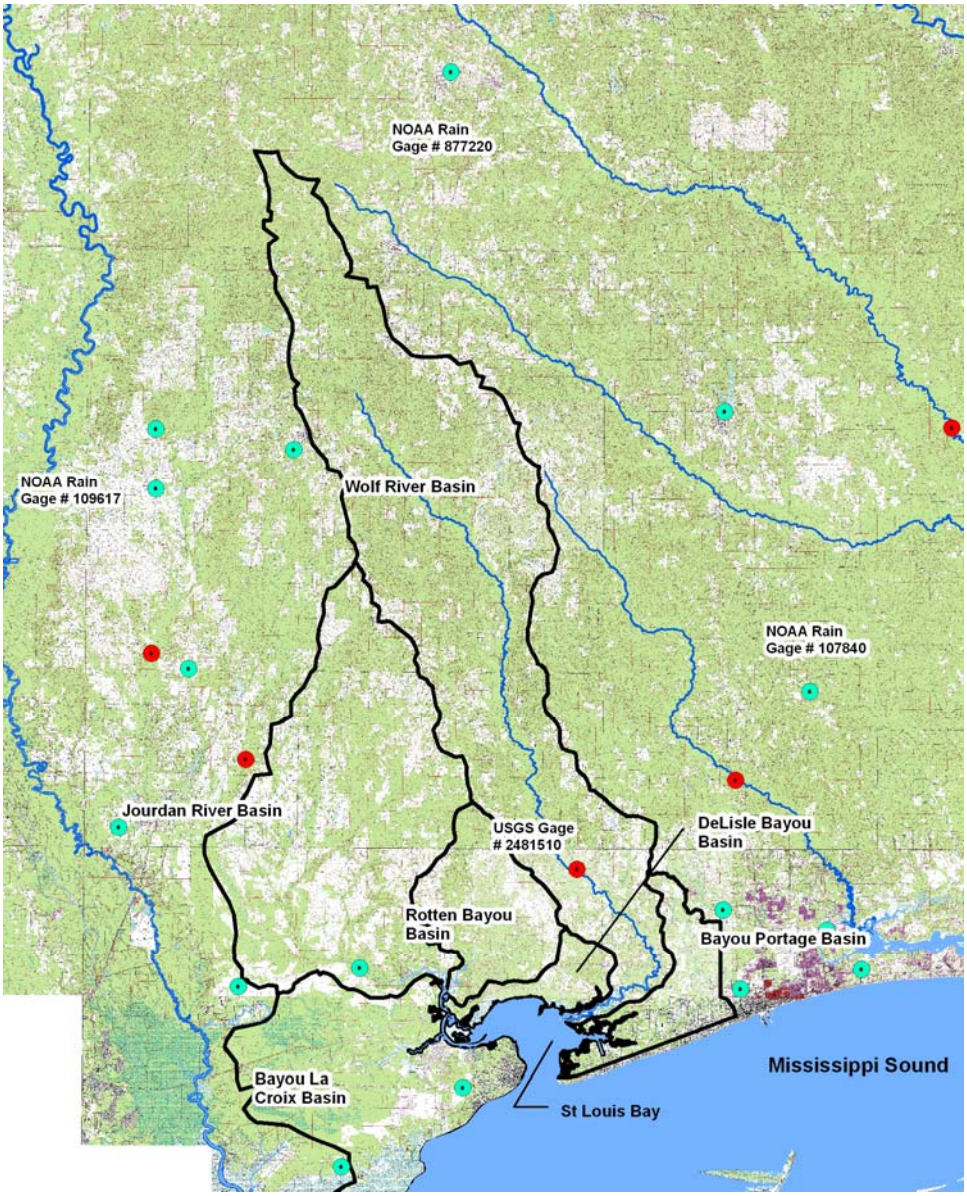


Figure 3.4.3.1-2. St. Louis Bay Watershed

Calibration results agree reasonably well with observed data as shown in Figure 3.4.3.1-3.

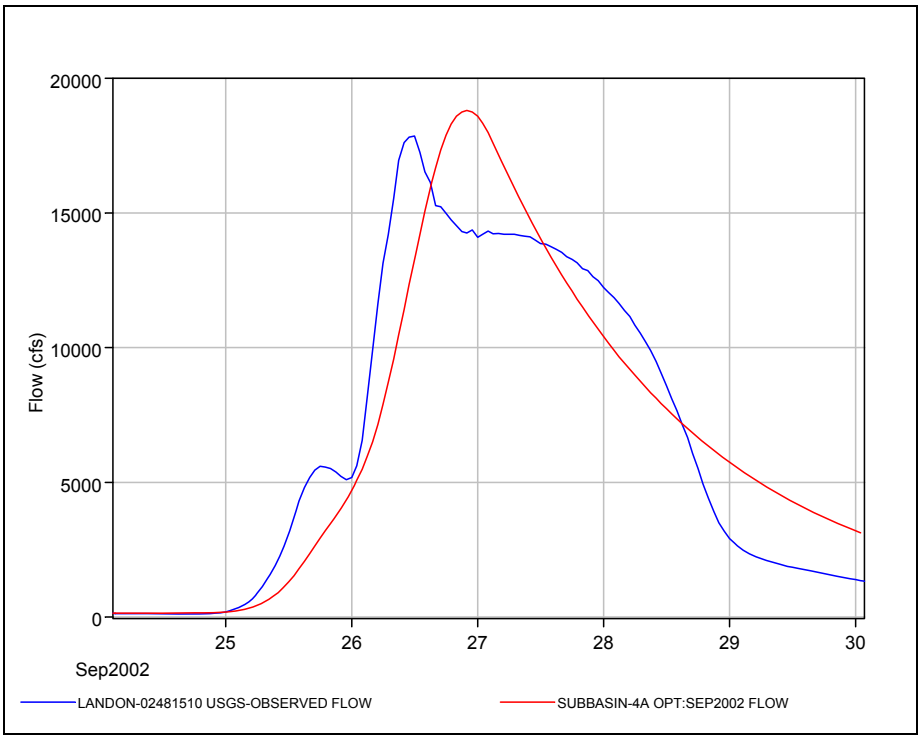


Figure 3.4.3.1-3. St. Louis Bay Watershed Calibration

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V. Goodyear, Office Hydrology, July 1968. The second is “National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District, U.S. Army Corps of Engineers.

The 24-hour period of highest inflow from the flow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

Based on this method of analysis, the resulting elevations for the various storms are shown in Table 3.4.3.1-1, with the 10-yr elevation of 6.8 ft NAVD88 the design condition.

Table 3.4.3.1-1.
St. Louis Bay Ponding

St. Louis Bay 4 ft. Base Elevations	
Strom Event	**Bay Elevation (ft NAVD88)**
2-year	5.5
5-year	6.3
10-year	6.8
25-year	7.5
50-year	7.9
100-year	8.4

The ponded water area in above the surge barrier gates is approximated by the 8-ft ground contour line shown in Figure 3.4.3.1-4.

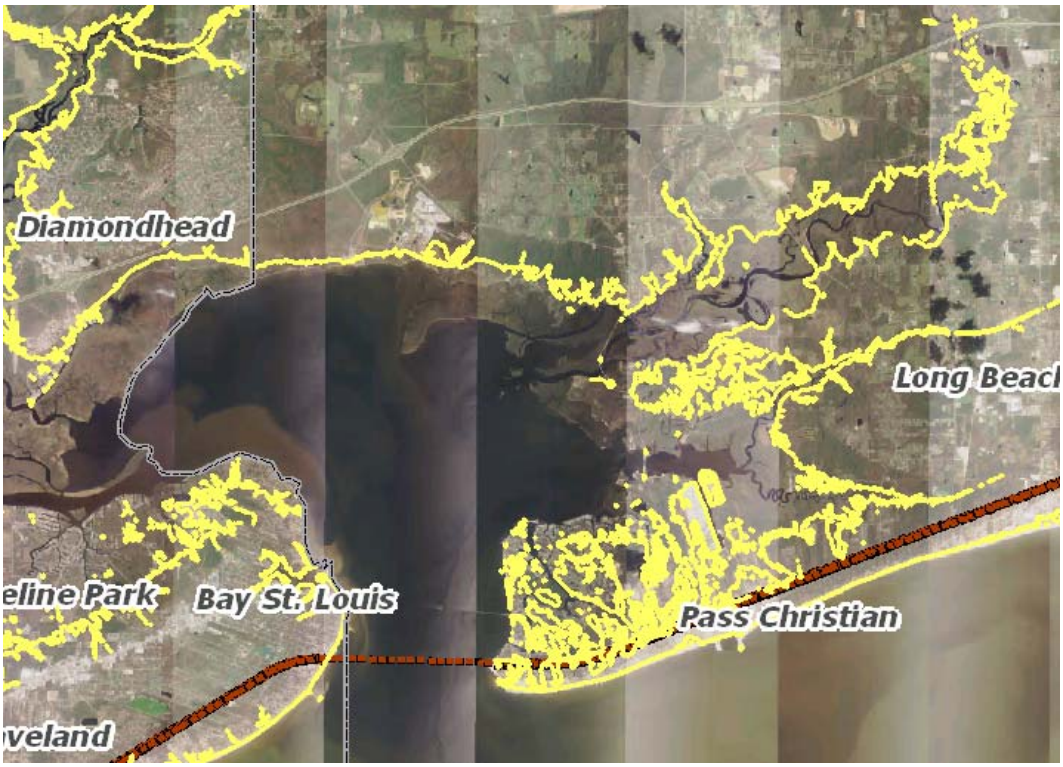


Figure 3.4.3.1-4. St. Louis Bay 10-yr Ponding to Elev 6.8 ft NAVD88

3.4.3.1.2 Geotechnical Data

The available mapping covering the bay bottom is very sketchy consisting mostly of quad maps. This data indicates that the existing bay bottom elevation along the study alignment would be fairly uniform at approximate (-)7 to (-) 8 feet across much of the bay width. The water depth naturally tapers from full depth to the water's edge over some distance out from each bank. Information gathered from the Mississippi Department of Transportation indicates that the bay bottom materials are very loose and unstable to a significant depth below the bay bottom indicating that a significant amount of undercutting would be required for any structure that might be installed, and that structures of the magnitude under consideration would require very deep pile foundations.

3.4.3.1.3 Structural, Mechanical and Electrical

See sections 3.4.3.1.3.1 through 3.4.3.1.3.3.

3.4.3.1.3.1 Structural

Structurally, the Barrier as configured for this study would consist of a series of 38 large stainless steel clad, structural steel framed gates called rising sector gates. Each of these would be supported on reinforced concrete piers resting on large continuous concrete sills with pile foundations. The tentative layout used to estimate the scope of the structure was configured having gates 132 feet long mounted on 28-foot wide piers. The number of gates was determined by the extent of water having depth sufficient to support their operation. To facilitate as nearly as possible the normal ebb and flow of tide waters through the barrier, the concrete connector wall and rock fill portions of the barrier either side of the gated structure would be fitted with a series of closely spaced low level gated culverts. The gate and pier heights were varied to accommodate the "level of protection" under consideration. The three elevations selected for this study were 20, 30, and 40 NAVD88. In each instance the gate heights were set to match the protection level elevations with pier heights set approximately 3 feet higher to provide minor wave clearance for protection of operating equipment. Atop each pier an operating machinery block would be mounted to house the operating equipment. No lateral access over the tops of the piers was envisioned because of the long spans and the desire to keep the vista across the structure as clear as possible. Operating and utility access would be provided through two continuous tunnels passing through the sill section and the rock fill, to operating facilities located on each bank.

3.4.3.1.3.2 Mechanical

The mechanical equipment and appurtenances required for operation of these facilities would include very large steel gate linkages and hydraulic rams and pivot pins for operation of each gate. Each gate would rotate on large bearings and pivot hubs at each end of the gate. Various operating hydraulic and lubrication oil systems would also be required. Each gate would have an opening/closing time of approximately 15 minutes.

3.4.3.1.3.3 Electrical

Primary electrical power for operating the gates would be provided using dedicated, standard transformers with emergency back-up generators. The size of the generators would be greatly reduced by minimizing the wattage output through reduction of the demand on the facility. The demand would be minimized by phasing the operation of the gates to the greatest extent possible. For this study it was determined that this could possibly be done by operating a maximum of eight gates at a time, with the last eight gates being left open until the storm threat was definite and eminent. The operation would require that a maximum of four gates be started at one time, with the remaining four gates sequenced to start 1 minute later. It was determined that this would allow the entire closure and subsequent opening operations to be done over a period of 4 to 6 hours. The supplemental generation aspect was considered to be a vital component of the design because of the very high cost of Commercial standby power and because commercial electric power would almost certainly be unavailable during and immediately following a storm event.

3.4.3.1.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report

therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.3.1.5 Construction Procedures and Water Control Plan

Following is a very tentative description of a sequence of construction by which the barrier structure and embankments might be built. There are admittedly myriad other means by which this could be accomplished as demonstrated by the construction methods used in construction of the Thames River Barrier and various structures in The Netherlands and elsewhere, any one of which might result in more economical and expeditious construction of the barrier. However, at this juncture, in the interest of clarity and brevity, it was considered expedient to describe this work using customary construction techniques common to most of our large civil works projects constructed to date.

3.4.3.1.5.1 Construction Procedure

As configured for this study, the physical construction of the barrier would begin with installation of the first of what would likely be a three stage cellular cofferdam. The arrangement assumed for this study consisted of a series of circular sheet pile cells and connecting arcs measuring approximately 60 feet in diameter and extending 100 feet from the top of the cell to the pile tip elevation. These cells would encompass either the east side or west side transition monoliths and approximately one-third of the gated portion of the structure. It was assumed that for structures designed to provide the highest protection level (Elevation 40 NAVD88) the top of cells could be placed at elevation 35 with reasonable degree of safety. This would provide cell embedment of approximately 30 feet below the lowest structure foundation elevation. This configuration was, naturally, modified to fit the lower levels of protection, but in each case the configuration was made to provide the same relative of protection during construction. With the cofferdam in place the interior would be dewatered using hydraulic pumps, and excavation for the concrete structures would begin. Once the excavation in a given area is brought to the required grade work would continue in this area with the installation of foundation piles. Prior to completion of this phase of the work, installation would begin on the next phase of the cofferdam.

Once the first phase of the concrete structure is completed and the first phase cofferdam removed, installation of the gates and operating machinery would begin. Fabrication of the gates would have been done on land in an outfitting yard and the gates transported by water to the proper installation site. Note that this would likely require dredging of a temporary construction channel parallel to the barrier for a portion of its length.

Construction of the rock fill embankments would require surcharging and pre-consolidation of the bay bottom materials. (See section 3.4.3.1.2 above for discussion of the Geotechnical aspects of this site.)

3.4.3.1.5.2 Water Control Plan

As this work progresses the flow into and out of Saint Louis Bay would be somewhat restricted for practically the entire construction time. This restriction could be minimized by removal of the cofferdams immediately upon completion of the concrete piers to some point above the normal high tide level thus allowing flow over the completed sill sections as construction continues on the piers and as the gates are being installed. It is estimated the maximum flow restriction at any time would be approximately 30% of the inlet width and that this restriction could endure for as much as four to seven years using the methods and approximate sequence of construction indicated above.

3.4.3.1.6 Physical Security

As described in 3.4.1.7, the construction of the project the contractor would be responsible for maintaining security of all his work sites. This would be done in accordance with latest AT/FP guidance for projects of this type and scope in addition to the normal site security requirements.

Upon completion of the project the facilities security responsibilities would pass to the U.S. Army Corps of Engineers and the state, county and municipal law enforcement entities, all of whom would coordinate a program of oversight under which the facilities would be operated and maintained and under which specific security responsibilities would be defined and allocated. These agreements would also be required to meet AT/FP requirements in addition to normal security criteria.

3.4.3.1.7 Operations and Maintenance

In order to assure proper functioning of the facilities once they are placed in service a program of Operations and Maintenance would be developed by the U.S. Army Corps of Engineers, in conjunction and cooperation with the affected state and local entities. This O & M Plan would address specific responsibilities as to daily operation of the facilities, the periodic testing and maintenance of the operating machinery, maintenance of specified stocks of replacement parts, security of the facilities, and maintenance of any buildings and grounds associated with the operation and maintenance of the facilities. As presently envisioned, this O & M responsibility would remain under control of the U.S. Army Corps of Engineers and would be administered under its Operations mission.

3.4.3.1.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.3.8 Cost Summary. Construction costs for the various options are included in Table 3.4.3.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.3.8-2. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates exclude project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.3.1.9 Schedule and Design for Construction

The scheduling for events following this conceptual study would of necessity include further study to ascertain in greater detail the specific requirements of the project and the most feasible means by which to fulfill these requirements. The Sequence of events would include but not be limited to the following:

a. The alignment and extent of the proposed barrier should be subjected to detailed study to determine the most feasible routing. This study should address, among other factors, the exact location of utilities features crossing the bay inlet, the present and projected future needs of boat traffic passing through the barrier, and how best to minimize the effects that the barrier could have on the existing marine environment.

b. Detailed deep geotechnical investigation should be made to determine as accurately as possible the engineering capabilities of the soils making up the bay bottom along the alignment (or alignments) under consideration.

c. A more thorough and painstaking investigation of various types of gate structures should be undertaken to confirm the choice of the rising sector gate for this application, or to replace this type gate with another perhaps more appropriate to the circumstances.

d. Once exhaustive search and investigations and analyses have been completed a thorough design of the structures to be included in the final facility would be undertaken addressing the full range of hydraulic events that the structure might see, and making certain that all pertinent design considerations are accounted for.

e. A thorough analysis of the power required to operate the gates in a timely manner in time of storm must be made and the very best, most dependable means of providing this power determined.

f. The link between the operation of the gates and the best available storm forecasting system(s) would be designed and its operating features and equipment detailed.

3.4.3.2 Location

The alignment suggested herein for the barrier structure would run parallel with and south of the Railroad Bridge crossing Saint Louis Bay. This would approximate the shortest route across the inlet leading form the Mississippi Sound into the bay. As the layout of the barrier was developed it became apparent that, because of the excavation required, a significant amount of separation would be required between the railroad bridge and the ultimate location of the structures included in the barrier. For this study the centerline of the barrier was positioned approximately 260 feet from the center of the railroad bridge. This was left unaltered for all protection levels. The entire barrier would be approximately 10,320 feet in length from water's edge to water's edge, and would consist of rock fill levees extending from the overland levee at each bank for some distance into the bay and enveloping the mass concrete non-overflow wall sections leading to each end of the gated structure.

3.4.3.3 Existing Conditions

The points at which the barrier would come ashore in Jackson County on the east and Harrison County on the west, are in urban areas with extensive residential and commercial development. Several structures would need to be relocated and it is uncertain the extent to which existing utilities might have to be relocated to clear the way for this facility.

3.4.3.4 Coastal and Hydraulic Data

Historic coastal data is shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 8-ft(dark green), 12-ft(light green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown in Figure 3.4.3.4-1. The data indicates the Katrina high water was as high as 22 ft NAVD88 at the mouth of the bay.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown

elsewhere in this report. Points near the mouth of the bay at which data from hydrodynamic modeling was saved are shown in Figure 3.4.3.4-2.

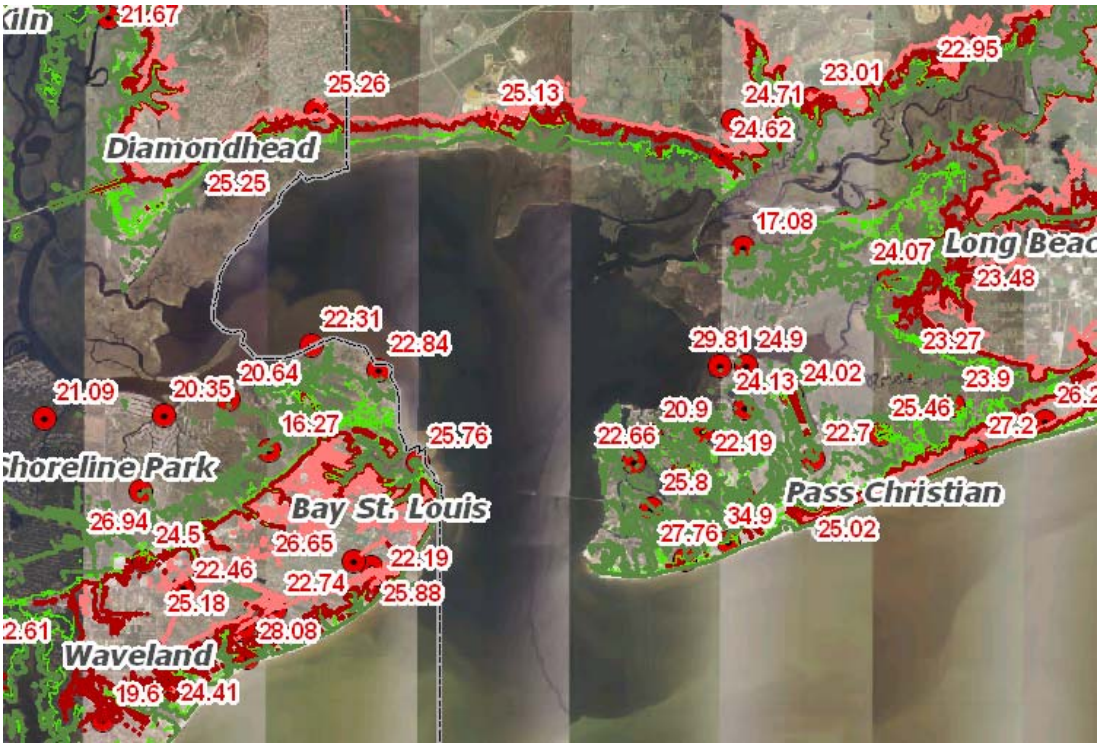


Figure 3.4.3.4-1. Ground Contours and Katrina High Water



Figure 3.4.3.4-2. Hydrodynamic Modeling Save Points near St Louis Bay

Existing Condition Stage –Frequency data for Save Point 61, near the mouth of the bay, is shown in Figure 3.4.3.4-3. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

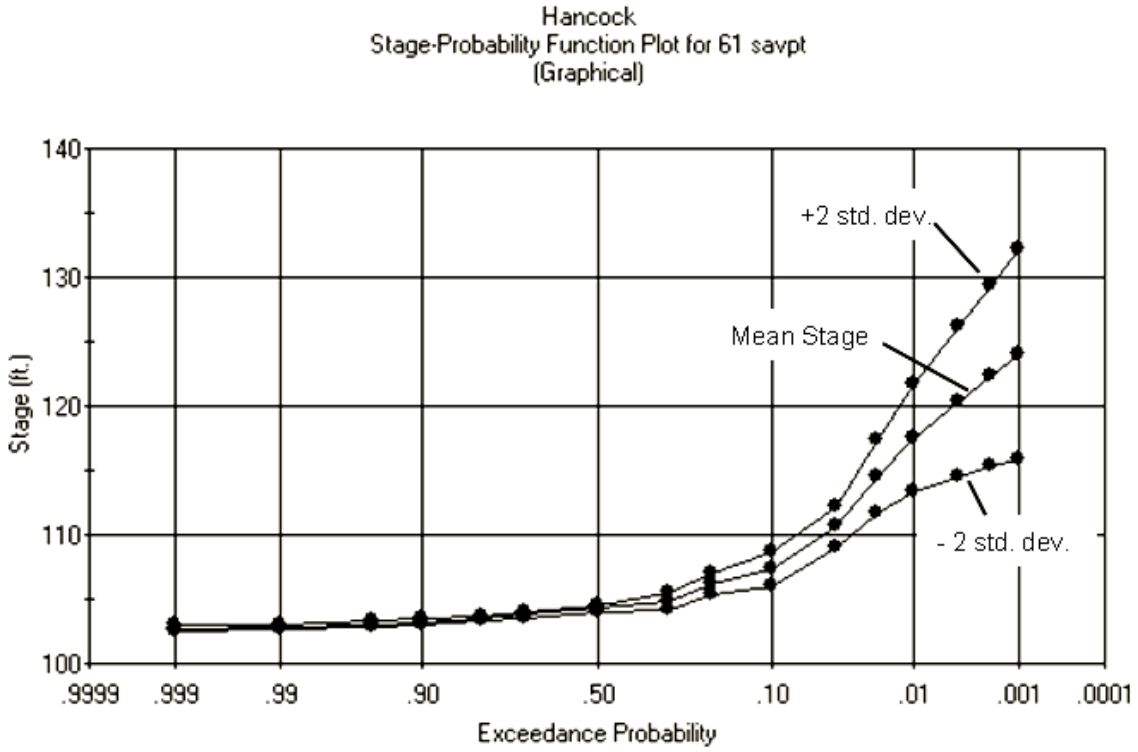


Figure 3.4.3.4-3. Existing Conditions at Save Point 61, near the Mouth of St. Louis Bay

3.4.3.5 Option A – Elevation 20.0

In order to reasonably accurately approximate the scope of the structures required to form a moveable barrier to elevation 20 a very preliminary rising sector gate design was made for the gate and its operating disks, and the piers and foundations were approximated on a proportional basis. A system of foundation piles was then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation "Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 20 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 20 resulted in gross quantities of basic construction materials as indicated in Table 3.4.3.5-1 below.

Table 3.4.3.5-1.
Gross Quantities for Saint Louis Bay Surge Barrier Elevation 20.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	38,008	Tons
Foundation Piling	20,540	Each
Concrete	493,700	Cubic Yards
Reinforcement	1,210	Tons
Rising Sector Gates (25 Each)	19,750	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.3.6 Option B – Elevation 30.0

In order to reasonably accurately approximate the scope of the structures required to form a moveable barrier to elevation 30, a very preliminary rising sector gate design was made for the gate and its operating disks, and the piers and foundations were approximated on a proportional basis. The foundation piles were then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation "Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 30 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 30 resulted in gross quantities of basic construction materials as indicated in Table 3.4.3.6-1 below.

Table 3.4.3.6-1.
Gross Quantities for Saint Louis Bay Surge Barrier Elevation 30.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	47,511	Tons
Foundation Piling	14,538	Each
Concrete	552,800	Cubic Yards
Reinforcement	1,083	Tons
Rising Sector Gates (25 Each)	24,260	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.3.7 Option C – Elevation 40.0

In order to reasonably accurately approximate the scope of The structures required to form a moveable barrier to elevation 40, a very preliminary rising sector gate design was made for the gate and its operating disks, and the piers and foundations were approximated on a proportional basis. The foundation piles were then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation

"Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 40 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 40 resulted in gross quantities of basic construction materials as indicated in Table 3.4.3.7-1 below.

Table 3.4.3.7-1.
Gross Quantities for Saint Louis Bay Surge Barrier Elevation 40.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	47,511	Tons
Foundation Piling	20,540	Each
Concrete	561,300	Cubic Yards
Reinforcement	1,061	Tons
Rising Sector Gates (25 Each)	40,291	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.3.8 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.4.3.8-1.
St Louis Bay Surge Barrier Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$1,628,000,000
Option B – Elevation 30 ft NAVD88	$1,963,600,000
Option C – Elevation 40 ft NAVD88	$2,362,200,000

Table 3.4.3.8-2.
St Louis Bay Surge Barrier O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$22,674,000
Option B – Elevation 30 ft NAVD88	$27,364,000
Option C – Elevation 40 ft NAVD88	$32,936,000

3.4.3.9 References

See 3.4.3 General discussion above for references.

3.4.4 Harrison County Inland Barrier

3.4.4.1 General

Residential and business areas along the coast in Harrison County are susceptible to storm surge damage. A damage reduction option is to construct an inland barrier to various elevations were evaluated. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.14 of the Engineering Appendix and in the Economic Appendix.

3.4.4.2 Location

The location of the barrier in Harrison County is shown in Figure 3.4.4-1 extending from Biloxi Bay to Pass Christian approximately 1000-3000 ft north of, and parallel to, the shoreline. This alignment is evaluated in Options A through E. For Options F through J, an alternate alignment is evaluated. This alternate alignment extends from Biloxi Bay to Menge Avenue, thence northward along Menge Avenue to high ground. Both alignments are shown on the map. They are also shown in more detail in the Option A section (Figures 3.4.4-12 through 3.4.4-14) and the Option F section (Figures 3.4.4-29 through 3.4.4-31).

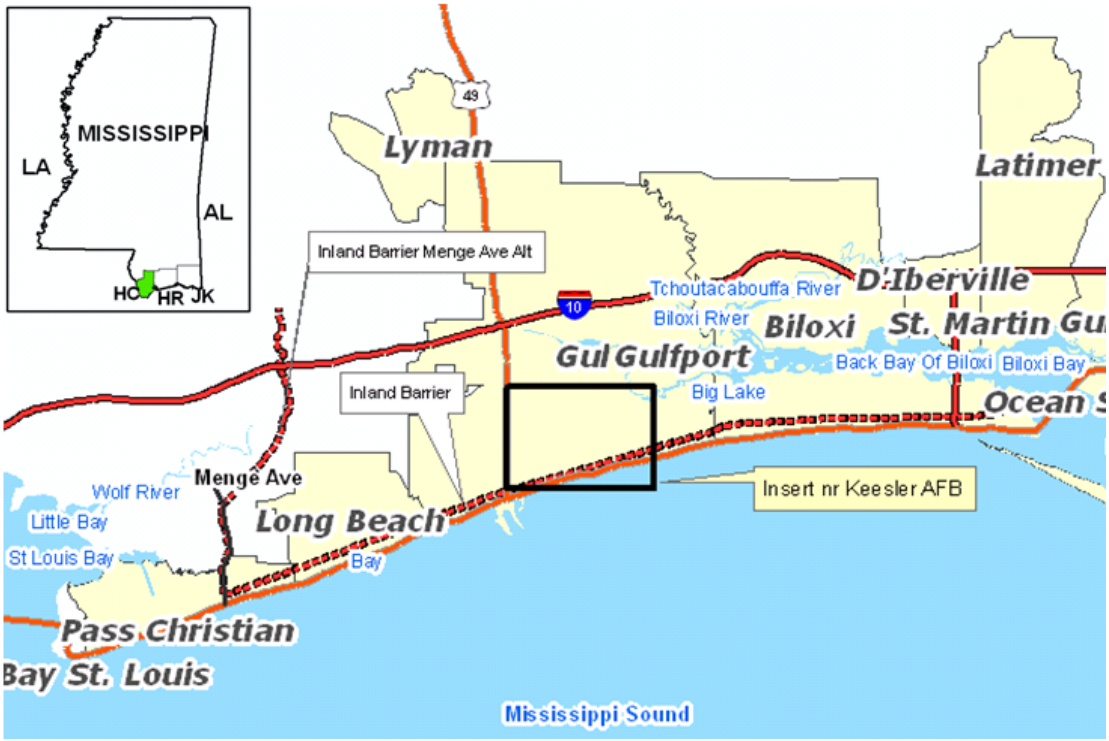


Figure 3.4.4-1. Vicinity Map Harrison County, MS

3.4.4.3 Existing Conditions

In Harrison County, ground elevations over most of the residential and business areas vary between elevation 8-12 ft NAVD88 on the coast and rising within 1000 ft to elevation 30-36 along a ridge parallel to the coast line, then decreasing to the north. The 4-ft (blue), 8-ft (green), 20-ft (pink), 30-ft (dark blue) and 34-ft (gold) ground contours show the pattern at the coastline for the county and are shown in Figure 3.4.4-2.

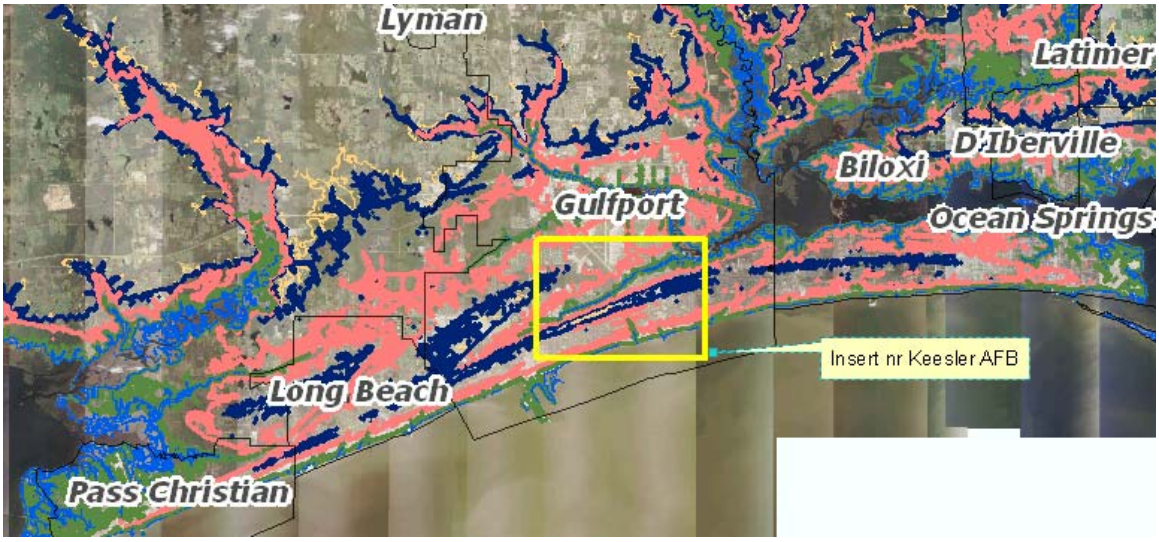


Figure 3.4.4-2. Existing Conditions Harrison County, MS

A close-up near Keesler Air Force Base is shown in Figure 3.4.4-3. The 4-ft(blue), 8-ft(dark green), 12-ft(light green), 16-ft(brown), 20-ft(pink), 24-ft(light purple), 28-ft (teal), and 32-ft (gold) ground contour lines are shown.

The area is drained by natural and some improved channels. Above the ridge water drains o the north, thence to either the Back Bay of Biloxi on the east side of the county, or to the west to the St Louis Bay. South of the ridge, the water drains to Mississippi Sound.

Drainage from ordinary rainfall is hindered on occasions when either of the rivers in the area or the gulf is high, but impacts from hurricanes are devastating.

Damage from Hurricane Katrina in August, 2005 in the Pascagoula area are shown in Figures 3.4.4-4 and 3.4.4-5. Many homes are still un-repaired, pending settlement of insurance claims.

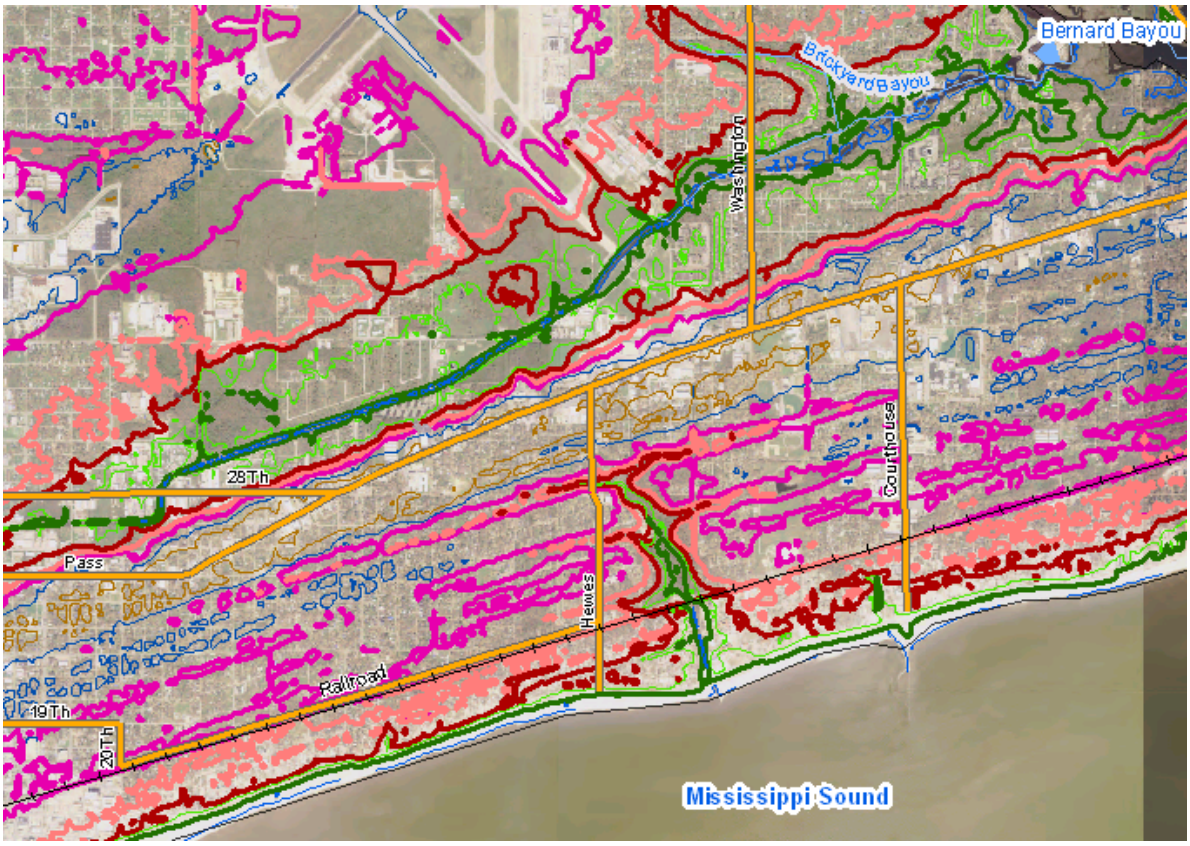
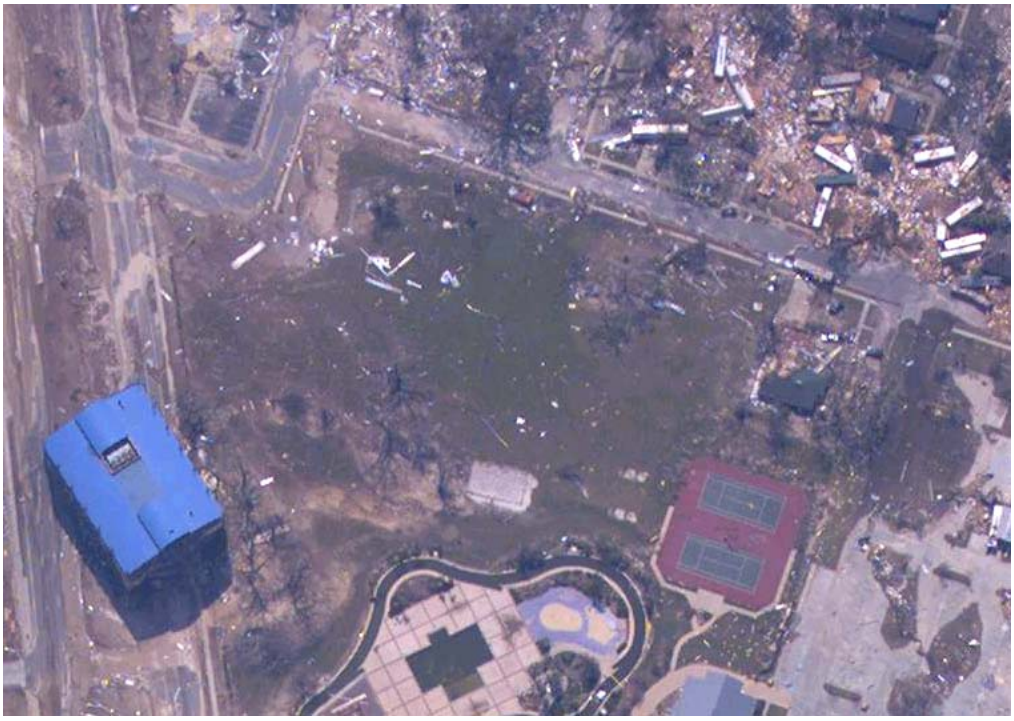


Figure 3.4.4-3. Existing Conditions Harrison County near Keesler AFB



Source: http://ngs.woc.noaa.gov/storms/katrina/24330924.jpg

Figure 3.4.4-4. Hurricane Katrina Damage Harrison County, MS



Source: danakay, http://www.flickr.com/photo_zoom.gne?id=45235550&size=m

Figure 3.4.4-5. Hurricane Katrina Damage Harrison County, MS

3.4.4.4 Coastal and Hydraulic Data

Typical coastal data is shown in Section 1.4, of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the Katrina inundation limits are shown in Figures 3.4.4-6 and 3.4.4-7. The data indicates the Katrina high water was as high as 21 ft NAVD88 Biloxi, and 28 ft NAVD88 at Pass Christian.

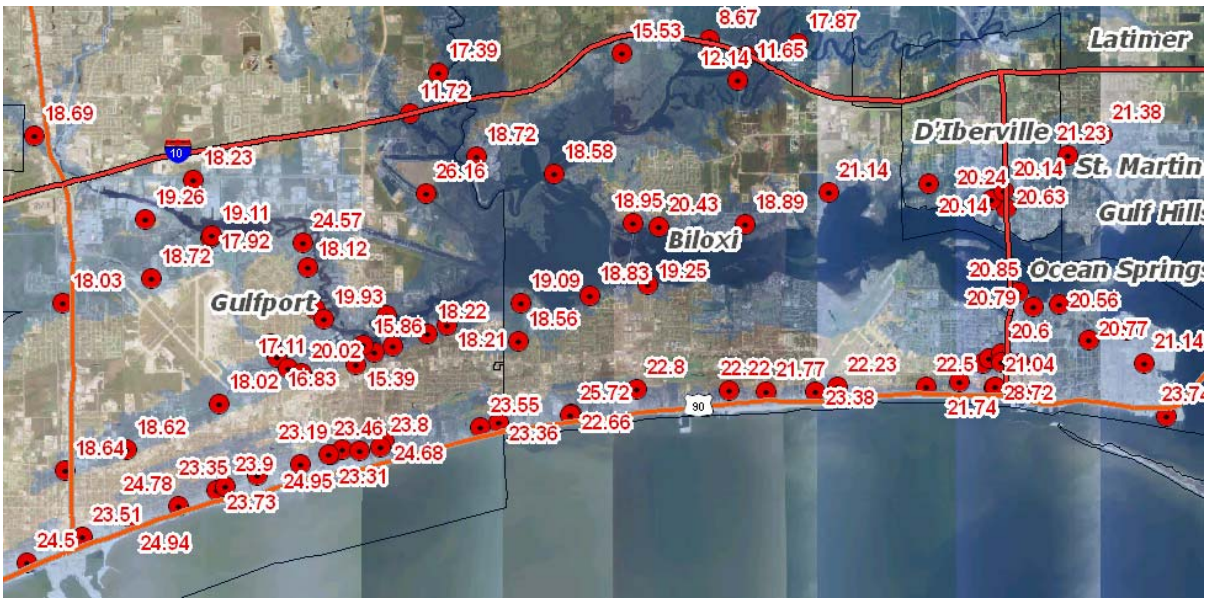


Figure 3.4.4-6. Hurricane Katrina High Water Elevations

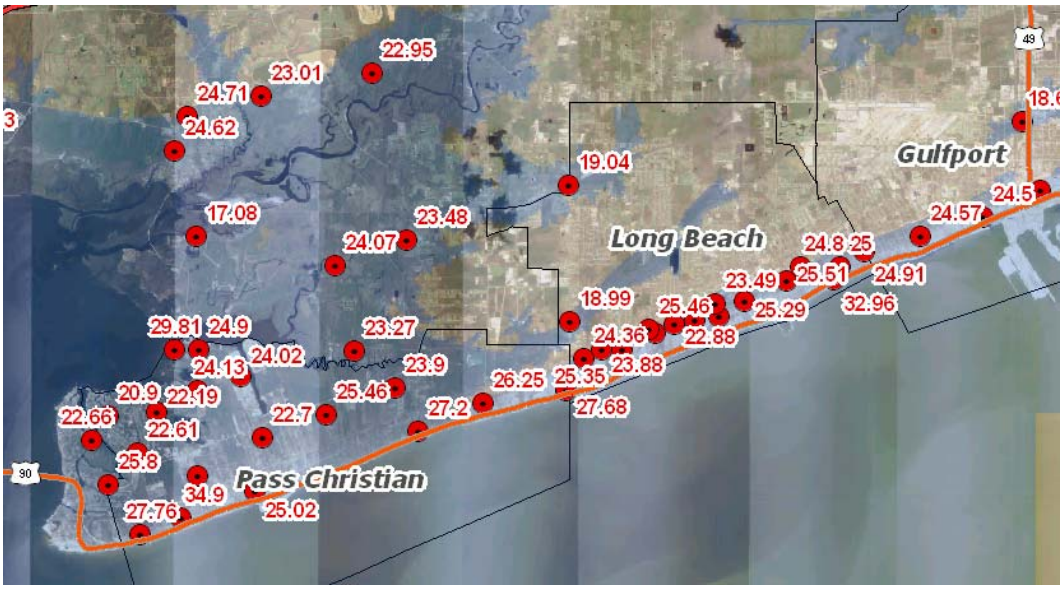


Figure 3.4.4-7. Hurricane Katrina High Water Elevations

A closer view at the intersection of Hwy 90 and US Hwy 49 in Gulfport of existing flooding potential along Harrison County is shown in Figure 3.4.4-8. Ground contours shown are 4-ft (blue), 8-ft (dark green), 12-ft (light green), 16-ft (brown), 20-ft (pink), 24-ft (light purple), 28-ft (teal), and 32-ft (gold).

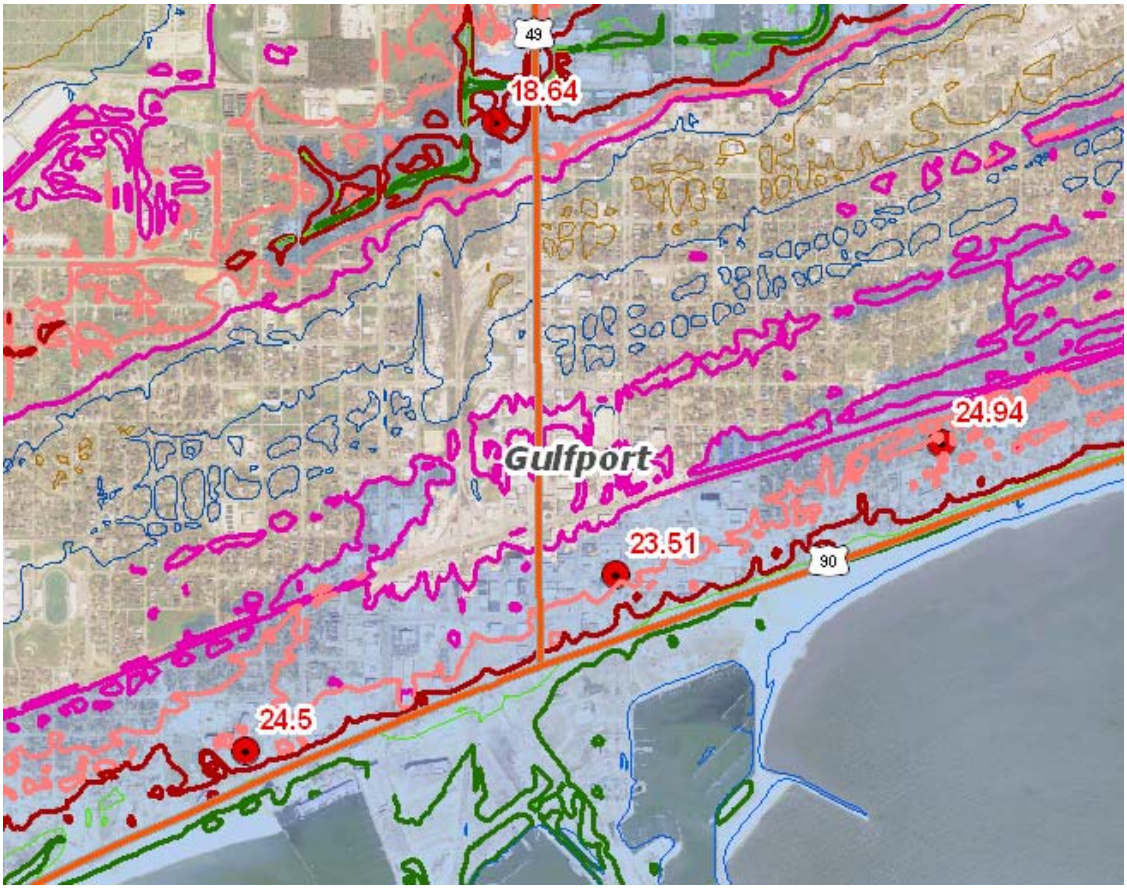


Figure 3.4.4-8. Ground Contours and Katrina High Water Elevations near Hwy 49

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.14 of the Engineering Appendix and in the Economic Appendix. Points near the coast in Harrison County at which data from hydrodynamic modeling was saved are shown in Figures 3.4.4-9 and 3.4.4-10.

Existing Condition Stage –Frequency data for Save Point 50, just off the coast of Harrison County, is shown in Figure 3.4.4-11. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.



Figure 3.4.4-9. Hydrodynamic Modeling Save Points in Harrison County



Figure 3.4.4-10. Hydrodynamic Modeling Save Points in Harrison County

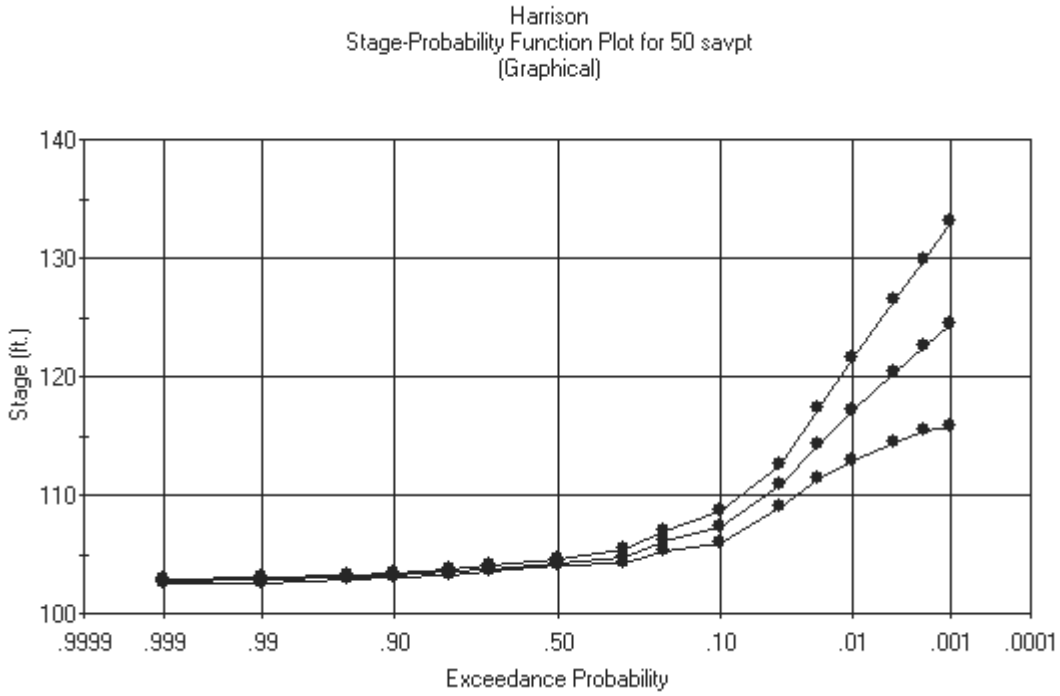


Figure 3.4.4-11. Existing Conditions at Save Point 50, near Pass Christian, MS

3.4.4.5 Option A – Elevation 20 ft NAVD88

This option consists of constructing a levee to elevation 20 ft NAVD88 along the coast of Harrison County as shown on Figures 3.4.4-12 through 3.4.4-14, along with the internal sub-basins and levee culvert/pump locations. Drainage basins 24 and 25 drain north against the levee. These sites will be ditched along the levee to St. Louis Bay.

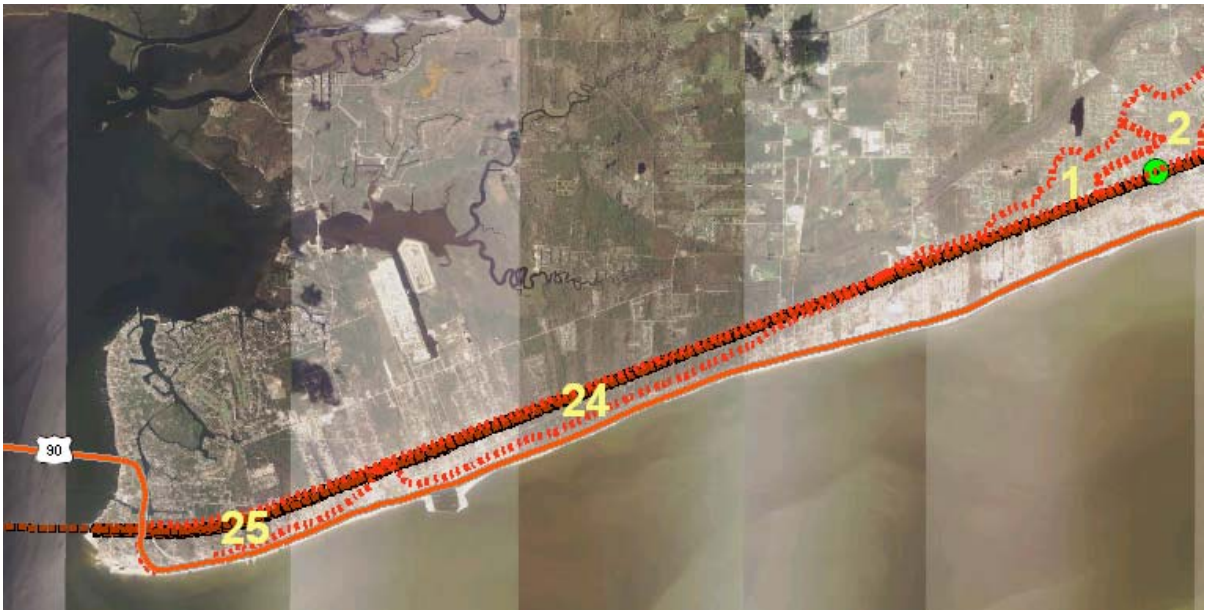


Figure 3.4.4-12. Pump/Culvert/Sub-basin Site Locations



Figure 3.4.4-13. Pump/Culvert/Sub-basin Site Locations

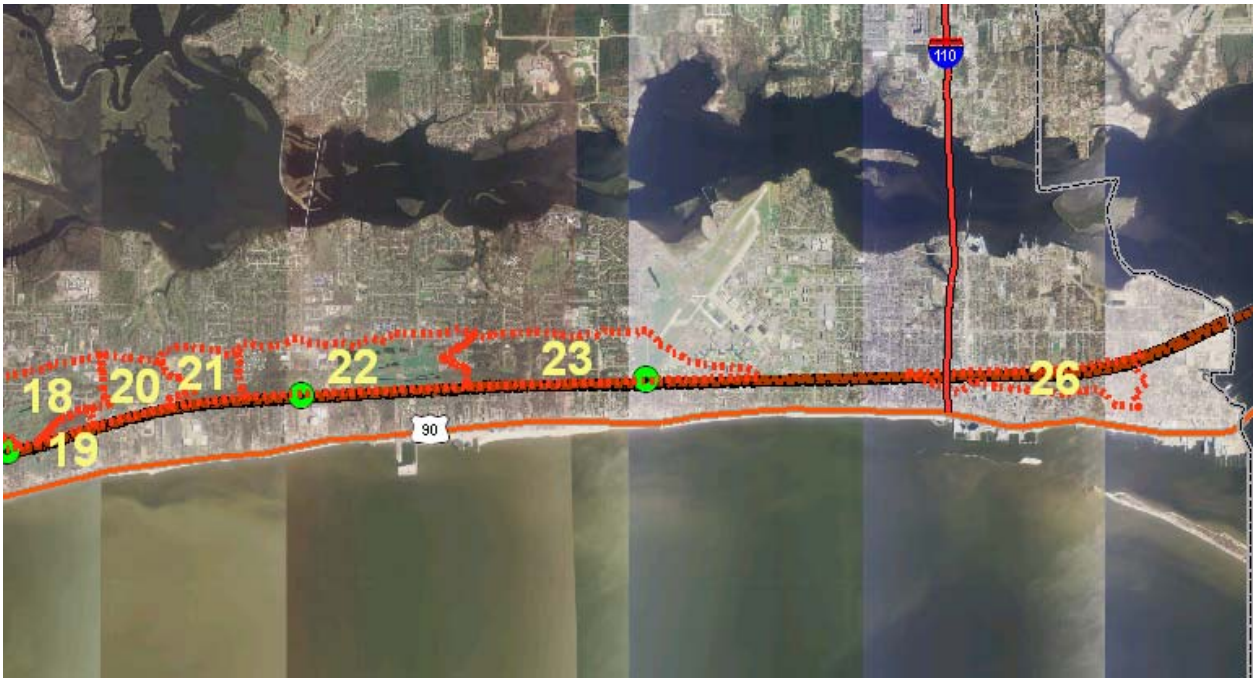


Figure 3.4.4-14. Pump/Culvert/Sub-basin Site Locations

Drainage basin 26 drains north against the levee. This site will be ditched along the levee to Biloxi Bay.

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in the Figure 3.4.4-15.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo: Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.4.4-15. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major

damage did not occur from wave action. The erosion shown in Figure 3.4.4-16 was caused by approximately 1-2 ft of overtopping crest depth.



Source: ERDC, Steven Hughes

Figure 3.4.4-16. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment will be included in the levee design to prevent overtopping failure.

The levee will be protected by gabions on filter cloth as shown in Figure 3.4.4-17, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

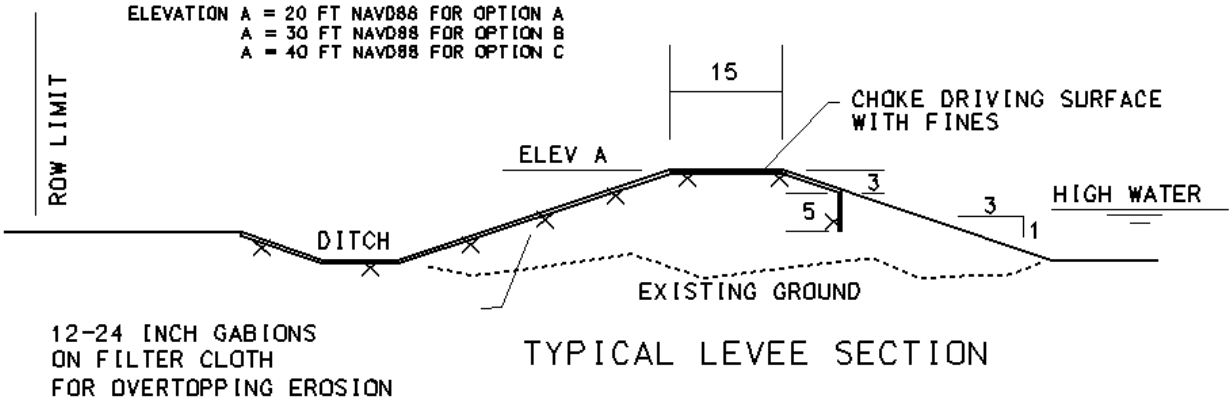


Figure 3.4.4-17. Typical Section at Levee

3.4.4.5.1 Interior Drainage

Drainage on the interior of the raised highway would be collected at the highway and channeled to culverts placed at locations shown above. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert for control in the event the flap gate malfunctions. A typical section is shown in Figure 3.4.4-18.

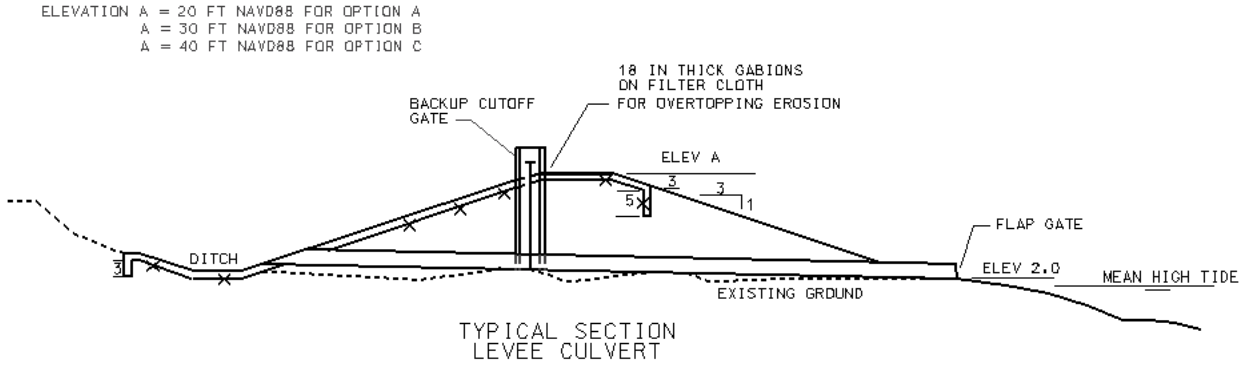


Figure 3.4.4-18. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the drainage basin into major sub-basins and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number.

Peak flows for the 1-yr to 100-yr storms were computed. Culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater/tailwater elevation difference was maintained at 3.0 ft or less. Drainage ditches along the toe of the highway will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data is considered beyond the level of detail required for this report.

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico" US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is "National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)", R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report; therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.4.4.5.1.1 Surge Barrier

In order to prevent hurricane surges from circumventing the levee, surge barrier gates would be constructed across both Biloxi Bay and St. Louis Bay. In the event of an imminent hurricane, the gates across the Back Bay of Biloxi and St. Louis Bay would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates. The location of the barriers are shown in Figure 3.4.4-19 and 3.4.4-20.

The gates would be similar to the rising sector gates across the Thames River in London, England, shown in Figure 3.4.4-21.

The gates are described in more detail elsewhere in this report.

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used to model both the Biloxi Bay watershed and the St Louis Bay watershed in order to predict the maximum water elevation behind the gates in the bays under several different storm scenarios. These two basins will be described separately.

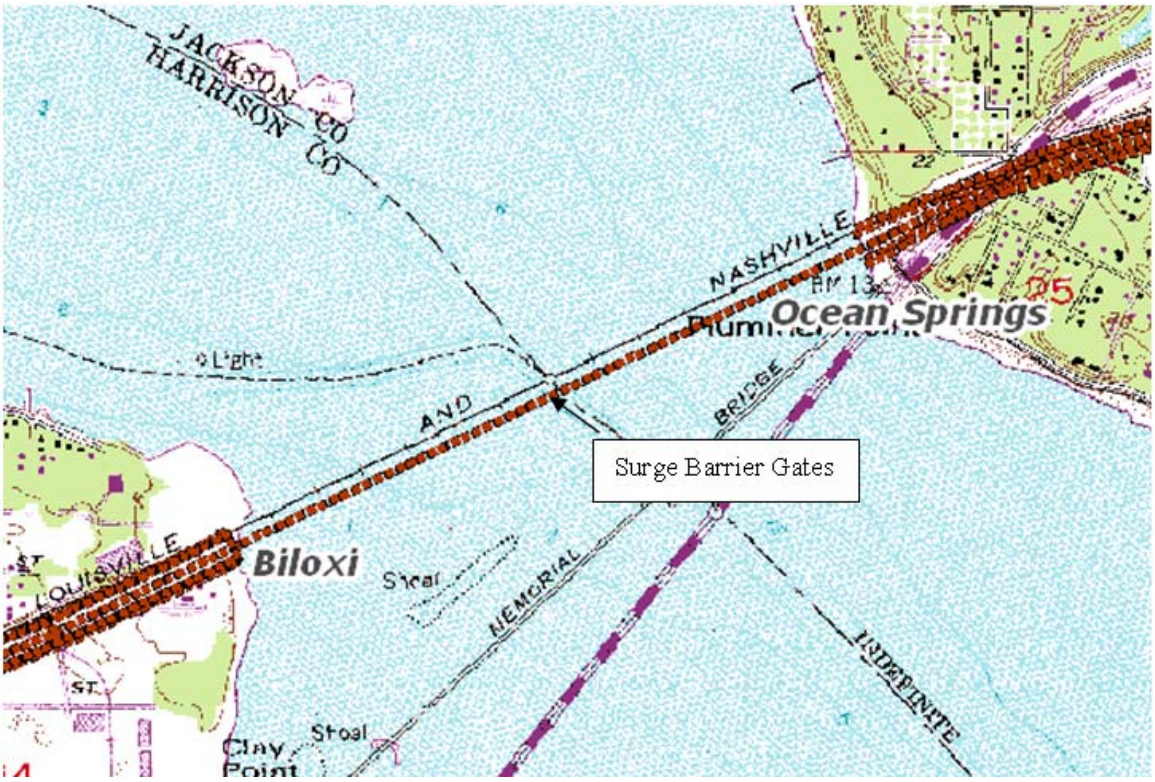


Figure 3.4.4-19. Biloxi Bay Surge Barrier Location

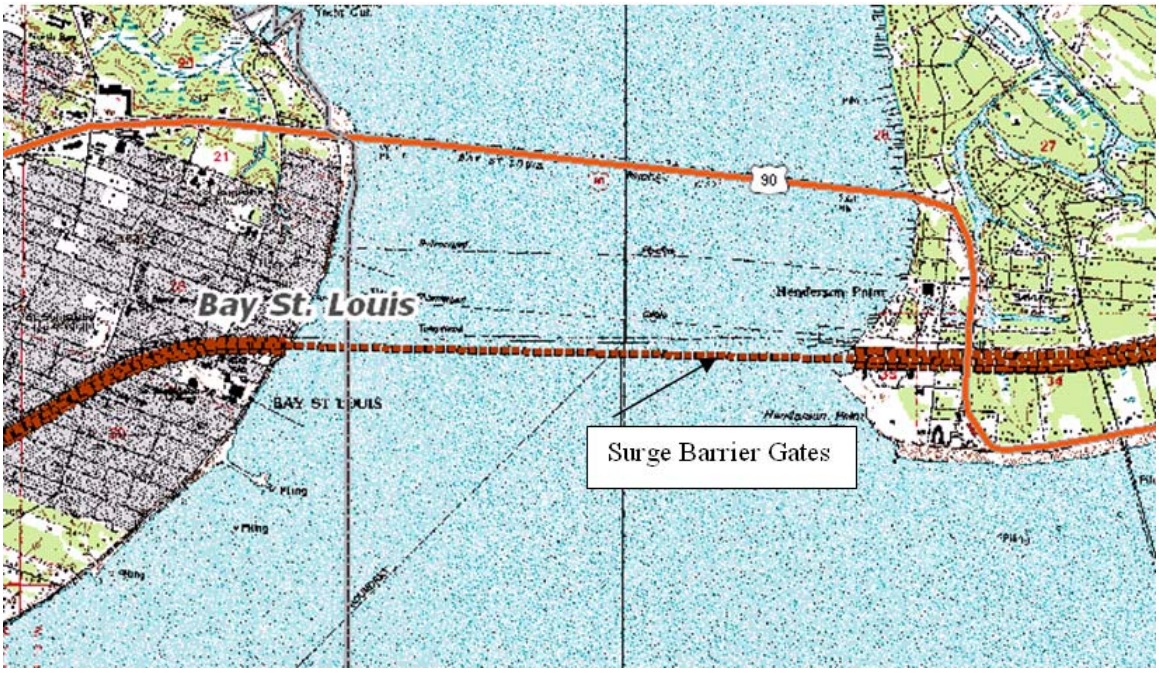


Figure 3.4.4-20. St Louis Bay Surge Barrier Location

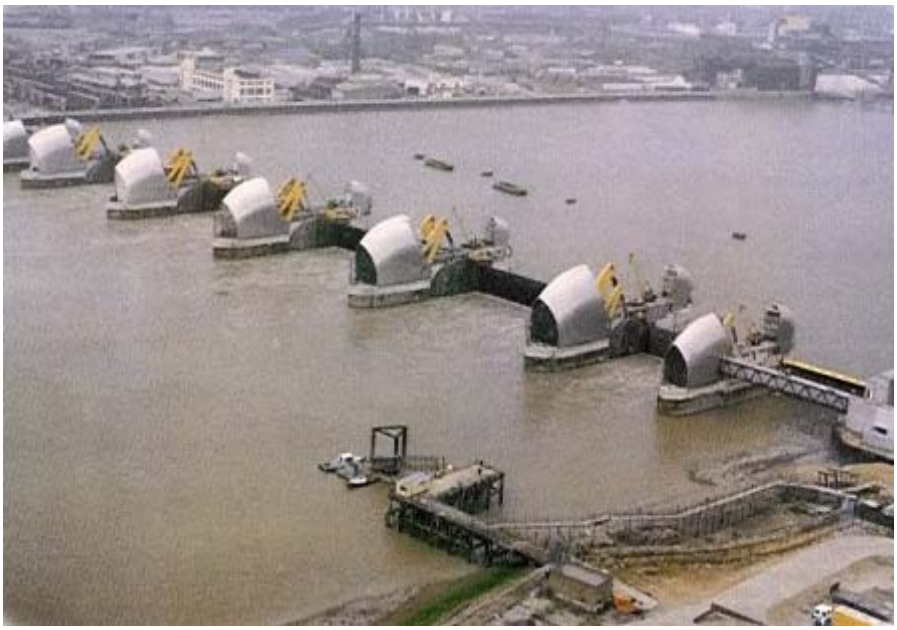


Figure 3.4.4-21. Thames River Barrier Gates

3.4.4.5.1.2 Biloxi Bay Modeling

The Biloxi Bay watershed is an approximately 640 square mile watershed comprised of six subbasins that stretch across Harrison, Stone, and Jackson County, MS. There is one United States Geological Survey (USGS) discharge gage located in the watershed along the Biloxi River and one National Oceanic and Atmospheric Administration (NOAA) hourly precipitation gage located on the east side of the watershed. The discharge gage is USGS gage 2481000 at Wortham, MS and the precipitation gage is NOAA gage 107840 (Saucier Experimental Forest). Data from these gages,

along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering Biloxi Bay from the Biloxi Bay watershed for the 2-100 year rainfall events. The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The Biloxi Bay watershed is shown in Figure 3.4.4-22.

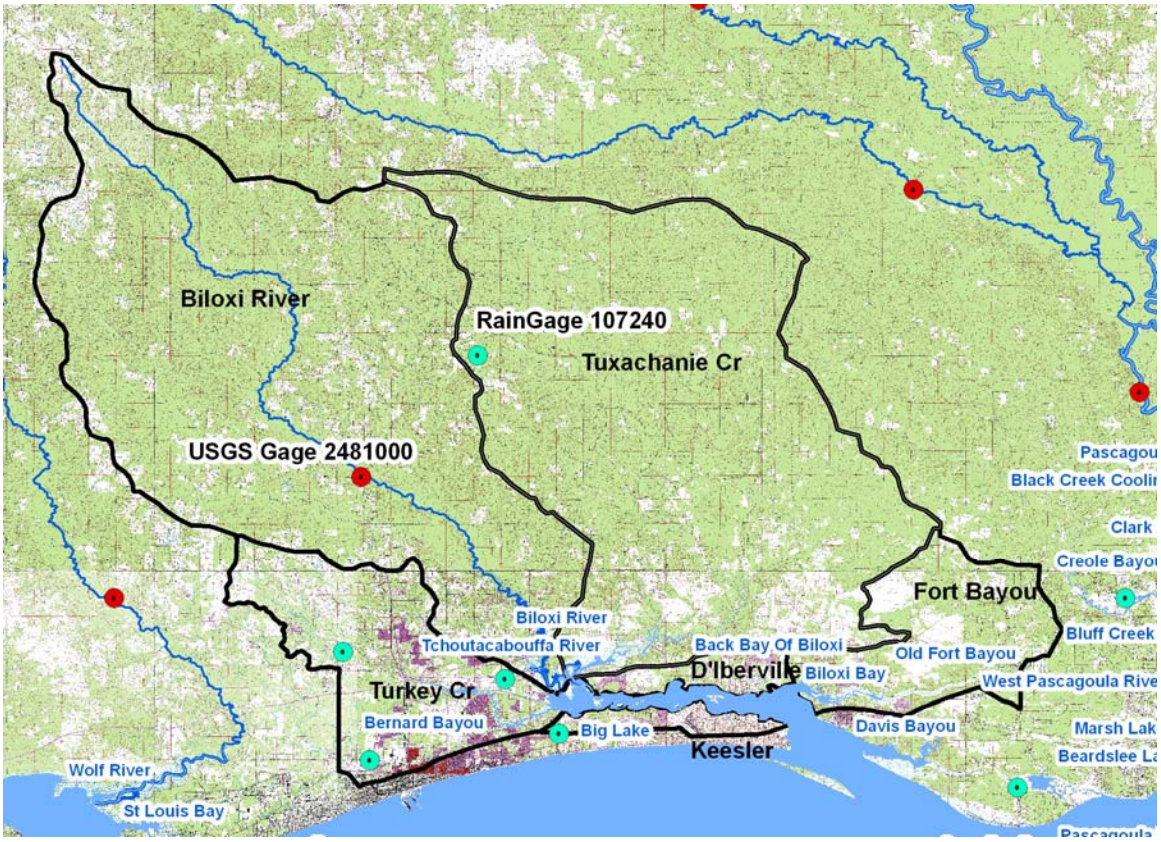


Figure 3.4.4-22. Biloxi Bay Watershed

The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gage 107840 and the 2-100 year 24-hour TP-40 rainfall events. For the loss model some basins used the initial and constant loss model and others (D'Iberville and Keesler) used SCS curve number method. For the direct runoff model, all the basins used the Snyder's unit hydrograph (UH) model. The model was calibrated to observed hourly discharge data for two events at USGS gage 2481000. The basin models used in the calibration used the initial constant loss model and Snyder's method for the direct runoff. The two calibration events (May 1991 and Jan 1993) had rainfall of about 6.4 inches and 7.6 inches each, corresponding to approximately 2-yr to 5-yr theoretical rainfall frequency.

Calibration results agree reasonable well with observed data as shown in Figures 3.4.4-23 and 3.4.4-24.

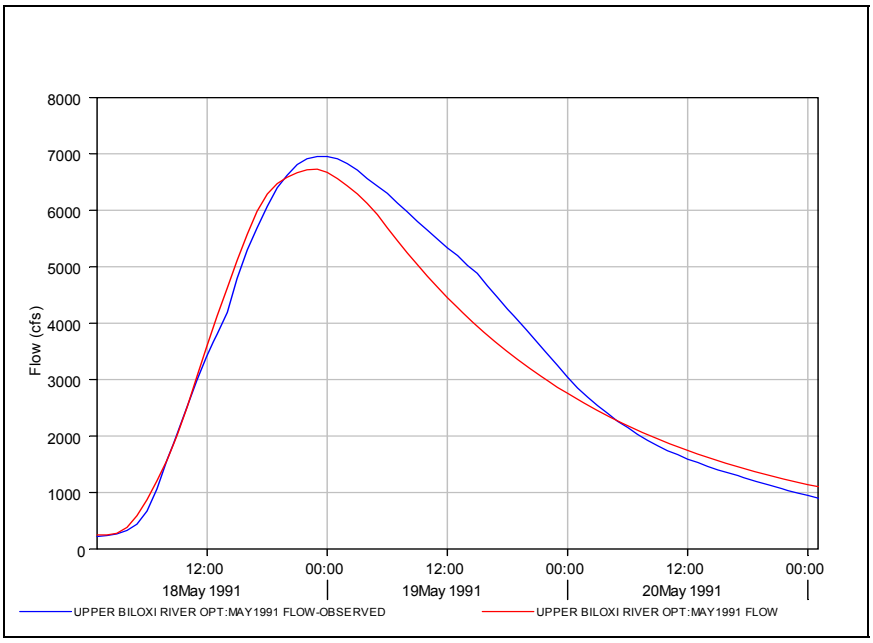


Figure 3.4.4-23. Biloxi Bay Watershed Calibration, May 18, 1991

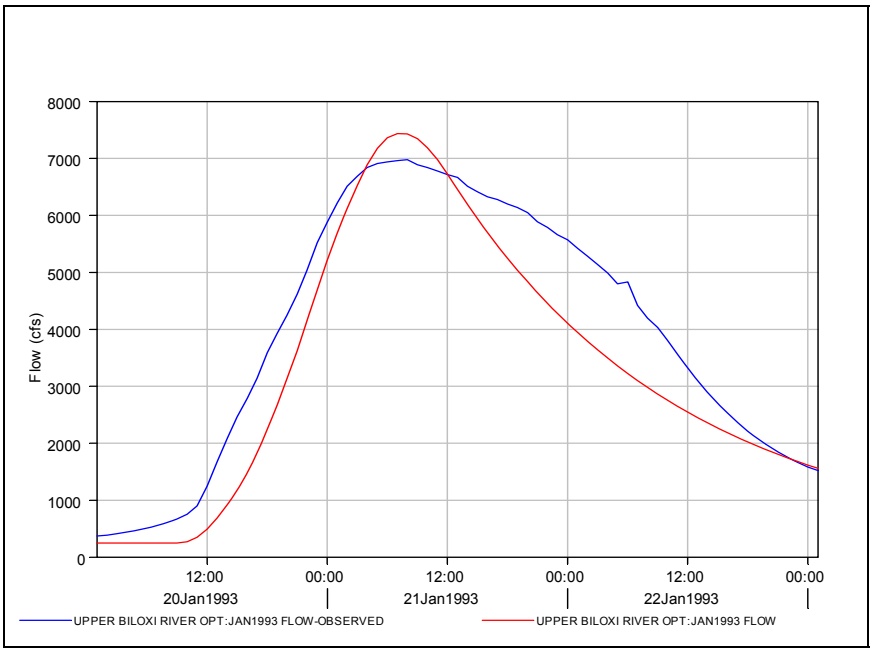


Figure 3.4.4-24. Biloxi Bay Watershed Calibration, Jan 21, 1993

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition, in accordance with studies

cited above. The highest inflow period of the inflow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

Based on this method of analysis, the resulting elevations for the various storms are shown in Table 3.4.4-1, with the 10-yr elevation of 8.4 ft NAVD88 the design condition.

Table 3.4.4-1.
Biloxi Bay Ponding

Biloxi Bay 4 ft. Base Elevations	
Strom Event	**Bay Elevation (ft NAVD88)**
2-year	6.0
5-year	7.6
10-year	8.4
25-year	9.4
50-year	10.0
100-year	10.8

This ponded water area in Harrison County above the surge barrier gates at the 10-yr flood is at 8.4 ft NAVD88 and is approximated by the 8-ft ground contour line shown in Figure 3.4.4-25.

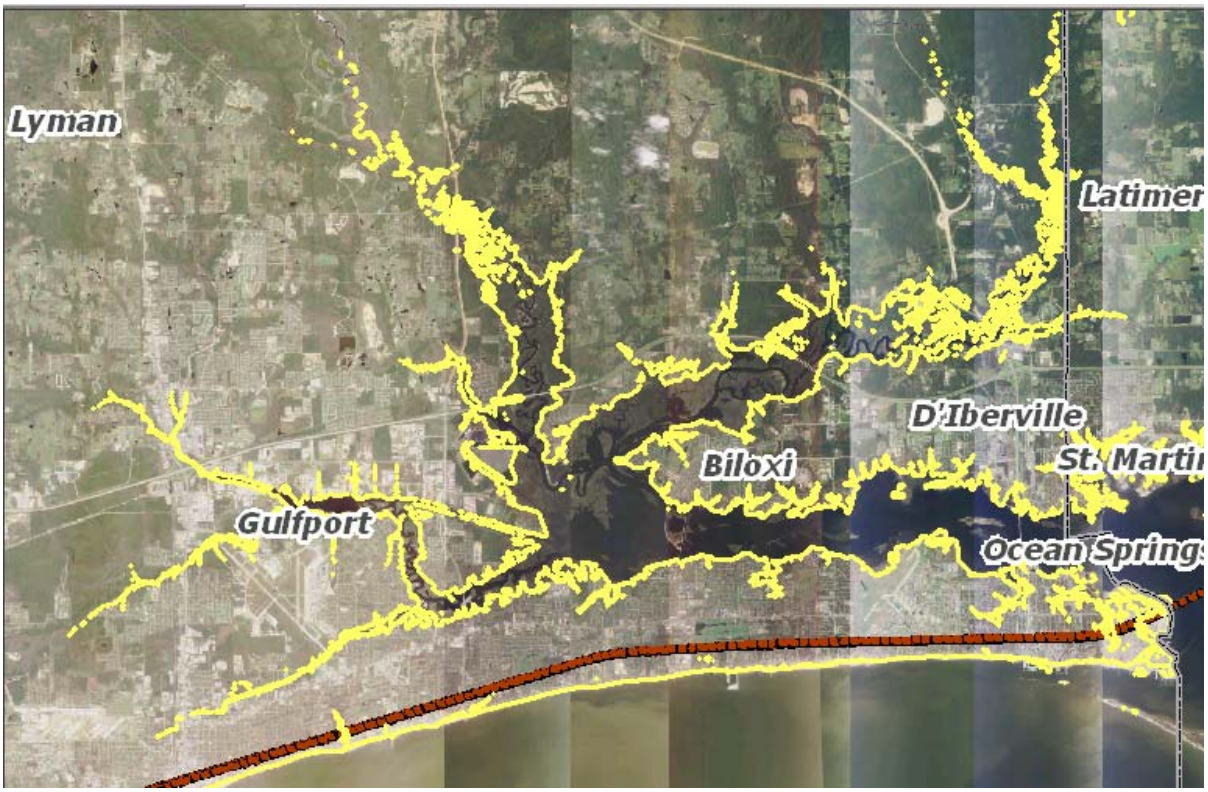


Figure 3.4.4-25. Biloxi Bay 10-yr Ponding to Elev. 8.4 ft NAVD88

3.4.4.5.1.3 St. Louis Bay Modeling

The St. Louis Bay watershed covers approximately 654 square miles and is comprised of six sub-basins that stretch across the Mississippi counties of Harrison, Hancock, Stone, and Pearl River.

There is one United States Geological Survey (USGS) discharge stream gage (#2481510) located in the watershed along the Wolf River, near Landon, Mississippi. There are three significant National Oceanic and Atmospheric Administration (NOAA) hourly precipitation gages located nearby to the watershed: #109617 White Sand located to the west, #87720 Purvis 2 N to the north, and #109617, 87720, and 107840 Saucier Experimental Forest to the east of the basin. Data from these gages, along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering St. Louis Bay from the St. Louis Bay watershed for the 2 year, 5 year, 10 year, 25 year, 50 year and 100 year rainfall events. The St. Louis Bay watershed is shown in Figure 3.4.4-26.

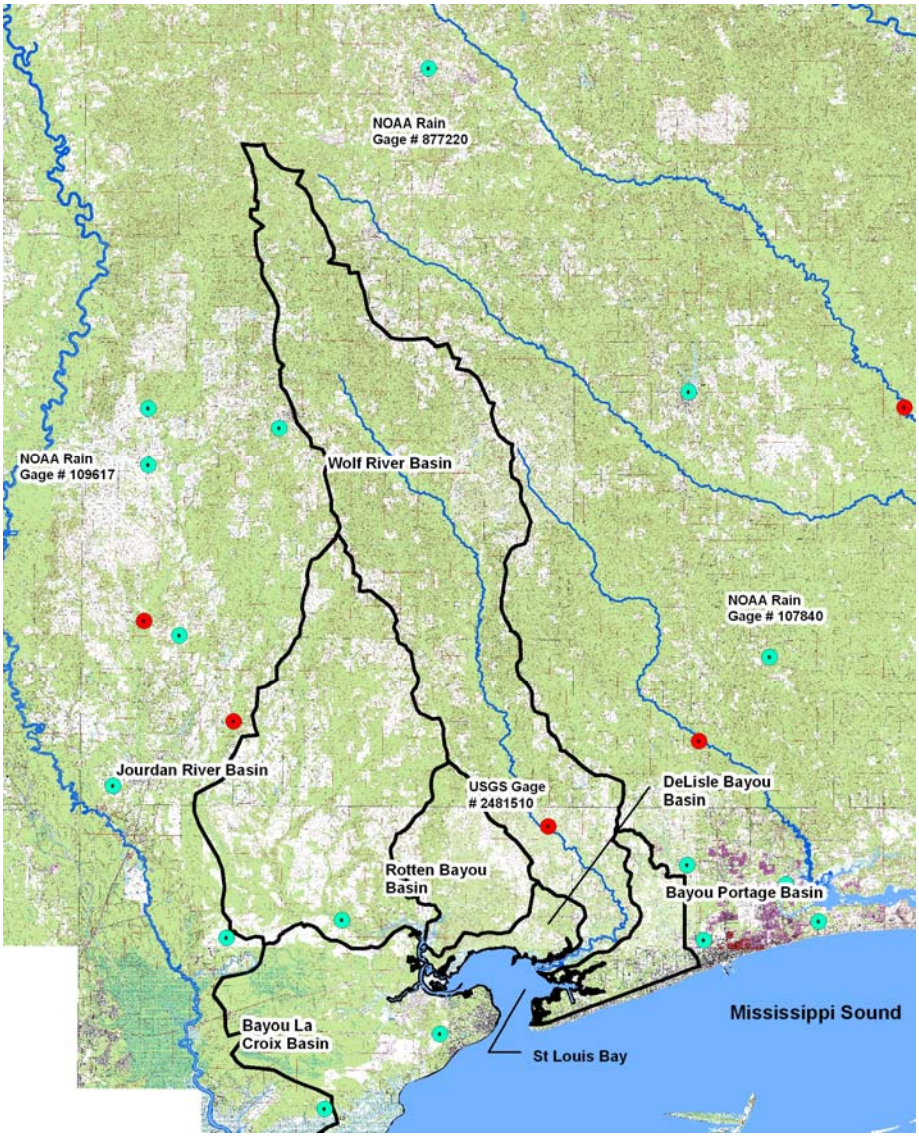


Figure 3.4.4-26. St Louis Bay Watershed

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gages 109617, 87720, and 109617, 87720, and 107840 and the 2-100 year 24-hour TP-40 rainfall events. The initial and constant loss rate method

was used for the loss model while the Snyder's unit hydrograph (UH) method was used for the direct runoff model. The model was calibrated to observed hourly discharge data for one event at USGS gage 2481510. Several other events were analyzed but not used because the observed hourly precipitation for those events did not match the TP-40 rainfall.

The HEC-HMS St. Louis Bay watershed model was calibrated to the September 24-30, 2002 storm events. The model was calibrated at the Upper Wolf River sub-basin using observed precipitation data from NOAA gages 109617, 87720, and 107840 and observed discharge data from USGS gage 2481510. This event had a total rainfall of 13.75 inches and peak discharge of 17,854 cfs. This event was chosen due to the availability of both the hourly precipitation and discharge data. The observed and computed hydrographs are shown in Figure 3.4.4-27.

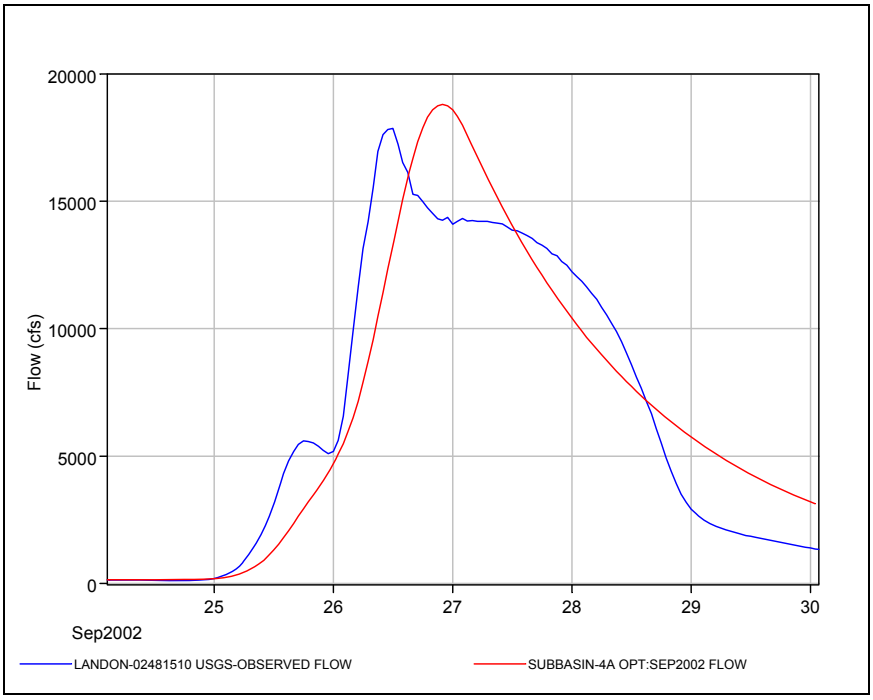


Figure 3.4.4-27. St. Louis Bay Watershed Calibration

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition, in accordance with studies cited above. The highest inflow period of the inflow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

Based on this method of analysis, the resulting elevations for the various storms are shown in Table 3.4.4-2, with the 10-yr elevation of 6.8 ft NAVD88 the design condition.

Table 3.4.4-2.
St. Louis Bay Ponding

St. Louis Bay 4 ft. Base Elevations	
Storm Event	**Bay Elevation (ft NAVD88)**
2-year	5.5
5-year	6.3
10-year	6.8
25-year	7.5
50-year	7.9
100-year	8.4

This ponded water area in Harrison County above the surge barrier gates is at the 10-yr flood elevation of 6.8 ft NAVD88, but is approximated by the 8-ft ground contour line shown in Figure 3.4.4-28.

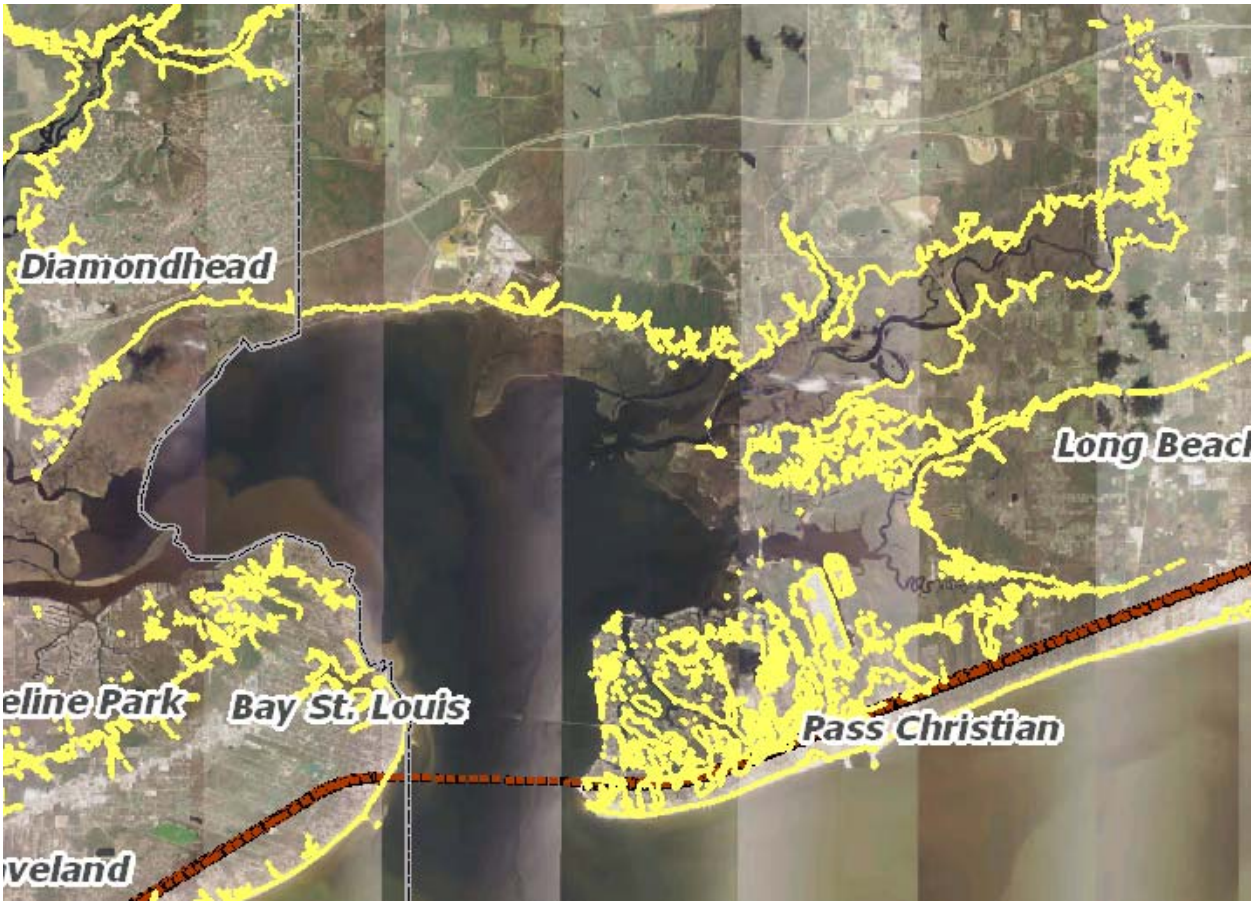


Figure 3.4.4-28. St Louis Bay 10-yr Ponding to Elev. 8.4 ft NAVD88

3.4.4.5.2 Geotechnical Data

Geology: The Prairie formation is found southward of Interstate 10 and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an

economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.4.5.3 Option A – Elevation 20 ft.NAVD88. Structural, Mechanical and Electrical

See sections 3.4.4.5.3.1 and 3.4.2.5.3.2.

3.4.4.5.3.1 Pumping Stations

Design hydraulic head derived for the one pumping facility included in the Harrison County Inland Barrier for the elevation 20 protection level was 15 feet and the corresponding flow required was 294,882 gallons per minute. The facility thus derived would consist of one plant having four, 60-inch diameter and 560 horsepower pumps.

3.4.2.5.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 20, 45 roadway intersections would have to be accommodated. For this study it was estimated that 18 roller gate structures and 27 swing gate structures would be required.

3.4.4.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.4.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.4.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. This security level will be applicable to this option.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.4.5.7 Operation and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.4.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.4.15, Cost Summary. Construction costs for the various options are included in Table 3.4.4-3 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.4-4. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.4.5.9 Schedule for Design and Construction

Because of the size and scope of the possible options, feasibility study level of detail could not be attained in this report. A significant additional detailed design effort will be required prior to attaining feasibility level, and construction would normally not proceed until that level is completed and an appropriate plan selected. After feasibility level design is complete and the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.4.6 Option B – Elevation 30 ft NAVD88

Option B is similar to option A except for the following items.

3.4.4.6.1 Option B – Elevation 30 ft.NAVD88. Interior Drainage

The alignment of the levee is the same as Option A, above, and is not reproduced here. Differences between the description of this option and preceding description of Option A include the height of the levee, pumping facilities (because of the increased head), and the length of the levee culverts. The methods of analysis for interior drainage and computed flows are the same as for Option A.

3.4.4.6.2 Option B – Elevation 30 ft.NAVD88. Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.4.4.6.3 Option B – Elevation 30 ft.NAVD88. Structural, Mechanical and Electrical

See sections 3.4.4.6.3.1 and 3.4.4.6.3.2.

3.4.4.6.3.1 Pumping Stations

Design hydraulic heads derived for the 7 pumping facilities included in the Harrison County Inland Barrier for the elevation 30 protection level varied from 5 and 20 feet and the corresponding flows required varied from 172,800 to 294,882 gallons per minute respectively. The facilities thus derived would consist of one plant having three, 54-inch diameter, 175 horsepower pumps and one having four, 60-inch diameter pumps each running at 750 horsepower.

3.4.4.6.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 30, 158 roadway/railway intersections would have to be accommodated. For this study it was estimated that 78 roller gate structures and 78 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.6.4 Option B – Elevation 30 ft.NAVD88. HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.4.4.6.5 Option B – Elevation 30 ft.NAVD88. Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.4.4.6.6 Option B – Elevation 30 ft.NAVD88. Project Security

The Project Security paragraphs for Option B are the same as for Option A, above

3.4.4.6.7 Option B – Elevation 30 ft.NAVD88. Operations and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.4.4.6.8 Option B – Elevation 30 ft.NAVD88. Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.4.4.6.9 Option B – Elevation 30 ft.NAVD88. Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.4.4.7 Option C – Elevation 40 ft NAVD88

Option C is similar to option A except for the following items.

3.4.4.7.1 Interior Drainage

The alignment of the levee is the same as Option A, above, and is not reproduced here. Differences between the description of this option and preceding description of Option A include the height of the levee, pumping facilities (because of the increased head), and the length of the levee culverts. The methods of analysis for interior drainage and computed flows are the same as for Option A.

3.4.4.7.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.4.4.7.3 Structural, Mechanical and Electrical

See sections 3.4.4.7.3.1 and 3.4.2.7.3.2.

3.4.4.7.3.1 Pumping Stations

Design hydraulic heads derived for the 7 pumping facilities included in the Harrison County Inland Barrier for the elevation 40 protection level varied from 15 and 30 feet and the corresponding flows required varied from 172,800 to 294,882 gallons per minute respectively. The facilities thus derived

would consist of one plant having three, 54-inch diameter, 420 horsepower pumps and one having four, 60-inch diameter pumps each running at 1150 horsepower.

3.4.2.7.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 40, 161 roadway/railway intersections would have to be accommodated. For this study it was estimated that 1 roller gate structure and 158 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.7.4 HTRW

The HTRW paragraphs for Option C are the same as for Option A, above.

3.4.4.7.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Planl paragraphs for Option C are the same as for Option A, above.

3.4.4.7.6 Project Security

The Project Security paragraphs for Option C are the same as for Option A, above.

3.4.4.7.7 Operations and Maintenance

The Operations and Maintenance paragraphs for Option C are the same as for Option A, above.

3.4.4.7.8 Cost Estimate

The Cost Estimate paragraphs for Option C are the same as for Option A, above.

3.4.4.7.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option C are the same as for Option A, above.

3.4.4.8 Option D – Levee for Roadway, Elevation 20 ft NAVD88

Option D is similar to option A except for the following items.

3.4.4.8.1 Interior Drainage

The alignment of the levee is the same as Option A, above, and is not reproduced here. The difference between this option and Option A is that the width of the top of the levee in Harrison County is 75 ft for Option D and 15 ft for Option A. This will allow Hwy 90 to be relocated along the top of the levee. The methods of analysis for interior drainage and computed flows are the same as for Option A.

3.4.4.8.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option D are the same as for Option A, above.

3.4.4.8.3 Structural, Mechanical and Electrical

See sections 3.4.4.8.3.1 and 3.4.4.8.3.2.

3.4.4.8.3.1 Pumping Stations

Design hydraulic head derived for the one pumping facility included in the Harrison County Inland Barrier for the elevation 20 protection level was 15 feet and the corresponding flow required was 294,882 gallons per minute. The facility thus derived would consist of one plant having four, 60-inch diameter and 560 horsepower pumps.

3.4.4.8.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 20, 42 roadway/railway intersections would have to be accommodated. For this study it was estimated that 18 roller gate structures and 48 swing gate structures would be required at the roadway crossings.

3.4.4.8.4 HTRW

The HTRW paragraphs for Option D are the same as for Option A, above.

3.4.4.8.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option D are the same as for Option A, above.

3.4.4.8.6 Project Security

The Project Security paragraphs for Option D are the same as for Option A, above

3.4.4.8.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option D are the same as for Option A, above.

3.4.4.8.8 Cost Estimate

The Cost Estimate paragraphs for Option D are the same as for Option A, above.

3.4.4.8.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option D are the same as for Option A, above.

3.4.4.9 Option E – Levee for Roadway, Elevation 30 ft NAVD88

Option E is similar to option A except for the following items.

3.4.4.9.1 Interior Drainage

The alignment of the levee is the same as Option A, above, and is not reproduced here. The difference between this option and Option A is that the width of the top of the levee in Harrison County is 75 ft for Option E and 15 ft for Option A. In addition, the height of the levee is at 30 ft NAVD88 for Option E and 20 ft NAVD88 for Option A. The added width will allow Hwy 90 to be relocated along the top of the levee. The methods of analysis for interior drainage and computed flows are the same as for Option A.

3.4.4.9.2 Option E – Levee for Roadway, Elevation 30 ft.NAVD88. Geotechnical Data

The Geology and Geotechnical paragraphs for Option E are the same as for Option A, above.

3.4.4.9.3 Structural, Mechanical and Electrical

See setions 3.4.4.9.3.1 through 3.4.4.9.3.2.

3.4.4.9.3.1 Pumping Stations

Design hydraulic heads derived for the 7 pumping facilities included in the Harrison County Inland Barrier for the elevation 30 protection level varied from 5 and 20 feet and the corresponding flows required varied from 172,800 to 294,882 gallons per minute respectively. The facilities thus derived would consist of one plant having three, 54-inch diameter, 175 horsepower pumps and one having four, 60-inch diameter pumps each running at 750 horsepower.

3.4.4.9.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 30, 140 roadway/railway intersections would have to be accommodated. For this study it was estimated that 82 roller gate structures and 112 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.9.4 HTRW

The HTRW paragraphs for Option E are the same as for Option A, above.

3.4.4.9.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option E are the same as for Option A, above.

3.4.4.9.6 Project Security

The Project Security paragraphs for Option E are the same as for Option A, above

3.4.4.9.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option E are the same as for Option A, above.

3.4.4.9.8 Cost Estimate

The Cost Estimate paragraphs for Option E are the same as for Option A, above.

3.4.4.9.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option E are the same as for Option A, above.

3.4.4.10 Option F – Menge Avenue Alternate Route, Elevation 20 ft NAVD88

Option F is similar to Option A except for the following items.

3.4.4.10.1 Interior Drainage

The alignment of the levee is the same as Option A on the east side of Harrison County but extends to the north along Menge Avenue as shown on Figures 3.4.4-29 through 3.4.4-31 instead of continuing westward. These figures also show the pump/culvert locations and the sub-basins. For Option F, culverts are required at all sub-basins, but no pumps are required for sub-basins M3 – M8. The methods of analysis for interior drainage and computed flows are the same as for Option A, except that no surge barrier was included or evaluated for St Louis Bay.

3.4.4.10.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option F are the same as for Option A, above.

3.4.4.10.3 Structural, Mechanical and Electrical

See sections 3.4.4.10.3.1 and 3.4.4.10.3.2.

3.4.4.10.3.1 Pumping Stations

Design hydraulic head derived for the two pumping facilities included in the Harrison County Inland Barrier for the elevation 20 protection level was 16 feet, and the corresponding flow required varied from 555,626 and 772,358 gallons per minute. The facilities thus derived would consist of one plant having eleven, 42-inch diameter, 290 horsepower pumps, and one having thirteen, 48-inch diameter, 340 horsepower pumps.

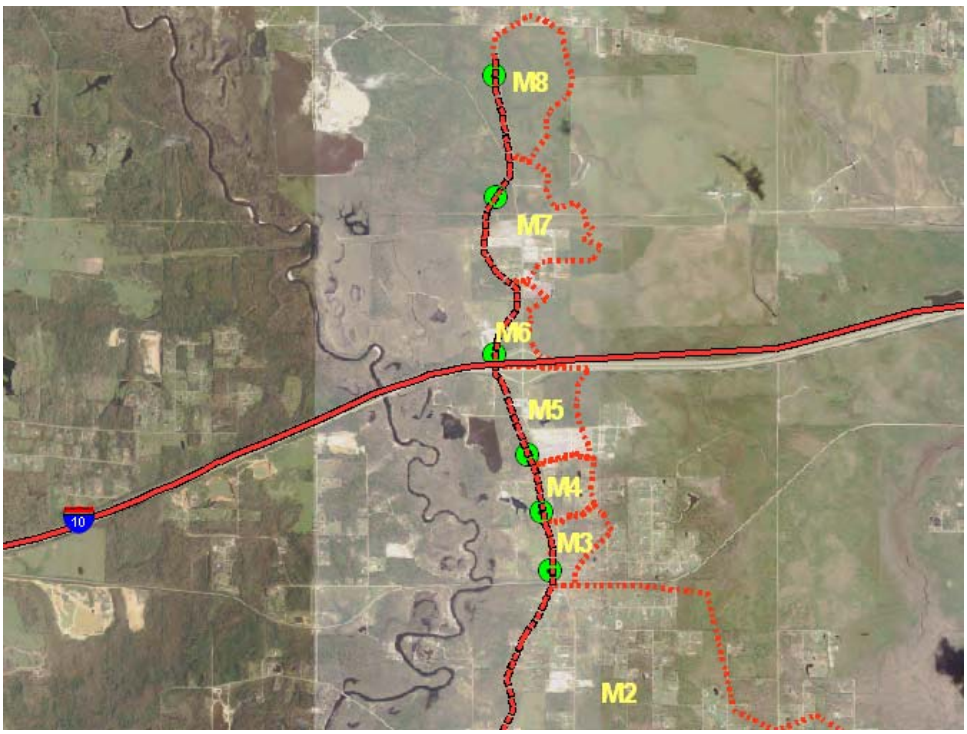


Figure 3.4.4-29. Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations

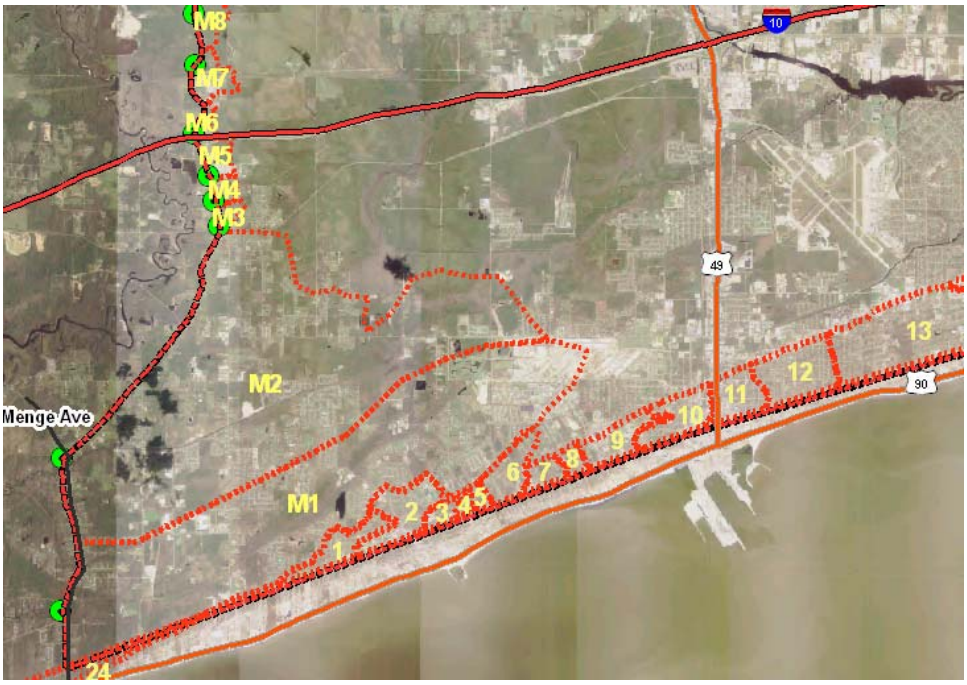


Figure 3.4.4-30. Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations



Figure 3.4.4-31. Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations

3.4.4.10.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 20, 21 roadway/railway intersections would have to be accommodated. For this study it was estimated that 17 roller gate structures and 4 swing gate structures would be required at the roadway crossings.

3.4.4.10.4 HTRW

The HTRW paragraphs for Option F are the same as for Option A, above.

3.4.4.10.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option F are the same as for Option A, above.

3.4.4.10.6 Project Security

The Project Security paragraphs for Option F are the same as for Option A, above

3.4.4.10.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option F are the same as for Option A, above.

3.4.4.10.8 Cost Estimate

The Cost Estimate paragraphs for Option F are the same as for Option A, above.

3.4.4.10.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option F are the same as for Option A, above.

3.4.4.11 Option G – Menge Avenue Alternate Route, Elevation 30 ft NAVD88

Option G is similar to option A except for the following items.

3.4.4.11.1 Interior Drainage

The alignment of the levee is the same as Option F, shown above in Figures 3.4.4-29 through 3.4.4-31 and is not repeated here. The primary difference between this option and Option F is the height of the levee. Option F levee height is elevation 20 ft NAVD88 and Option G levee height is elevation 30 ft NAVD88. For this option, culverts are required at all sub-basins, but no pumps are required for sub-basins M3 – M8. The methods of analysis for interior drainage and computed flows are the same as for Option A, except that no surge barrier was included or evaluated for St Louis Bay.

3.4.4.11.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option G are the same as for Option A, above.

3.4.4.11.3 Structural, Mechanical and Electrical

See sections 3.4.4.11.3.1 and 3.4.4.11.3.2.

3.4.4.11.3.1 Pumping Stations

Design hydraulic head derived for the two pumping facilities included in the Harrison County Inland Barrier for the elevation 30 protection level was 26 feet, and the corresponding flow required varied

from 555,626 and 772,358 gallons per minute. The facilities thus derived would consist of one plant having eleven, 42-inch diameter, 475 horsepower pumps, and one having thirteen, 48-inch diameter, 600 horsepower pumps.

3.4.4.11.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 30, 125 roadway/railway intersections would have to be accommodated. For this study it was estimated that 86 roller gate structures and 37 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.11.4 HTRW

The HTRW paragraphs for Option G are the same as for Option A, above.

3.4.4.11.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option G are the same as for Option A, above.

3.4.4.11.6 Project Security

The Project Security paragraphs for Option G are the same as for Option A, above

3.4.4.11.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option G are the same as for Option A, above.

3.4.4.11.8 Cost Estimate

The Cost Estimate paragraphs for Option G are the same as for Option A, above.

3.4.4.11.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option G are the same as for Option A, above.

3.4.4.12 Option H – Menge Avenue Alternate Route, Elevation 40 ft NAVD88

Option H is similar to option A except for the following items.

3.4.4.12.1 Interior Drainage

The alignment of the levee is the same as Option F, shown above in Figures 3.4.4-29 through 3.4.4-31 and is not repeated here. The primary difference between this option and Option F is the height of the levee. Option F levee height is elevation 20 ft NAVD88 and Option H levee height is Elevation 40 ft NAVD88. For this option, culverts are required at all sub-basins, but no pump is required for sub-basin M8. The methods of analysis for interior drainage and computed flows are the same as for Option A, except that no surge barrier was included or evaluated for St Louis Bay.

3.4.4.12.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option H are the same as for Option A, above.

3.4.4.12.3 Structural, Mechanical and Electrical

See sections 3.4.4.12.3.1 and 3.4.4.12.3.2.

3.4.4.12.3.1 Pumping Stations

Design hydraulic head derived for the 7 pumping facilities included in the Harrison County Inland Barrier for the elevation 40 protection level varied from 10 to 36 feet, and the corresponding flow required varied from 46,225 to 772,358 gallons per minute. The facilities thus derived would consist of one plant having two, 36-inch diameter, 125 horsepower pumps, and one having thirteen, 48-inch diameter, 800 horsepower pumps.

3.4.4.12.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 40, 157 roadway/railway intersections would have to be accommodated. For this study it was estimated that 3 roller gate structures and 152 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.12.4 HTRW

The HTRW paragraphs for Option H are the same as for Option A, above.

3.4.4.12.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option H are the same as for Option A, above.

3.4.4.12.6 Project Security

The Project Security paragraphs for Option H are the same as for Option A, above

3.4.4.12.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option H are the same as for Option A, above.

3.4.4.12.8 Cost Estimate

The Cost Estimate paragraphs for Option H are the same as for Option A, above.

3.4.4.12.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option H are the same as for Option A, above.

3.4.4.13 Option I – Levee for Roadway with Menge Avenue Alternate Route, Elevation 20 ft NAVD88

Option I is similar to option A except for the following items.

3.4.4.13.1 Interior Drainage

The alignment of the levee is the same as Option F, shown above in Figures 3.4.4-29 through 3.4.4-31 and is not repeated here. The primary difference between this option and Option F is the top width of the east-west leg of the levee (Biloxi Bay to Menge Avenue). The east-west leg of Option F barrier top width is 15 ft and the east-west leg of Option I barrier top width is 75 ft. This will allow Hwy 90 to be relocated along the top of the levee. For this option, culverts are required at all sub-basins, but no pumps are required for sub-basins M3 - M8. The methods of analysis for interior drainage and computed flows are the same as for Option A, except that no surge barrier was included or evaluated for St Louis Bay.

3.4.4.13.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option I are the same as for Option A, above.

3.4.4.13.3 Structural, Mechanical and Electrical

See section 3.4.4.13.3.1 and 3.4.4.13.3.2.

3.4.4.13.3.1 Pumping Stations

Design hydraulic head derived for the fourteen pumping facilities included in the Harrison County Inland Barrier for the elevation 20 protection level varied from 8 to 18 feet, and the corresponding flow required varied from 62,388 to 490,083 gallons per minute. The facilities thus derived would consist of one plant having two, 36-inch diameter, 125 horsepower pumps, and one having seven, 54-inch diameter, 290 horsepower pumps.

3.4.4.13.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 20, 20 roadway/railway intersections would have to be accommodated. For this study it was estimated that 16 roller gate structures and 4 swing gate structures would be required at the roadway crossings.

3.4.4.13.4 HTRW

The HTRW paragraphs for Option I are the same as for Option A, above.

3.4.4.13.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option I are the same as for Option A, above.

3.4.4.13.6 Project Security

The Project Security paragraphs for Option I are the same as for Option A, above

3.4.4.13.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option I are the same as for Option A, above.

3.4.4.13.8 Cost Estimate

The Cost Estimate paragraphs for Option I are the same as for Option A, above.

3.4.4.13.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option I are the same as for Option A, above.

3.4.4.14 Option J – Levee for Roadway with Menge Avenue Alternate Route, Elevation 30 ft NAVD88

Option J is similar to option A except for the following.

3.4.4.14.1 Interior Drainage

The alignment of the levee is the same as Option F, shown above in Figures 3.4.4-29 through 3.4.4-31 and is not repeated here. The primary difference between this option and Option F is the top

width of the east-west leg of the levee (Biloxi Bay to Menge Avenue). The east-west leg of Option F barrier top width is 15 ft and the east-west leg of Option J barrier top width is 75 ft. This will allow Hwy 90 to be relocated along the top of the levee. In addition, the height of this Option J is at elevation 30 ft NAVD88. For this option, culverts are required at all sub-basins, but no pumps are required for sub-basins M3 - M8. The methods of analysis for interior drainage and computed flows are the same as for Option A, except that no surge barrier was included or evaluated for St Louis Bay.

3.4.4.14.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option J are the same as for Option A, above.

3.4.4.14.3 Structural, Mechanical and Electrical

See sections 3.4.4.14.3.1 and 3.4.4.14.3.2.

3.4.4.14.3.1 Pumping Stations

Design hydraulic head derived for the two pumping facilities included in the Harrison County Inland Barrier for the elevation 30 protection level varied from 15 to 28 feet, and the corresponding flow required varied 62,388 to 490,083 gallons per minute. The facilities thus derived would consist of one plant having two, 36 inch diameter, 250 horsepower pumps, and one having five, 60-inch diameter, 1145 horsepower pumps.

3.4.4.14.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to Elevation 30, 123 roadway/railway intersections would have to be accommodated. For this study it was estimated that 86 roller gate structures and 35 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.14.4 HTRW

The HTRW paragraphs for Option J are the same as for Option A, above.

3.4.4.14.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option J are the same as for Option A, above.

3.4.4.14.6 Project Security

The Project Security paragraphs for Option J are the same as for Option A, above

3.4.4.14.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option J are the same as for Option A, above.

3.4.4.14.8 Cost Estimate

The Cost Estimate paragraphs for Option J are the same as for Option A, above.

3.4.4.14.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option J are the same as for Option A, above.

3.4.4.15 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.4.4-3.
Harrison Co Inland Barrier Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$435,800,000
Option B – Elevation 30 ft NAVD88	$731,600,000
Option C – Elevation 40 ft NAVD88	$947,100,000
Option D – Roadway El 20 NAVD88	$205,400,000
Option E – Roadway El 30 NAVD88	$768,300,000
Option F – Menge El 20 NAVD88	$140,400,000
Option G – Menge El 30 NAVD888	$317,100,000
Option H – Menge El 40 NAVD88	$506,300,000
Option I – Road/Menge El 20 ft NAVD88	$178,600,000
Option J – Road/Menge El 30 ft NAVD88	$462,900,000

Table 3.4.4-4.
Harrison Co Inland Barrier O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$2,007,000
Option B – Elevation 30 ft NAVD88	$5,805,000
Option C – Elevation 40 ft NAVD88	$8,343,000
Option D – Roadway El 20 NAVD88	$1,868,000
Option E – Roadway El 30 NAVD88	$5,871,000
Option F – Menge El 20 NAVD88	$1,800,000
Option G – Menge El 30 NAVD888	$4,052,000
Option H – Menge El 40 NAVD88	$6,564,000
Option I – Road/Menge El 20 ft NAVD88	$2,073,000
Option J – Road/Menge El 30 ft NAVD88	$6,016,000

3.4.4.16 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

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USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

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Environmental Science Services Administration. 1968. “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968.

Weather Bureau and USACE. 1956. National Hurricane Research Project Report No. 3, “Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers.

3.4.5 Back Bay of Biloxi Surge Barrier

3.4.5.1 General

In order to protect the properties surrounding Biloxi Bay and along the lower portions of the various rivers and streams flowing into the bay, a barrier would be required at some point to block storm waters during major storm events.

As outlined above, a search of other similar facilities constructed world wide revealed that the structure model best satisfying both the engineering and socio-ecological necessities of this site was that used for the Thames River Barrier in London, UK. The structure tentatively chosen for incorporation into this work was thus, patterned after the Thames River Barrier with certain minor modifications to adapt to the site and environment specific conditions enumerated previously.

3.4.5.1.1 Interior Drainage

In the event of an imminent hurricane, the gates across the Back Bay of Biloxi would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates. The tentative location of the barrier chosen for this study is shown Figure 3.4.5.1-1.

The Biloxi Bay watershed is an approximately 640 square mile watershed comprised of six subbasins that stretch across Harrison, Stone, and Jackson County, MS. There is one United States Geological Survey (USGS) discharge gage located in the watershed along the Biloxi River and one National Oceanic and Atmospheric Administration (NOAA) hourly precipitation gage located on the east side of the watershed. The discharge gage is USGS gage 2481000 at Wortham, MS and the precipitation gage is NOAA gage 107840 (Saucier Experimental Forest). Data from these gages, along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering Biloxi Bay from the Biloxi Bay watershed for the 2-100 year rainfall events. The Hydrologic Engineering Center’s Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The Biloxi Bay watershed is shown in Figure 3.4.5.1-2.

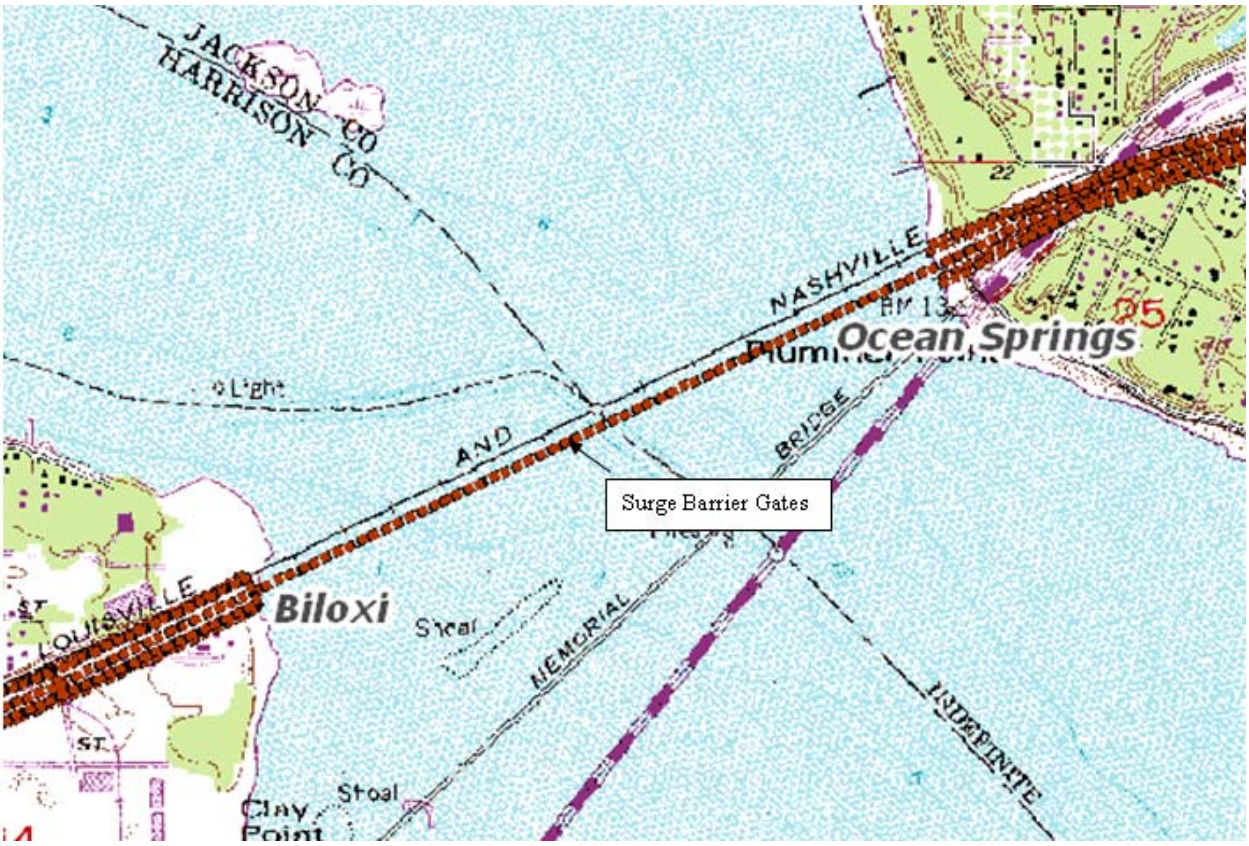


Figure 3.4.5.1-1. Biloxi Bay Surge Barrier Location

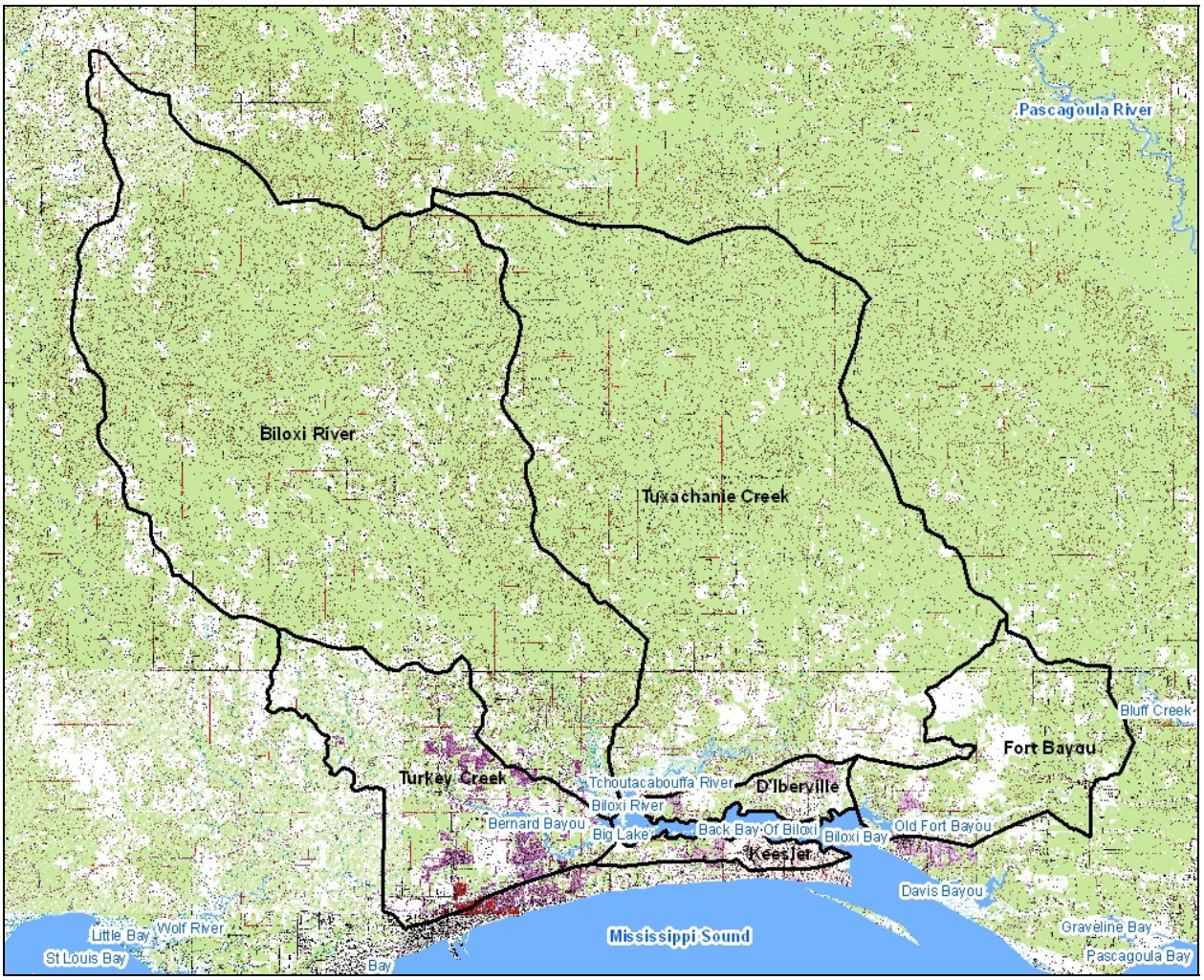


Figure 3.4.5.1-2. Biloxi Bay Watershed

The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gage 107840 and the 2-100 year 24-hour TP-40 rainfall events. The initial and constant loss rate and SCS curve number methods were used for the loss model while the Snyder's unit hydrograph (UH) and SCS UH methods were used for the direct runoff model. The model was calibrated to observed hourly discharge data for two events at USGS gage 2481000.

Calibration results agree reasonable well with observed data as shown in Figures 3.4.5.1-3 and 3.4.5.1-4.

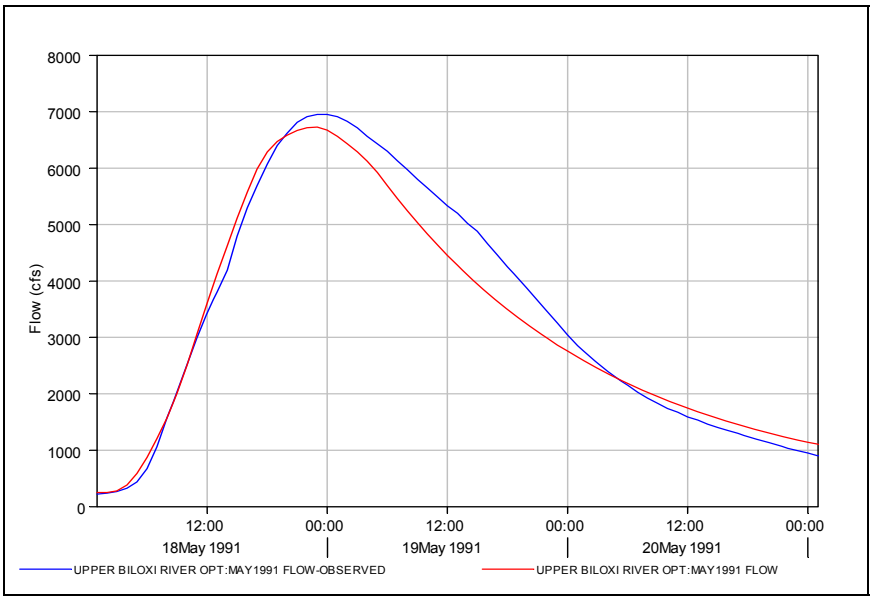


Figure 3.4.5.1-3. Biloxi Bay Watershed Calibration

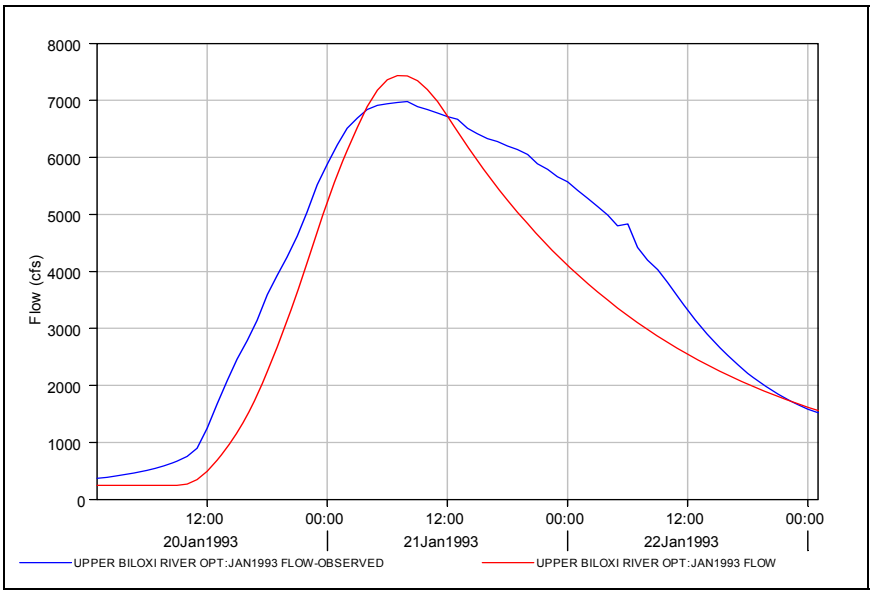


Figure 3.4.5.1-4. Biloxi Bay Watershed Calibration

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V. Goodyear, Office Hydrology, July 1968. The

second is “National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District, U.S. Army Corps of Engineers.

The 24-hour period of highest inflow from the flow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

Based on this method of analysis, the resulting elevations for the various storms are shown in Figure 3.4.5.1-1, with the 10-yr elevation of 8.4 ft NAVD88 the design condition.

Table 3.4.5.1-1.
Biloxi Bay Ponding

Biloxi Bay 4 ft. Base Elevations	
Strom Event	**Bay Elevation (ft NAVD88)**
2-year	6.0
5-year	7.6
10-year	8.4
25-year	9.4
50-year	10.0
100-year	10.8

This ponded water area in Jackson County above the surge barrier gates at the 10-yr flood is at 8.4 ft NAVD88 and is approximated by the 8-ft ground contour line shown in Figure 3.4.5.1-5.



Figure 3.4.5.1-5. Biloxi Bay 10-yr Ponding to Elev 8.4 ft NAVD88

This ponded water area in Harrison County above the surge barrier gates at the 10-yr flood is at 8.4 ft NAVD88 and is approximated by the 8-ft ground contour line shown in Figure 3.4.5.1-6.

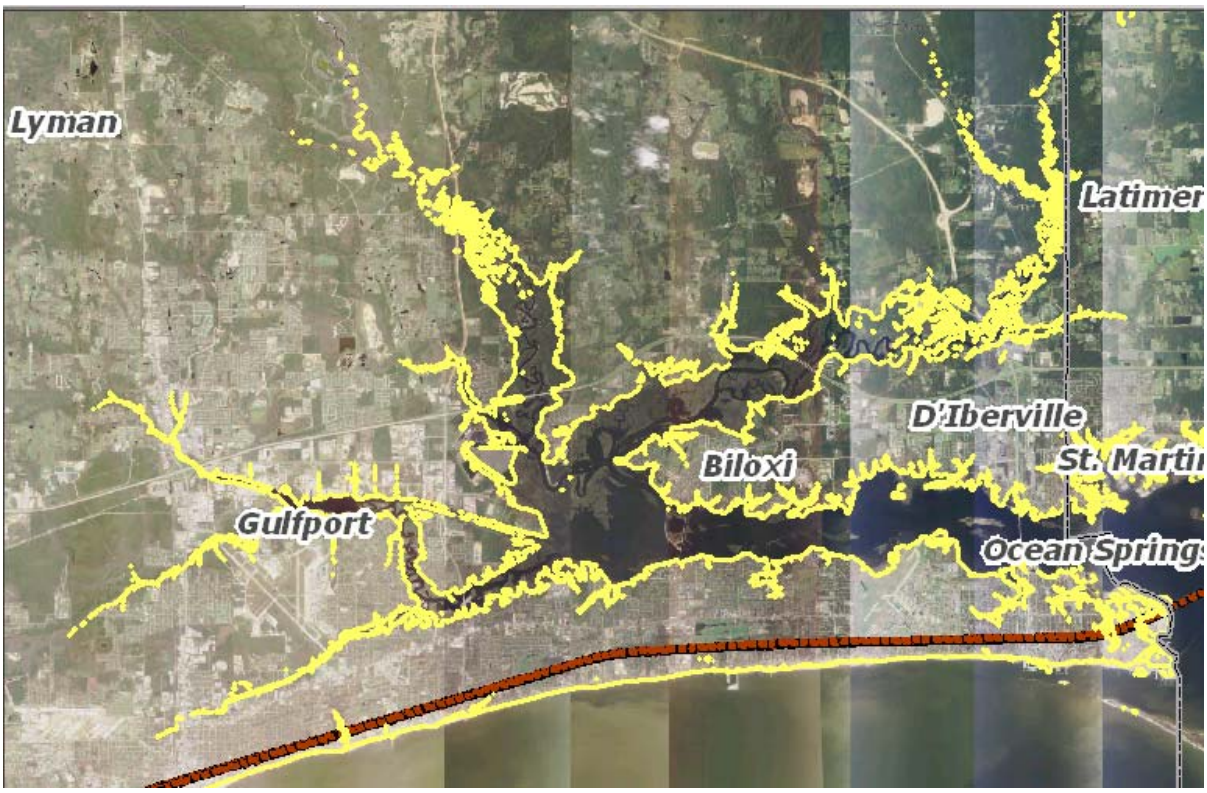


Figure 3.4.5.1-6. Biloxi Bay 10-yr Ponding to Elev 8.4 ft NAVD88

3.4.5.1.2 Geotechnical Data

The available mapping covering the bay bottom is very sketchy consisting mostly of quad maps. This data indicates that the existing bay bottom elevation along the study alignment would vary from a maximum of about (-)12 feet at the maintained channel (the nominal channel depth) to approximately (-)3 feet near, and for some distance out from, each bank. Information gathered from the Mississippi Department of Transportation subsequent to their emergency replacement of the U.S. Highway 90 Bridge indicates that the bay bottom materials are very loose and unstable to a significant depth below the bay bottom, indicating that a significant amount of undercutting would be required for any structure that might be installed, and that structures of the magnitude under consideration would require very deep pile foundations.

3.4.5.1.3 Structural, Mechanical and Electrical

See sections 3.4.5.1.3.1 through 3.4.5.1.3.3.

3.4.5.1.3.1 Structural

Structurally, the Barrier as configured for this study would consist of a series of 25 large stainless steel clad, structural steel framed gates called rising sector gates. Each of these would be supported on reinforced concrete piers resting on large continuous concrete sills with pile foundations. The tentative layout used to estimate the scope of the structure was configured having gates 132 feet long mounted on 28-foot wide piers. The number of gates was determined by the extent of water

having depth sufficient to support their operation. To facilitate as nearly as possible the normal ebb and flow of tide waters through the barrier, the concrete connector wall and rock fill portions of the barrier either side of the gated structure would be fitted with a series of closely spaced low level gated culverts. The gate and pier heights were varied to accommodate the "level of protection" under consideration. The three elevations selected for this study were 20, 30, and 40 NAVD88. In each case the gate heights were set to match the protection level elevations with pier heights set approximately 3 feet higher to provide minor wave clearance for protection of operating equipment. Atop each pier an operating machinery block would be mounted to house the operating equipment. No lateral access over the tops of the piers was envisioned because of the long spans and the desire to keep the vista across the structure as clear as possible. Operating and utility access would be provided through two continuous tunnels passing through the sill section and the rock fill, to operating facilities located on each bank.

3.4.5.1.3.2 Mechanical

The mechanical equipment and appurtenances required for operation of these facilities would include very large steel gate linkages and hydraulic rams and pivot pins for operation of each gate. Each gate would rotate on large bearings and pivot hubs at each end of the gate. Various operating hydraulic and lubrication oil systems would also be required. Each gate would have an opening/closing time of approximately 15 minutes.

3.4.5.1.3.3 Electrical

Primary electrical power for operating the gates would be provided using dedicated, standard transformers with emergency back-up generators. The size of the generators would be greatly reduced by minimizing the wattage output through reduction of the demand on the facility. The demand would be minimized by phasing the operation of the gates to the greatest extent possible. For this study it was determined that this could possibly be done by operating a maximum of eight gates at a time, with the last eight gates being left open until the storm threat was definite and eminent. The operation would require that a maximum of four gates be started at one time, with the remaining four gates sequenced to start 1 minute later. It was determined that this would allow the entire closure and subsequent opening operation to be done over a period of 4 to 6 hours. The supplemental generation aspect was considered to be a vital component of the design because of the very high cost of commercial standby power and because commercial electric power would almost certainly be unavailable during and immediately following a storm event.

3.4.5.1.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.5.1.5 Construction Procedures and Water Control Plan

Following is a very tentative description of a sequence of construction by which the barrier structure and embankments might be built. There are admittedly myriad other means by which this could be accomplished as demonstrated by the construction methods used in construction of the Thames River Barrier and various structures in The Netherlands and elsewhere, any one of which might result in more economical and expeditious construction of the barrier. However, at this juncture, in

the interest of clarity and brevity, it was considered expedient to describe this work using customary construction techniques common to most of our large civil works projects constructed to date.

3.4.5.1.5.1 Construction Procedure

As configured for this study, the physical construction of the barrier would begin with installation of the first of what would likely be a two stage cellular cofferdam. The arrangement assumed for this study consisted of a series of circular sheet pile cells and connecting arcs measuring approximately 60 feet in diameter and extending 100 feet from the top of the cell to the pile tip elevation. These cells would encompass either the east side or west side transition monoliths and the portion of the gated structure extending to the center of the boat channel. The second phase cofferdam would encompass the remainder of the gated structure and the remaining non-overflow concrete section. It was assumed that for structures designed to provide the highest protection level (Elevation 40 NAVD88) the top of cells could be placed at elevation 35 with reasonable degree of safety. This would provide cell embedment of approximately 30 feet below the lowest structure foundation elevation. This configuration was, naturally, modified to fit the lower levels of protection but in each case the configuration was made to provide the same relative of protection during construction. With the cofferdam in place the interior would be dewatered using hydraulic pumps, and excavation for the concrete structures would begin. Once the excavation in a given area is brought to the required grade work would continue in this area with the installation of foundation piles. Prior to completion of the first phase of the concrete work, installation would begin on the next phase of the cofferdam.

Once the first phase of the concrete structure is completed and the first phase cofferdam removed, installation of the gates and operating machinery would begin. Fabrication of the gates would have been done on land in an outfitting yard and the gates transported by water to the proper installation site. Note that this would likely require dredging of a temporary construction channel parallel to the barrier for a portion of its length.

Construction of the rock fill embankments would require surcharging and pre-consolidation of the bay bottom materials. (See section 3.4.3.1.2 above for discussion of the Geotechnical aspects of this site.)

3.4.5.1.5.2 Water Control Plan

As this work progresses the flow into and out of Biloxi Bay would be somewhat restricted for practically the entire construction time. This restriction could be minimized by removal of the cofferdams immediately upon completion of the concrete piers to some point above the normal high tide level thus allowing flow over the completed sill sections as construction continues on the piers and as the gates are being installed. It is estimated the maximum flow restriction at any time would be approximately 50% of the inlet width and that this restriction could endure for as much as three to five years using the methods and approximate sequence of construction indicated above.

3.4.5.1.6 Physical Security

During the construction of the project the contractor would be responsible for maintaining security of all his work sites. This would be done in accordance with guidance noted under Section 3.4.1.7 General, above, in addition to the normal site security requirements.

Upon completion of the project the facilities security responsibilities would pass to the U.S. Army Corps of Engineers and the state, county and municipal law enforcement entities, all of whom would coordinate a program of oversight under which the facilities would be operated and maintained and under which specific security responsibilities would be defined and allocated. These agreements would also be required to reflect the provisions of the guidance noted in Section 3.4.1.7 General, above, in addition to normal security criteria.

3.4.5.1.7 Operations and Maintenance

In order to assure proper functioning of the facilities once they are placed in service a program of Operations and Maintenance would be developed by the U.S. Army Corps of Engineers, in conjunction and cooperation with the affected state and local entities. This O & M Plan would address specific responsibilities as to daily operation of the facilities, the periodic testing and maintenance of the operating machinery, maintenance of specified stocks of replacement parts, security of the facilities, and maintenance of any buildings and grounds associated with the operation and maintenance of the facilities. As presently envisioned, this O & M responsibility would remain under control of the U.S. Army Corps of Engineers and would be administered under its Operations mission.

3.4.5.1.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.5.8 Cost Summary. Construction costs for the various options are included in Table 3.4.5.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.5.8-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates exclude project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.5.1.9 Schedule and Design for Construction

The scheduling for events following this conceptual study would of necessity include extensive further study to ascertain in greater detail the specific requirements of the project and the most feasible means by which to fulfill these requirements. The Sequence of events would include but not be limited to the following:

a. The alignment and extent of the proposed barrier should be subjected to detailed study to determine the most feasible routing. This study should address, among other factors, the exact location of utilities features crossing the bay inlet, the present and projected future needs of the boat channel passing through the barrier, and how best to minimize the effects that the barrier could have on the existing marine environment.

b. Detailed deep geotechnical investigation should be made to determine as accurately as possible the engineering capabilities of the soils making up the bay bottom along the alignment (or alignments) under consideration.

c. A more thorough and painstaking investigation of various types of gate structures should be undertaken to confirm the choice of the rising sector gate for this application, or to replace this type gate with another perhaps more appropriate to the circumstances.

d. Once this search and these investigations and analyses have been completed a thorough design of the structures to be included in the final facility would be undertaken addressing the full range of hydraulic events that the structure might see, and making certain that all pertinent design considerations are accounted for.

e. A thorough analysis of the power required to operate the gates in a timely manner in time of storm must be made and the very best, most dependable means of providing this power determined.

f. The link between the operation of the gates and the best available storm forecasting system(s) would be designed and its operating features and equipment detailed.

3.4.5.2 Location

The alignment suggested herein for the barrier structure would run parallel with and south of the Railroad Bridge crossing Biloxi Bay. This would approximate the shortest route across the inlet leading from the Mississippi Sound into the bay. As the preliminary layout of the barrier was developed it became apparent that, because of the excavation required, a significant amount of separation would be required between the railroad bridge and the ultimate location of the structures included in the barrier. For this study the centerline of the barrier was positioned approximately 260 feet from the center of the railroad bridge. This was left unaltered for all protection levels. The entire barrier would be approximately 6,100 feet in length from water's edge to water's edge, and would consist of rock fill levees extending from the overland levee at each bank for some distance into the bay and enveloping the mass concrete non-overflow wall sections leading to each end of the gated structure.

3.4.5.3 Existing Conditions

The points at which the barrier would come ashore in Jackson County on the east and Harrison County on the west, are in urban areas with extensive residential and commercial development. Several structures would need to be relocated and it is uncertain the extent to which existing utilities might have to be relocated to clear the way for this facility.

3.4.5.4 Coastal and Hydraulic Data

Historic coastal data is shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown in Figure 3.4.5.4-1. The data indicates the Katrina high water was as high as 21 ft NAVD88 at the mouth of the bay.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown elsewhere in this report. Points near the mouth of the bay at which data from hydrodynamic modeling was saved are shown in Figure 3.4.5.4-2.

Existing Condition Stage –Frequency data for Save Point 9, near the mouth of the bay, is shown in Figure 3.4.5.4-3. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.



Figure 3.4.5.4-1. Ground Contours and Katrina High Water

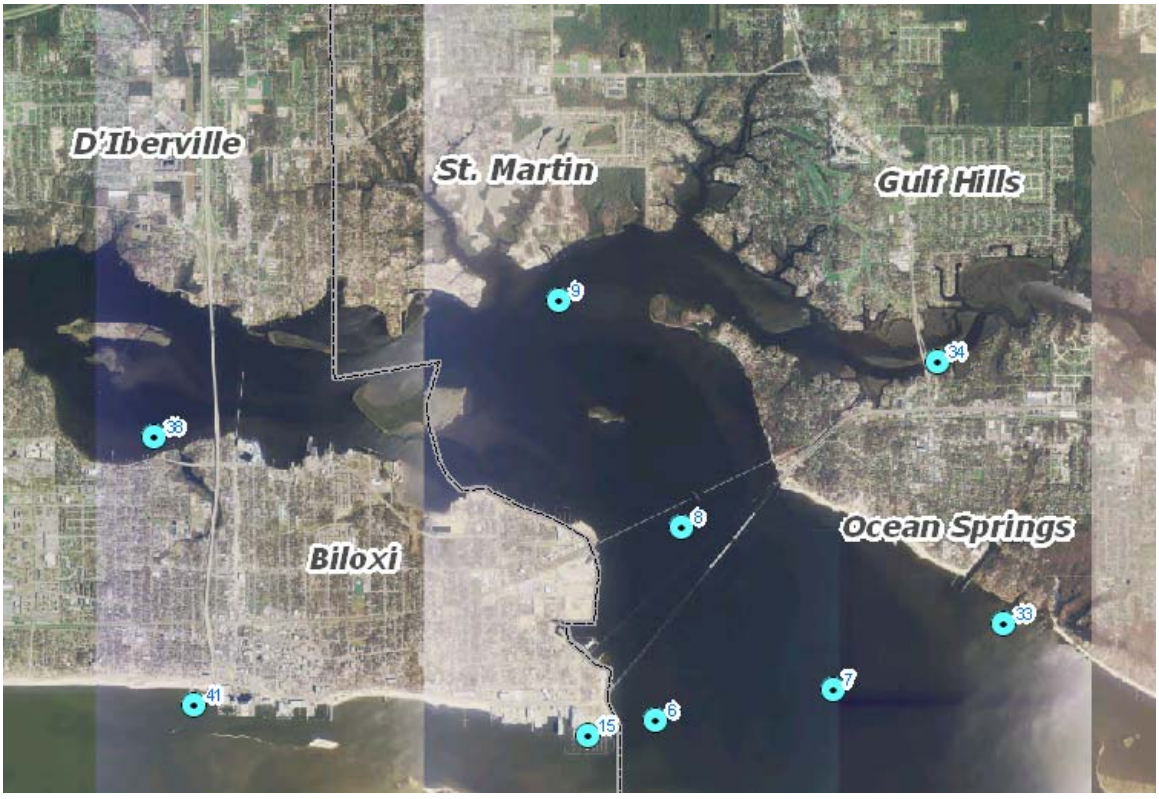


Figure 3.4.5.4-2. Hydrodynamic Modeling Save Points near Biloxi Bay

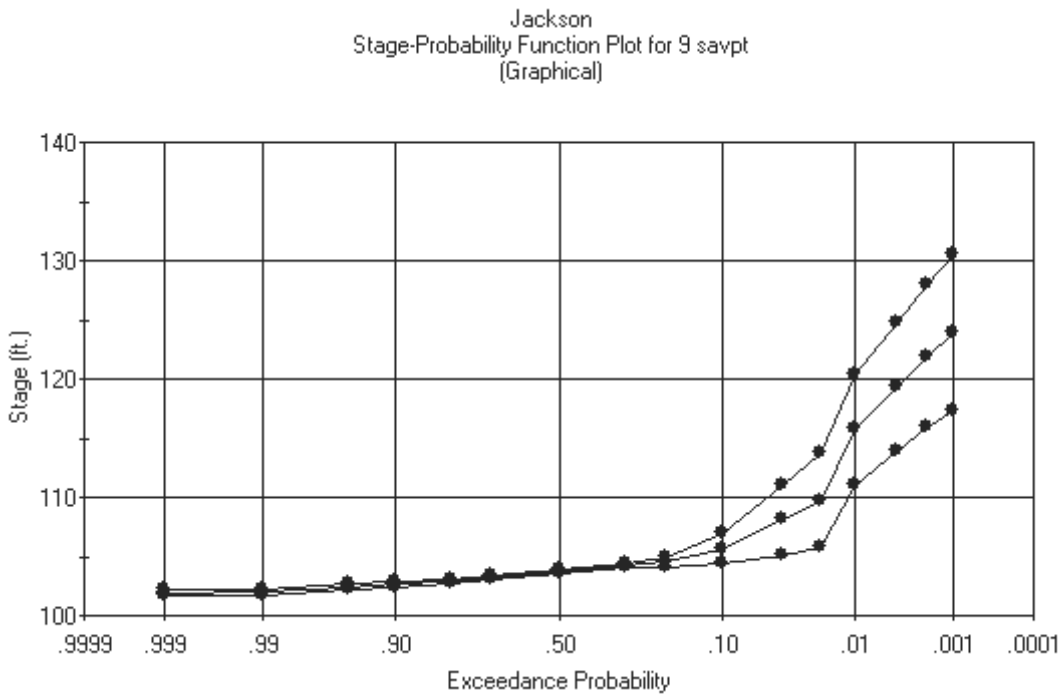


Figure 3.4.5.4-3. Existing Conditions at Save Point 8, near the Mouth of Biloxi Bay

3.4.5.5 Option A – Elevation 20.0

3.4.5.5.1 Structural

In order to reasonably accurately approximate the scope of the structures required to form a moveable barrier to elevation 20 a very preliminary rising sector gate design was made for the gate and its operating disks, and the piers and foundations were approximated on a proportional basis. A system of foundation piles was then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation "Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 20 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 20 resulted in gross quantities of basic construction materials as indicated in Table 3.4.5.5-1.

Table 3.4.5.5-1.
Gross Quantities for Biloxi Bay Surge Barrier Elevation 20.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	23,294	Tons
Foundation Piling	50,540	Each
Concrete	493,700	Cubic Yards
Reinforcement	1,210	Tons
Rising Sector Gates (25 Each)	19,750	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.5.6 Option B – Elevation 30.0

3.4.5.6.1 Structural

In order to reasonably accurately approximate the scope of the structures required to form a moveable barrier to elevation 30, a very preliminary rising sector gate design was made for the gate and its operating disks, and the piers and foundations were approximated on a proportional basis. The foundation piles were then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation "Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 30 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 30 resulted in gross quantities of basic construction materials as indicated in Table 3.4.5.6-1 below.

Table 3.4.5.6-1.
Gross Quantities for Biloxi Bay Surge Barrier Elevation 30.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	31,837	Tons
Foundation Piling	14,538	Each
Concrete	552,800	Cubic Yards
Reinforcement	1,083	Tons
Rising Sector Gates (25 Each)	24,260	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.5.7 Option C – Elevation 40.0

3.4.5.7.1 Structural

In order to reasonably accurately approximate the scope of The structures required to form a moveable barrier to elevation 40, a very preliminary rising sector gate design was made for the gate

and its operating disks, and the piers and foundations were approximated on a proportional basis. The foundation piles were then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation "Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 40 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 40 resulted in gross quantities of basic construction materials as indicated in Table 3.4.5.7-1 below.

Table 3.4.5.7-1.
Gross Quantities for Biloxi Bay Surge Barrier Elevation 40.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	31,837	Tons
Foundation Piling	20,540	Each
Concrete	561,300	Cubic Yards
Reinforcement	1,061	Tons
Rising Sector Gates (25 Each)	40,291	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.5.8 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.4.5.8-1.
Back Bay of Biloxi Surge Barrier Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$989,800,000
Option B – Elevation 30 ft NAVD88	$1,267,100,000
Option C – Elevation 40 ft NAVD88	$1,810,700,000

Table 3.4.5.8-2.
Back Bay of Biloxi Surge Barrier O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$13,770,000
Option B – Elevation 30 ft NAVD88	$17,646,000
Option C – Elevation 40 ft NAVD88	$25,243,000

3.4.5.9 References

See 3.4.3 General discussion above for references.

3.4.6 Jackson County Inland Barrier

3.4.6.1 General

Several high density residential and business areas are located in Jackson County. These are subject to damage from storm surges associated with hurricanes. Earthen levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88 and 40 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Storm surge gates across Biloxi Bay are also included to prevent flooding from hurricanes. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented elsewhere in this report.

3.4.6.2 Location

The location of the levee in Jackson County is shown in Figures 3.4.6-1 through 3.4.6-4 parallel to the CSX railroad, Hwy 57 and Hwy 90.



Figure 3.4.6-1. Vicinity Map Jackson County, MS

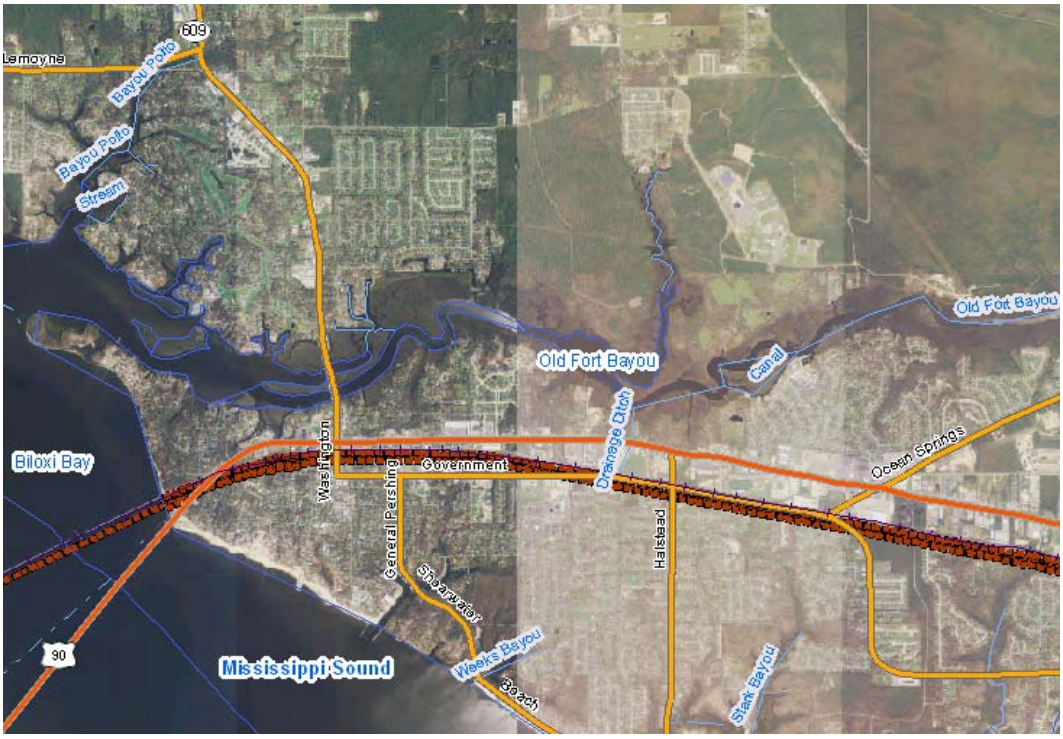


Figure 3.4.6-2. Jackson County Inland Barrier

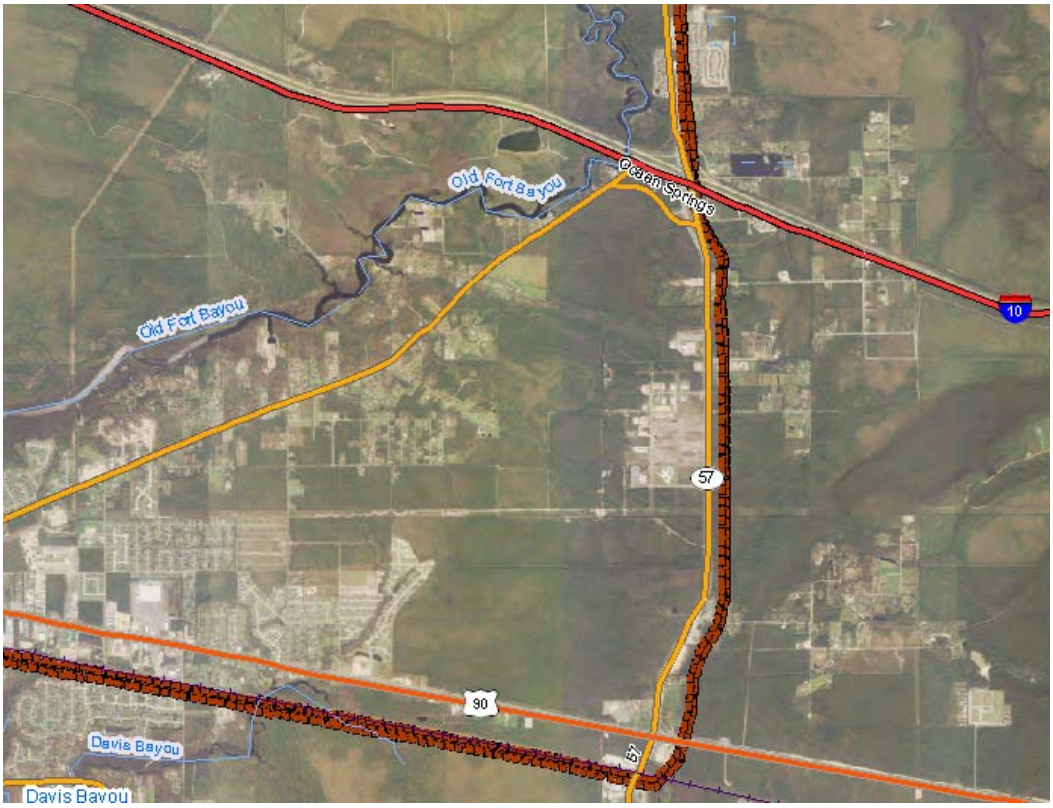


Figure 3.4.6-3. Jackson County Inland Barrier



Figure 3.4.6-4. Jackson County Inland Barrier

3.4.6.3 Existing Conditions

Jackson County is located on the east side of the Mississippi at the Mississippi Sound coast. The main residential and business area is at Ocean Springs, which is mostly south of the levee. Ground elevations over the areas behind the levee vary between Elevations 10-20 ft NAVD88 at low areas to as high as 50 ft NAVD88. The area is drained by Old Fort Bayou. The 4-ft (blue), 10-ft (green), 20-ft (pink), 30-ft (dark Blue), 40-ft (purple), and 50-ft (gray) ground contour lines are shown in Figure 3.4.6-5.

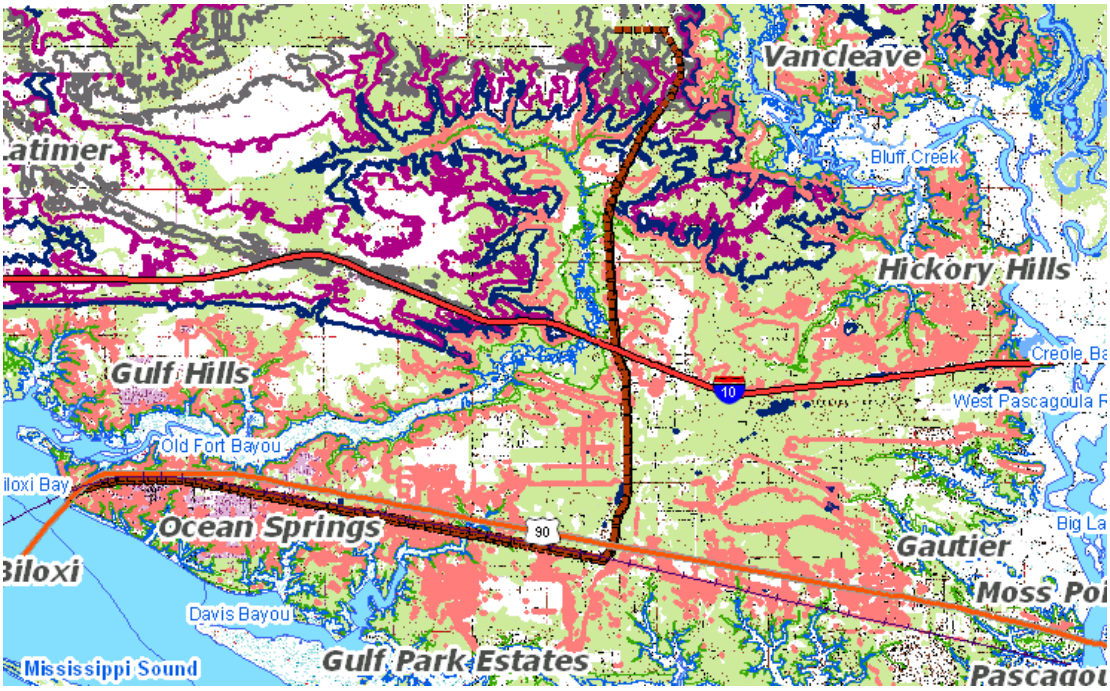


Figure 3.4.6-5. Existing Conditions Jackson County, MS

Drainage from ordinary rainfall is hindered on occasions when either of the rivers or the gulf is high, but impacts from hurricanes are devastating.

Recent damage from Hurricane Katrina in August, 2005 near the mouth of the Old Fort Bayou area are shown in Figures 3.4.6-6 and 3.4.6-7.

3.4.6.4 Coastal and Hydraulic Data

Historic coastal data is shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as 4-ft(blue), 10-ft(green),20-ft(pink), 30-ft(dark Blue), 40-ft(purple), and 50-ft(gray) ground contour lines are shown in Figure 3.4.6-8 below. The data indicates the Katrina high water was as high as 21-22 ft NAVD88 in the Old Fort Bayou area north of Ocean Springs.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is presented elsewhere in this report. Points near Gautier at which data from hydrodynamic modeling was saved are shown in Figure 3.4.6-9.



Source: http://ngs.woc.noaa.gov/storms/katrina/24806787.jpg

Figure 3.4.6-6. Hurricane Katrina Damage Near mouth of Old Fort Bayou, MS



Source: http://www.flickr.com/photos/cbsnaps/53488199/, cbatesteach

Figure 3.4.6-7. Hurricane Katrina Damage in St Martin (nr Ocean Springs), MS

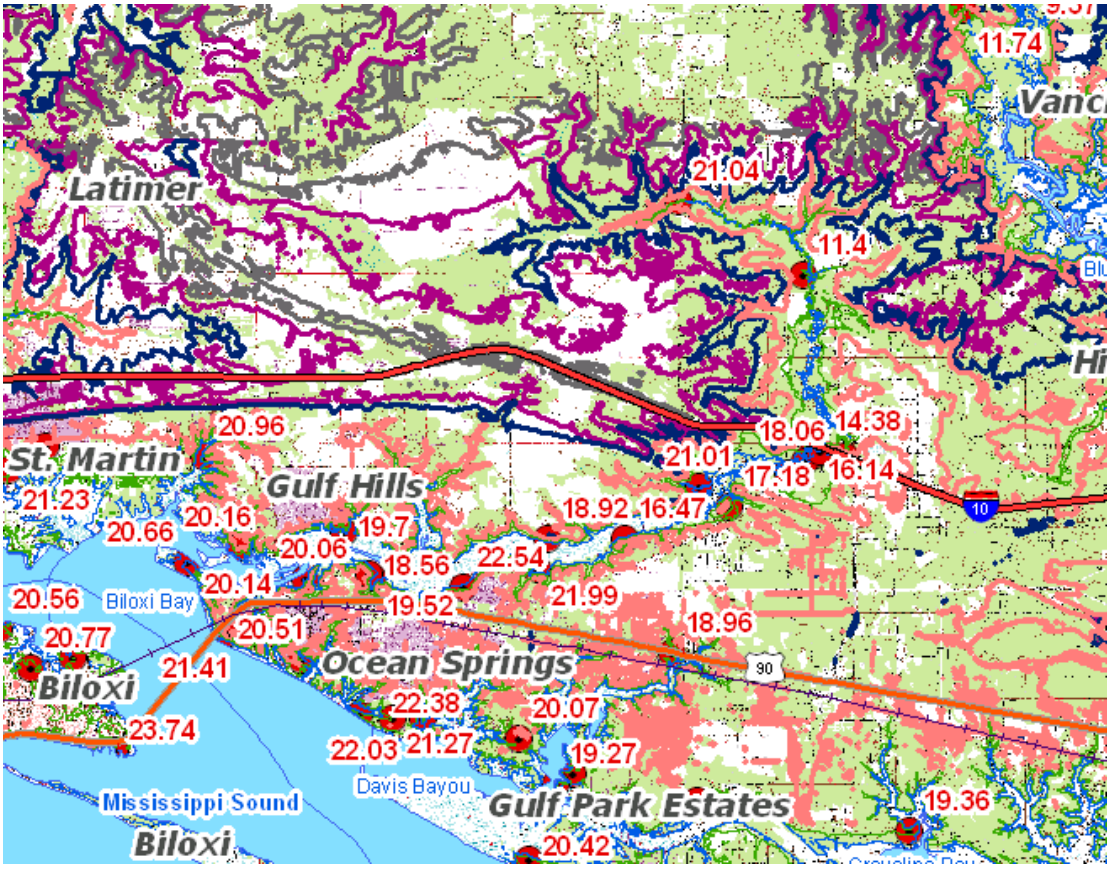


Figure 3.4.6-8. Ground Contours and Katrina High Water Elevations

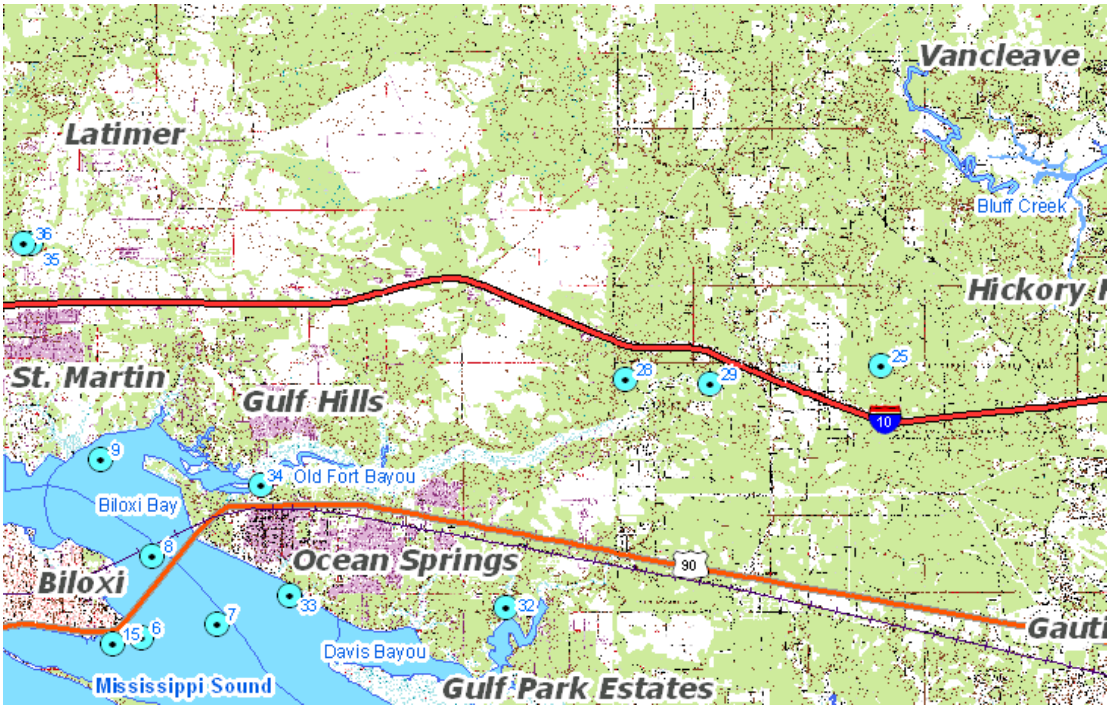


Figure 3.4.6-9. Hydrodynamic Modeling Save Points near Gautier, MS

Existing Condition Stage –Frequency data for Save Point 33, near the Ocean Springs, is shown in Figure 3.4.6-10 as an example. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

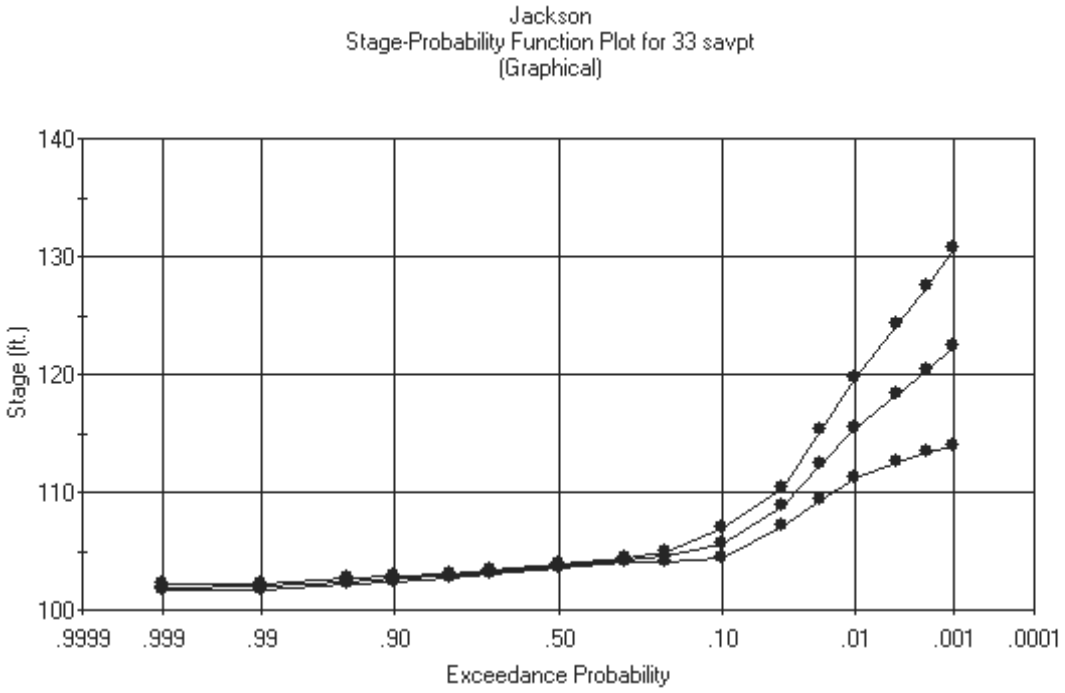


Figure 3.4.6-10. Existing Conditions at Save Point 33, near Ocean Springs, MS

3.4.6.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike around the areas north of Hwy 90 as shown on Figure 3.4.6-11, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal. The levee is located mostly along high ground so ponding at the levee would be minimal. The levee surfaces will be armored with a layer of gabions to prevent scour during overtopping. Ponding will occur on the outside of the levee which would require ditching to other drainage basins. The ditch locations are shown in Figure 3.4.6-11 in dark blue.

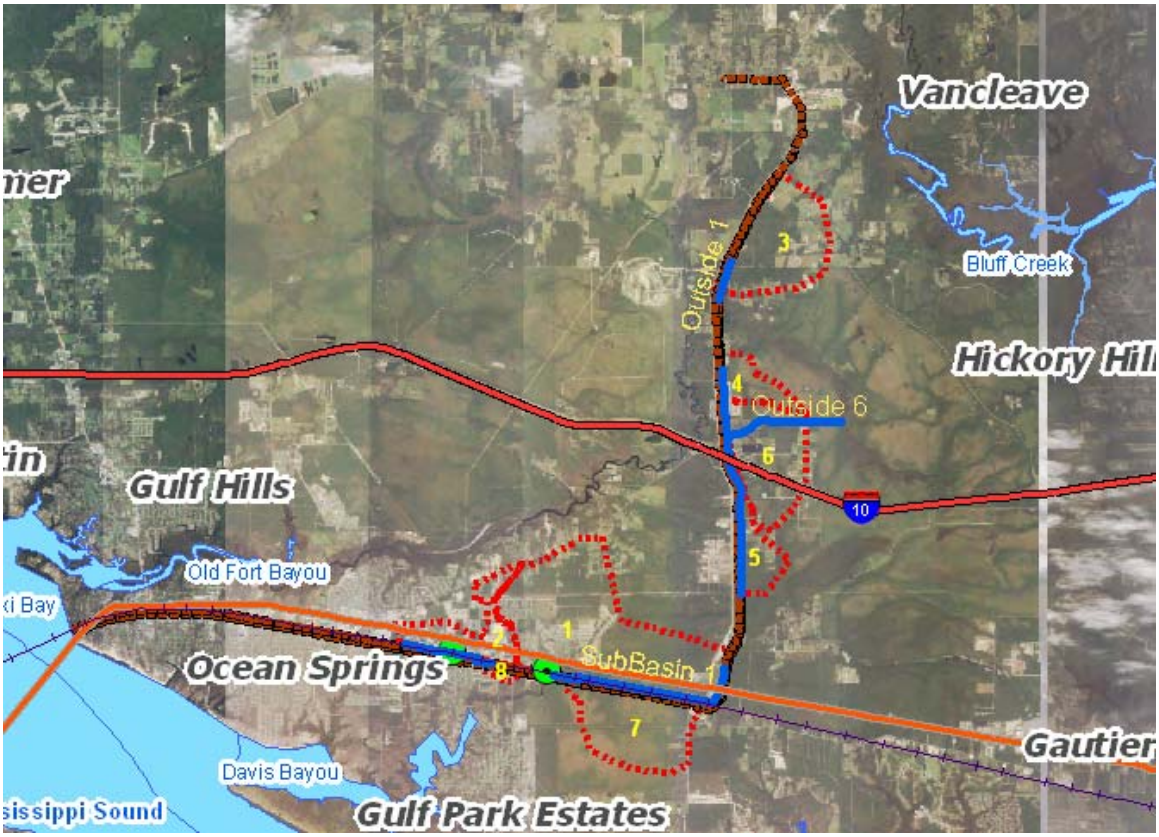


Figure 3.4.6-11. Pump/Culvert/Sub-basin Site Locations

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as depicted in Figure 3.4.6-12.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo: Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.4.6-12. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown in Figure 3.4.6-13 was caused by approximately 1-2 ft of overtopping crest depth.

Revetment would be included in the levee design to prevent overtopping failure.



Source: ERDC, Steven Hughes

Figure 3.4.6-13. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

The levee would be protected by gabions on filter cloth as shown in Figure 3.4.6-14, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

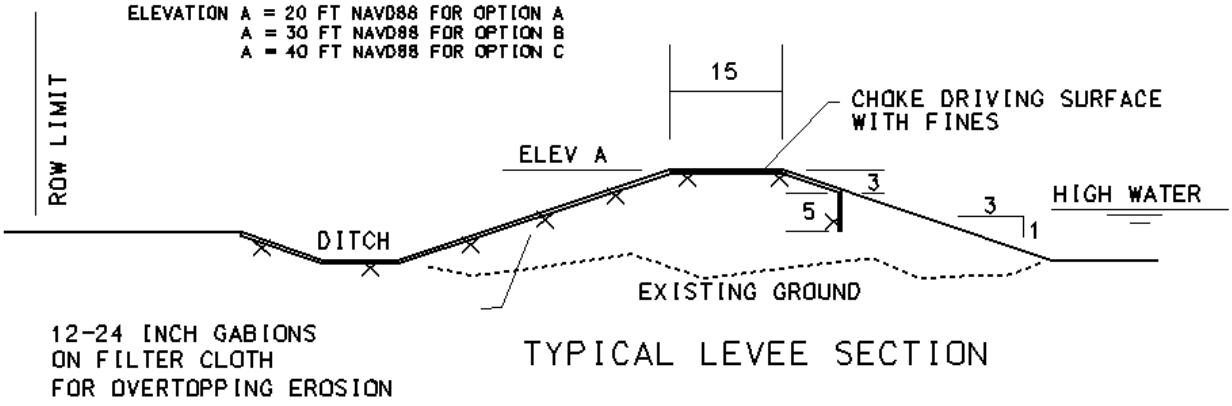


Figure 3.4.6-14. Typical Section at Inland Barrier

3.4.6.5.1 Interior Drainage

For smaller drainage areas, drainage on the interior of the inland barrier would be collected at the levee and channeled to culverts placed in the levee at the locations shown in Figure 3.4.6-11. The culverts would have tidal gates on the seaward ends to prevent backflow when the water in

Mississippi Sound is high. An additional closure gate would also be provided at the upstream end at every culvert in the levee for manual control in the event the tidal gate malfunctions. A typical section is shown in Figure 3.4.6-15.

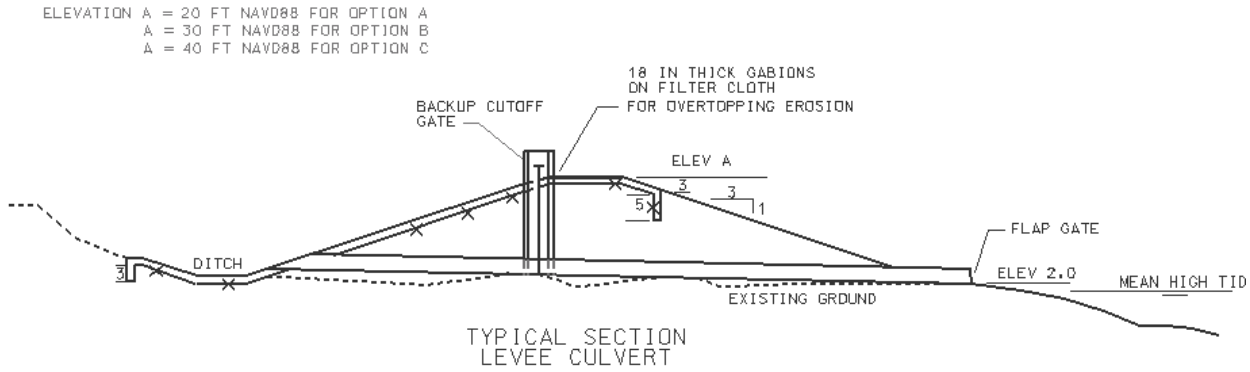


Figure 3.4.6-15. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the inland barrier into major sub-basins as shown in Figure 3.4.6-11 and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number.

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data is considered beyond the level of detail required for this report.

During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is “Frequency and Aerial Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is “National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report; therefore the exact extent of the ponding for extreme events is not precisely defined. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have

pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

In addition to the local drainage outlets at the levee described above, in the event of an imminent hurricane, barrier gates across the Back Bay of Biloxi would be closed, and flow from the Biloxi and Tchoutacabouffa Rivers, as well as local runoff would pond behind the gates. The location of the barrier is shown in Figure 3.4.6-16.

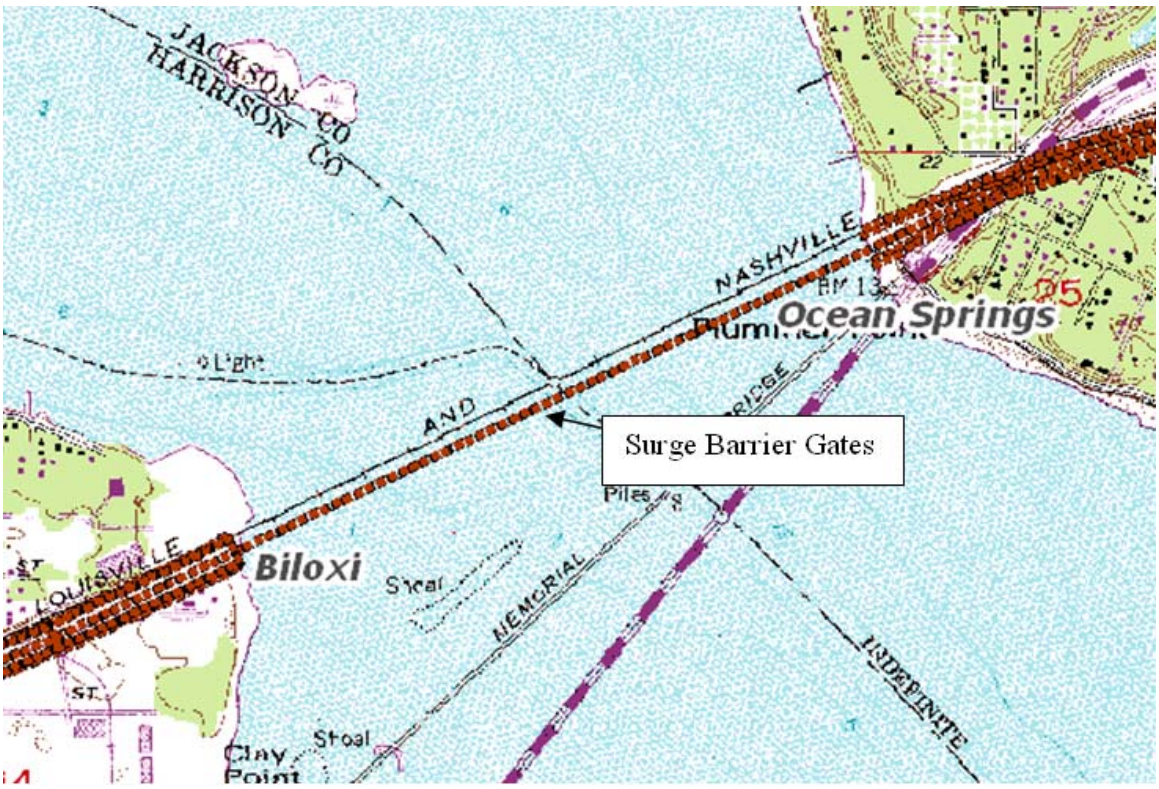


Figure 3.4.6-16. Biloxi Bay Surge Barrier Location

The gates would be similar to the gates across the Thames River in London, England, shown in Figure 3.4.6-17.

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used to model the Biloxi Bay watershed in order to predict the maximum water elevation behind the gates in the bay under several different scenarios.

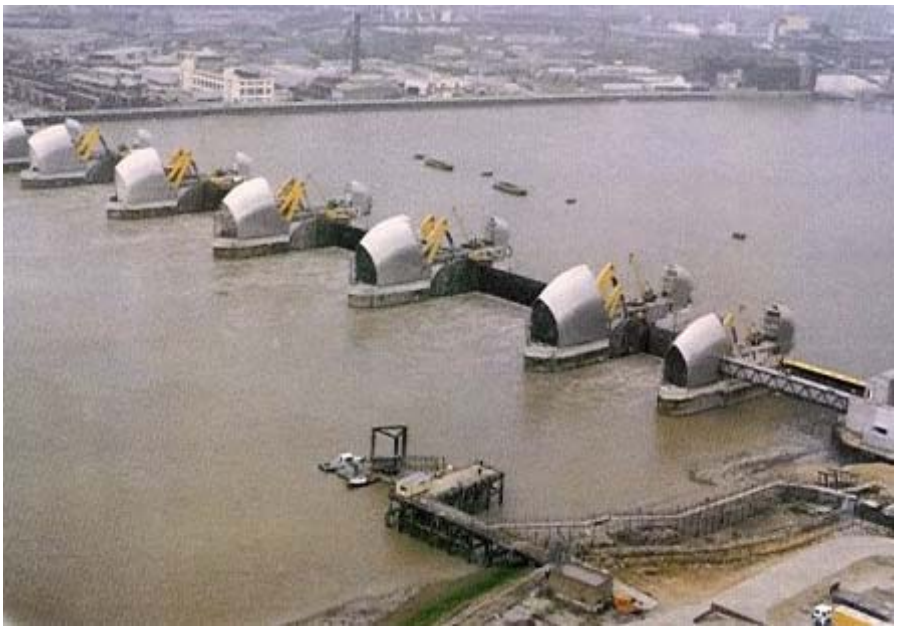


Figure 3.4.6-17. Thames River Barrier Gates

The Biloxi Bay watershed is an approximately 640 square mile watershed comprised of six subbasins that stretch across Harrison, Stone, and Jackson County, MS. There is one United States Geological Survey (USGS) discharge gage located in the watershed along the Biloxi River and one National Oceanic and Atmospheric Administration (NOAA) hourly precipitation gage located on the east side of the watershed. The discharge gage is USGS gage 2481000 at Wortham, MS and the precipitation gage is NOAA gage 107840 (Saucier Experimental Forest). Data from these gages, along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering Biloxi Bay from the Biloxi Bay watershed for the 2-100 year rainfall events. The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The Biloxi Bay watershed is shown in Figure 3.4.6-18.

The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gage 107840 and the 2-100 year TP-40 rainfall events. The initial and constant loss rate and SCS curve number methods were used for the loss model while the Snyder's unit hydrograph (UH) and SCS UH methods were used for the direct runoff model. The model was calibrated to observed hourly discharge data for two events at USGS gage 2481000.

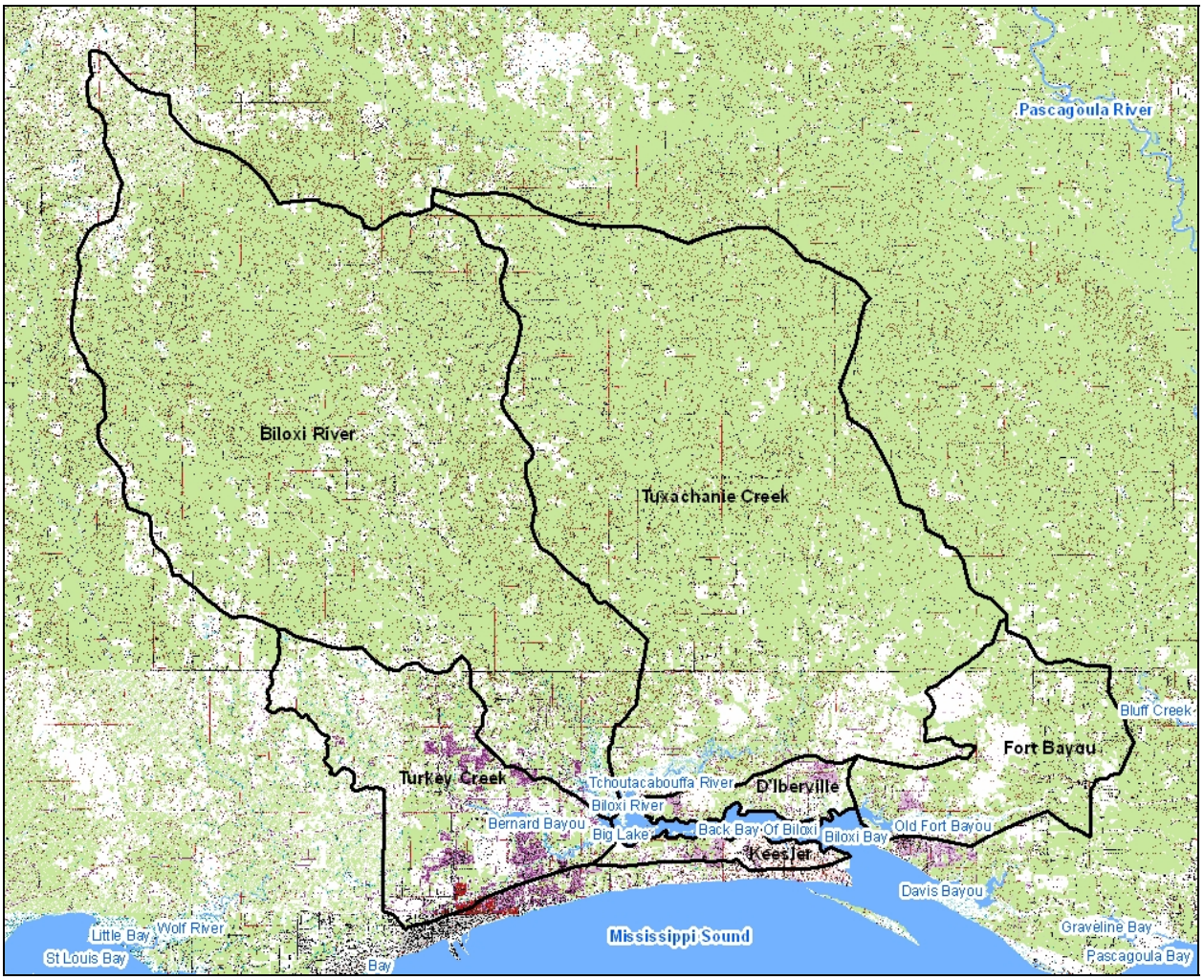


Figure 3.4.6-18. Biloxi Bay Watershed

Calibration results agree reasonable well with observed data as shown in Figures 3.4.6-19 and 3.4.6-20.

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition, in accordance with studies cited above. The highest inflow period of the inflow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

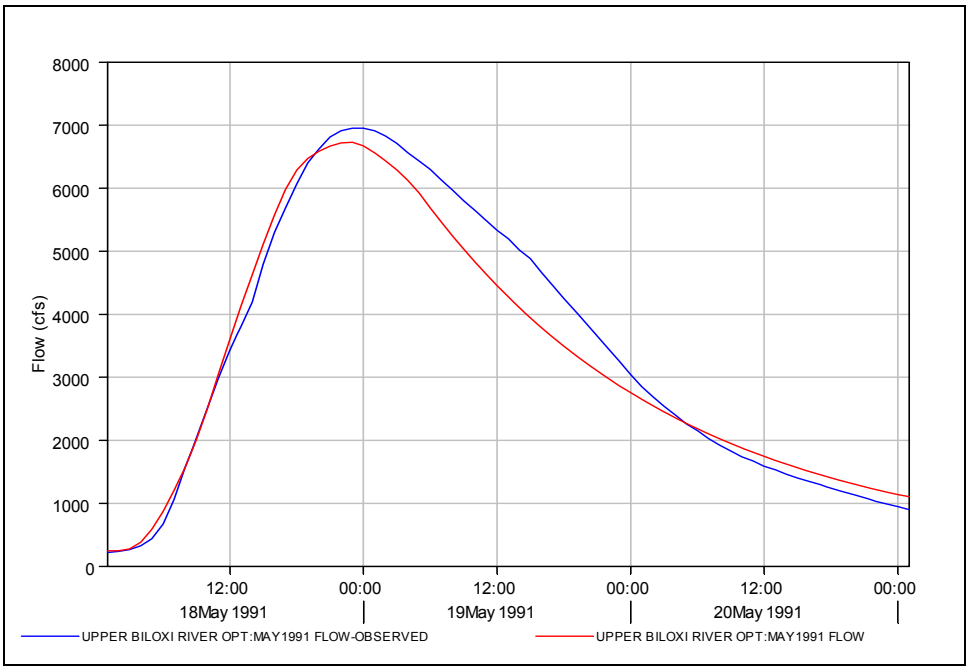


Figure 3.4.6-19. Biloxi Bay Watershed Calibration, 19 May 1991

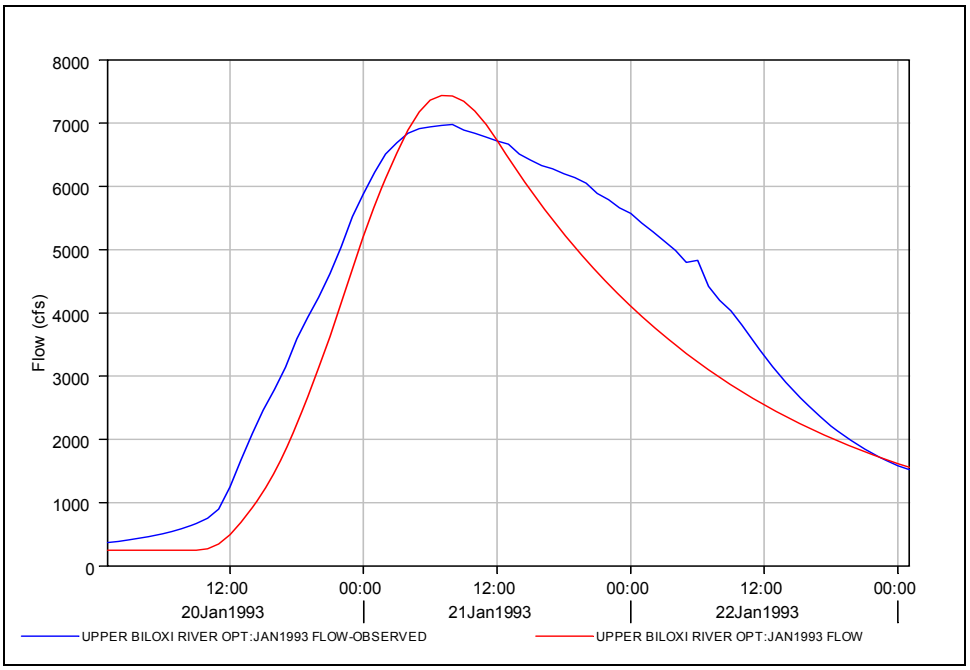


Figure 3.4.6-20. Biloxi Bay Watershed Calibration, 21 Jan 1993

Based on this method of analysis, the resulting elevations for the various storms are shown in Table 3.4.6.1-1, with the 10-yr elevation of 8.4 ft NAVD88 the design condition.

Table 3.4.6.1-1.
Biloxi Bay Ponding

Biloxi Bay 4 ft. Base Elevations	
Strom Event	**Bay Elevation (ft NAVD88)**
2-year	6.0
5-year	7.6
10-year	8.4
25-year	9.4
50-year	10.0
100-year	10.8

This area in Jackson County is approximated by the 8-ft ground contour line shown in Figure 3.4.6-21.



Figure 3.4.6-21. Biloxi Bay 10-yr Ponding to Elev. 8.4 ft NAVD88

3.4.6.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.6.5.3 Structural, Mechanical and Electrical

See sections 3.4.6.5.3.1 and 3.4.6.5.3.2.

3.4.6.5.3.1 Culverts

Reinforced concrete box culverts would be required at 2 locations, as described above, with the culvert requirement ranging from seven 7’ wide by 3’ high, to eleven 10’ wide by 4’ high water passages. Each of these culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a manually operated vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.6.5.3.2 Pumping Stations

Design hydraulic heads derived for the 2 pumping facilities included in the Jackson County Inland Barrier for the elevation 20 protection level were 15 and 10 feet and the corresponding flows required were 567,772 and 213,195 gallons per minute respectively. The facilities thus derived would consist of one plant having six, 60-inch diameter, 560 horsepower pumps and one having four, 54-inch diameter pumps each running at 290 horsepower.

3.4.6.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.6.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.6.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

3.4.6.5.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.6.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.6.8 Cost Summary. Construction costs for the various options are included in Table 3.4.6.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.6.8-2. Estimates are comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid

estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.6.5.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.6.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Gautier The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.4.6.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.4.6.6.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the

placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.6.6.3 Structural, Mechanical and Electrical

See sections 3.4.6.6.3.1 through 3.4.6.6.3.3.

3.4.6.6.3.1 Culverts

Reinforced concrete box culverts would be required at 2 locations, as described above, with the culvert requirement ranging from seven 7' wide by 3' high, to eleven 10' wide by 4' high water passages. Each of these culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a manually vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.6.6.3.2 Pumping Stations

Design hydraulic heads derived for the 2 pumping facilities included in the Jackson County Inland Barrier for the elevation 30 protection level were 25 and 20 feet and the corresponding flows required were 567,772 and 213,195 gallons per minute respectively. The facilities thus derived would consist of one plant having six, 60-inch diameter, 1000 horsepower pumps, and one having four, 54-inch diameter pumps each running at 560 horsepower.

3.4.6.6.3.3 Dedicated Flood Barriers

There are two sites in Jackson County that would require special flood protection with the flood protection level set at elevation 40, the court facilities located immediately south of the protection line in downtown Biloxi and similar governmental facilities in downtown Moss Point.

The Biloxi facilities would require a three sided Tee Wall structure approximately 1410 feet long originating and terminating in the levee at its northwest and northeast ends. It would be fitted with four face sealing roller gates to close off the required street and driveway access points in time of flood.

The Moss Point Tee Wall would be similarly configured and would extend approximately 1552 feet. It would require two roadway closure gates.

3.4.6.6.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report

therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.6.6.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.6.6.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied building and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. Level 2 Security is the level to be applied to this option.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.6.6.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.6.6.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.6.8 Cost Summary. Construction costs for the various options are included in Table 3.4.6.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.6.8.-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.6.6.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.6.7 Option C – Elevation 40 ft NAVD88

3.4.6.7.1 Interior Drainage

The alignment of the levee is the same as Option A, above, and is not reproduced here. Differences between the description of this option and preceding description of Option A include the height of the levee, pumping facilities (because of the increased head), and the length of the levee culverts. The methods of analysis for interior drainage and computed flows are the same.

3.4.6.7.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted

sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will not be armored for this option since the elevation of this option will not permit overtopping. The surface of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.6.7.3 Structural, Mechanical and Electrical

See sections 3.4.6.7.3.1 through 3.4.6.7.3.4.

3.4.6.7.3.1 Culverts

Reinforced concrete box culverts would be required at 2 locations, as described above, with the culvert requirement ranging from seven 7’ wide by 3’ high, to eleven 10’ wide by 4’ high water passages. Each of these culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.6.7.3.2 Pumping Stations

Design hydraulic heads derived for the 2 pumping facilities included in the Jackson County Inland Barrier for the elevation 30 protection level were 35 and 30 feet and the corresponding flows required were 567,772 and 213,195 gallons per minute respectively. The facilities thus derived would consist of one plant having eight, 54-inch diameter, 1000 horsepower pumps, and one having seven, 42-inch diameter pumps each running at 500 horsepower.

3.4.6.7.3.3 Levee and Roadway/Railway Intersections

With the installation of Line 4 protection to elevation 40, three roadway intersections would have to be accommodated. It was determined that roller gate structures would suffice for all three of these locations.

3.4.6.7.3.4 Dedicated Flood Barriers

There are two sites in Jackson County that would require special flood protection with the flood protection level set at elevation 40, the court facilities located immediately south of the protection line in downtown Biloxi and similar governmental facilities in downtown Moss Point.

The Biloxi facilities would require a three sided Tee Wall structure approximately 1410 feet long originating and terminating in the levee at its northwest and northeast ends. It would be fitted with

four face sealing roller gates to close off the required street and driveway access points in time of flood.

The Moss Point Tee Wall would be similarly configured and would extend approximately 1552 feet. It would require two roadway closure gates.

3.4.6.7.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.6.7.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.6.7.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied building and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. This option will be best supported by the Level 2 Security.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would

possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.6.7.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.6.7.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.6.8 Cost Summary. Construction costs for the various options are included in Table 3.4.6.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.6.8-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.6.7.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.6.8 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.4.6.8-1.
Jackson Co Inland Barrier Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$126,900,000
Option B – Elevation 30 ft NAVD88	$224,800,000
Option C – Elevation 40 ft NAVD88	$266,000,000

Table 3.4.6.8-2.
Jackson Co Inland Barrier O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$819,000
Option B – Elevation 30 ft NAVD88	$2,028,000
Option C – Elevation 40 ft NAVD88	$2,438,000

3.4.6.9 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

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USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

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Environmental Science Services Administration. 1968. “Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico” US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V. Goodyear, Office Hydrology, July 1968.

Weather Bureau and USACE. 1956. National Hurricane Research Project Report No. 3, “Rainfall Associated with Hurricanes (And Other Tropical Disturbances)”, R.W. Schoner and S. Molansky, 1956, Weather Bureau and Corps of Engineers.

3.5 Line of Defense 5 – Retreat and/or Relocation of Critical Facilities

3.5.1 General

Hurricanes are a naturally occurring phenomena that wreak havoc on natural and man-made environments through three different but related mechanisms: torrential rainfall, high winds, and storm surge. While each of these can produce costly outcomes in their own right, storm surge is typically the most damaging and particularly deadly. It is also the most difficult and costly to provide enduring and confident protection against. However, if one cannot be reached by storm surge by virtue of being on ground at elevation higher than any storm surge might reach, one cannot be directly damaged by it. The limit of storm surge represents the first line of avoidance to hurricane related damages. It therefore makes sense to identify the potential inland limit of storm surge so that prudent choices might be made by any and all regarding their exposure to damage by storm surge.

The primary measures identified for the project area include permanent acquisitions, floodproofing by elevation and other means, relocations of public buildings, flood preparedness and evacuation planning, public education, changes in the current municipal and county NFIP and building codes, implementation of either a transfer of development rights or purchase of development rights program, potential changes in zoning ordinances, development impact fees, and redirection of new development. These measures have been combined into several plans that can be implemented by either agencies of the Federal government or collaboratively by those agencies and state, county and local governmental units. In several cases, only local jurisdictions can implement some of the measures identified.

3.5.1.1 Existing Conditions

Computer simulations have predicted[8] how far inland storm surge will extend if the worse-case hurricane or maximum possible intensity (MPI) event hits the Mississippi coast.

This line of defense is shown in Figure 3.5-1. This line represents a line of safety where homes, facilities or transportation routes north of this line should not be directly damaged by storm surge. This would be an area where hospitals, schools, emergency response and management facilities, power stations, water supply facilities, or other critical infrastructure might be located. It would also represent an area whereby future development (commercial, industrial, or residential) might be redirected. The maximum water level along the Mississippi coastline was determined to be approximately 30 ft along the entire western half of the state and east of Pascagoula. The landward extent of the inundation indicates the storm surge reaches Interstate 10 for much of the western portion of the state. Lower peaks near Biloxi and Mobile Bay (24-27 ft) may be attributed to the protection afforded by the barrier islands. The line of defense accordingly approximates the 24 to 30 ft. (NAVD '88 datum) contours.

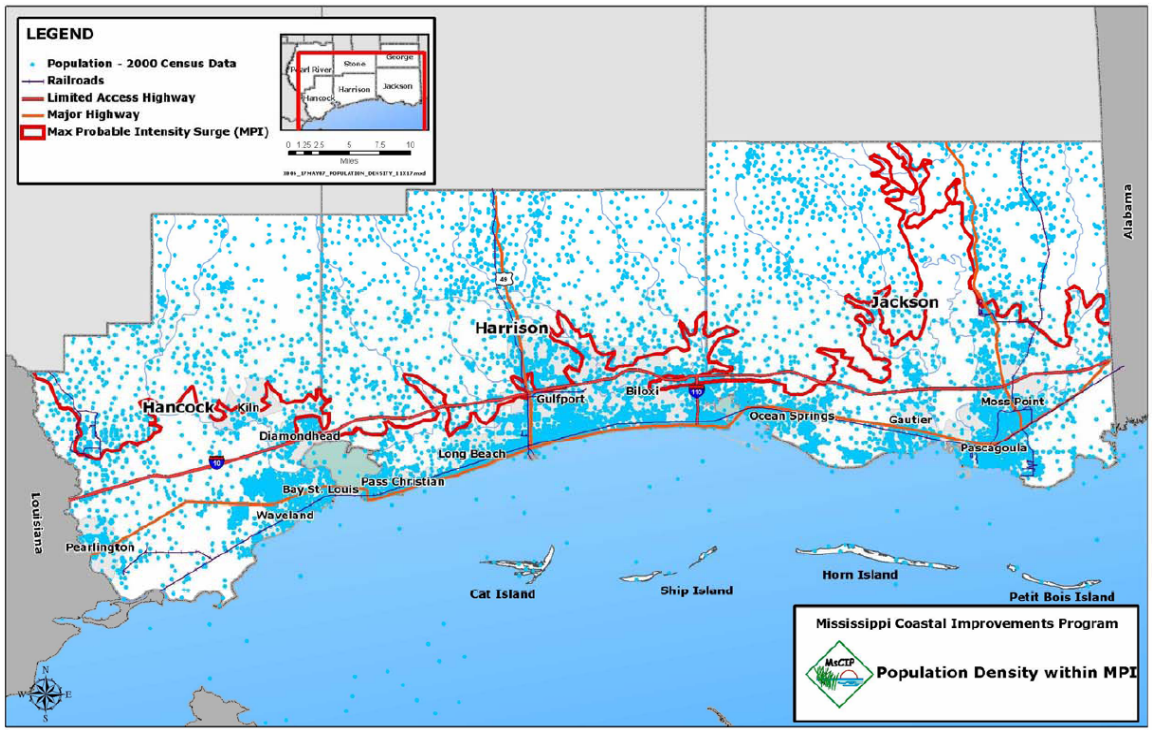


Figure 3.5-1. Maximum Probable Intensity Storm Surge Limits

[8] Storm surge modeling is described in Chapters 2.2 through 2.8.

This 'line of defense' is a naturally occurring measure against storm surge. This line of defense is not intended to suggest preferential protection against hurricane force winds. The line of defense is located based on storm surge only and is best considered jointly with riverine flood inundation maps published by FEMA for the purposes of promulgating the National Flood Insurance Program. FEMA is currently revising inland riverine regulatory flood maps. In keeping with historic hydrologic engineering practice, no probability of occurrence has been assigned to the MPI storm related surge, though in the future, USACE may adopt methods targeted at assigning risk to the occurrence of maximum probable storm events.

The area seaward of the line of defense is occupied by natural, rural, suburban, and urban environments and residential, commercial, and industrial development. Approximately 1/3 (visually estimated) of the coastal county areas fall within the estimated surge limits. With the exceptions of seawalls fronting Harrison County, Bay St. Louis, and the city of Pascagoula, there are no hurricane storm damage reduction structures in place. These structures provide little inundation protection over what the natural ground elevation would provide for and do not provide hurricane protection for surge events approaching or exceeding the 1 in 100 annual chance event.

3.5.1.2 Coastal and Hydraulic Data

The line of defense shown on Figure 3.5-1 is resultant of hydrodynamic modeling of six maximum possible intensity (MPI) storms with landfall points along the Mississippi coast were simulated to determine inundation limits for the Mississippi coastline. The six MPI storms made landfall at various points along the Mississippi Coast. All MPI storms were defined at their most intense point as having a minimum central pressure of 880 mb, radius to maximum winds of 36 n mi, and a forward speed of 11 kt. Peak water level envelopes from each of the six MPI simulations were computed. The six peak water level envelopes were then compared to compute the "peak of peaks", which is considered the inundation limit along the entire Mississippi coastline.

3.5.1.3 Alternative Plans

There are no alternative alignments to this line of defense. The line of defense alignment could be changed or modified due to any of the following: (a) revised hydrodynamic modeling results; (b) the construction of storm damage reduction measures, such as levees and/or storm surge barriers; (c) sea level rise; (d) construction of other infrastructure (e.g. roadway embankments) that might materially obstruct or alter surge flow pathways.

A thorough discussion of non-structural alternative measures is provided in the Non-Structural Formulation Appendix.

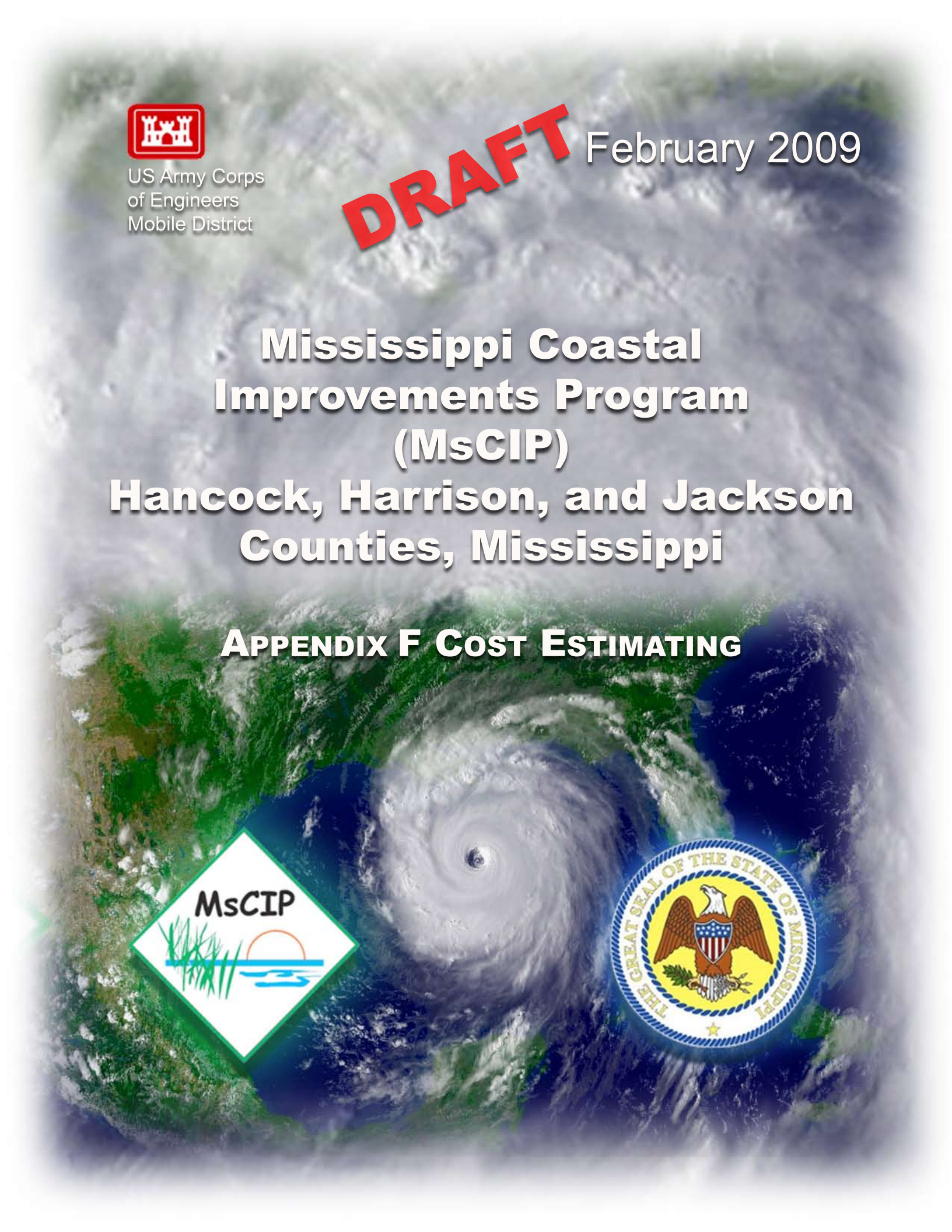
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of Engineers
Mobile District

DRAFT

February 2009

Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

Appendix F Cost Estimating



FOREWORD

This document is one of a number of technical appendices to the *Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison and Jackson Counties, Mississippi Comprehensive Plan and Integrated Feasibility Report and Environmental Impact Statement*.

The *Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Integrated Feasibility Report and Environmental Impact Statement* provides systems-based solutions and recommendations that address: hurricane and storm damage reduction, ecosystem restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion. The recommendations contained in the Main Report/EIS also provide measures that aid in*:* greater coastal environmental and societal resiliency, regional economic re-development, and measures to reduce long-term risk to the public and property, as a consequence of hurricanes and coastal storms. The recommendations cover a comprehensive package of projects and activities, that treat the environment, wildlife, and people, as an integrated system that requires a multi-tiered and phased approach to recovery and risk reduction, irrespective of implementation authority or agency.



The MsCIP Study Area

The purpose of the Comprehensive Plan Report is to present, to the Congress of the United States, the second of two packages of recommendations (i.e., the first being the “interim” recommendations funded in May 2007, and this “final” response, as directed by the Congress), directed at recovery of vital water and related land resources damaged by the hurricanes of 2005, and development of recommendations for long-term risk reduction and community and environmental resiliency, within the three-county, approximately 70 mile-long coastal zone, including Mississippi Sound and its barrier islands, of the State of Mississippi.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and an External Peer Review (EPR). Both review processes will have been conducted in accordance with the Corps “Peer Review of Decision Documents” process, has been reviewed by Corps staff outside the originating office, conducted by a Regional and national team of experts in the field, and coordinated by the National Center of Expertise in Hurricane and Storm Damage Protection, North Atlantic Division, U.S. Army Corps of Engineers.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing recommendations directed at assisting the people of the State of Mississippi in recovery, recommended actions and projects that would assist in the recovery of the physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

This appendix contains detailed technical information used in the analysis of existing and future without-project conditions, in the development of problem-solving measures, and in the analysis, evaluation, comparison, screening, and selection of alternative plans, currently presented as tentatively-selected recommendations contained in the Main Report/EIS.

Each appendix functions as a complete technical document, but is meant to support one particular aspect of the feasibility study process. However, because of the complexity of the plan formulation process used in this planning study, the information contained herein should not be used without parallel consideration and integration of all other appendices, and the Main Report/EIS that summarizes all findings and recommendations.

This appendix, Cost Estimating for Engineering, Environmental, Nonstructural, contains two parts. In Part 1, the estimates that are Comparative-Level “Parametric Type” and are based on Historical Data, Recent Pricing, and Estimator’s Judgment. The estimates are structured and priced as a general

prime supported by major subcontractors. Anticipated bidding conditions and construction duration with reasonable schedules are considered Normal. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Total Project Cost (Oct 07) without escalation. There are no formulated alternative plans in Part 1 of the Cost Appendix, only options and measures. Part 2 of the Cost Appendix contains updated and revised cost estimates for the recommended alternatives contained in the Comprehensive Plan. As required by Headquarters Memorandum dated 3 July 2007 and E&C Bulletin dated 10 September 2007, construction projects with estimated costs over 40 million dollars were subjected to a Cost Risk Analysis. The only recommended alternative subject to these criteria was the Comprehensive Barrier Island Restoration Plan.

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Line of Defense 3 — *Ring Levees*

Hancock County

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Harrison County

Options			
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Jackson County

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Forrest Heights Levee, Elevation 21.0
Mainland Beach and Dune Restoration

RECOMMENDED ENVIRONMENTAL RESTORATION ALTERNATIVES - COMPREHENSIVE STUDY

Admiral Island
Turkey Creek
Dantzler
Franklin Creek
Bayou Cumbest
Deer Island
Subaquatic Vegetation Pilot

RECOMMENDED NON-STRUCTURAL ALTERNATIVES, COMPREHENSIVE STUDY

Moss Point Municipal Complex Relocation
Waveland Floodproofing Pilot
Homeowners Assistance Relocation Program (HARP)

Part 2 - Recommended Alternatives

Cost Appendix Page Nos.

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COST APPENDIX

PART 1

PART 1

ROM COSTS FOR STUDY OPTIONS AND MEASURES

Part 1 of the Cost Appendix was used as the basis for the selected alternatives presented in Part 2 of this Appendix. The costs shown in Part 1 are based on October, 2007 pricing. The costs for the structural and environmental alternatives were completed by Mobile District and the costs for the nonstructural alternatives were completed by Huntington District.

Costs for Hazardous, Toxic and Radiological Waste issues were not specifically identified for the Cost Appendix, either Part 1 or 2. The higher than typical contingency of 25% was used to cover these unknowns due to the vast number of properties involved and the uncertainties associated with project footprints, there were no specific costs for assessments made for HTRW investigations and remediations. In discussions with the HTRW technical team in SAM, we developed an estimate based on a percentage that would be added to the usual cost contingencies for each project. This estimate is based on the mix of residential, commercial and industrial properties. HTRW concerns in the nonstructural measures particularly affect the acquisition and demolition of structures in the high-hazard zones and eligible structures where elevation would exceed 13 feet in height above the ground surface. HTRW concerns could also affect elevation of eligible homes where contaminated materials may be present in foundation components or HVAC units to be relocated. The presence of asbestos and underground storage tanks on residential and commercial properties is possible given the ages of many of the structures and the presence of numerous service stations and other commercial establishments (vehicle repair, dry cleaning, chemical distributors, etc.) that would possibly contain contaminants. A preliminary Phase I HTRW assessment will be conducted for all structures that are determined to be eligible for these nonstructural measures during the Detailed Project Report (DPR) phase. Costs and schedules for the Phase I HTRW assessment for homes and businesses would be included in the DPR PMP. Structures determined to contain hazardous materials will not be addressed by the program until the identified HTRW concerns are addressed by the owner or the local sponsor. A preliminary Phase I HTRW assessment will also be conducted during initial Engineering and Design for all properties included in the alternatives recommended in Part 2.

COST APPENDIX

PART 1
Rough Order of Magnitude (ROM) Costs

PART 1

ROM COSTS FOR STUDY OPTIONS AND MEASURES

Part 1 of the Cost Appendix was used as the basis for the selected alternatives presented in Part 2 of this Appendix. The costs shown in Part 1 are based on October, 2007 pricing. The costs for the structural and environmental alternatives were completed by Mobile District and the costs for the nonstructural alternatives were completed by Huntington District.

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BASIS of COST ESTIMATE and RATIONALE

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

Mississippi Coastal Improvements Program "MsCIP"

25-Jul-08

Joseph H. Ellsworth

Estimates are Comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Estimate is structured and priced as a general prime supported by major subcontractors. Bidding conditions for these estimates are considered normal and construction duration schedules are considered to be reasonable and not unduly compressed. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Total Project Cost (Oct 07) without escalation. There are no formulated alternative plans in the cost appendix at this stage...only OPTIONS and MEASURES. It is my understanding that we will move forward with recommended alternatives after this submital. At this time we will prepare Fully Funded Project Cost Estimates using MII & CEDEP. The structural cost estimates are structured and listed as per the "Engineering Appendix Table of Contents" by Line of Denfense. The Non-structural and Real Estate Cost were prepared by the Savannah & Huntington Districts.

Estimate Format is an Excel spreadsheet hyper-linked through-out the report. Format is structured by Line of Defense Level 1-4 and presented as per the Table of Contents.

Price Level of Estimate is Oct 07

Project Life (see Economics Appendix)

Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Where quantities were not available, assumptions were made based on historical information and Estimator's judgment.All approach & associated quantities fro Railway/Vehicle Gates are included in each Line of Defense OPTION.

Markups for both prime and subcontractors are included in the unit prices and include such items as field overheads, home office expenses, profit, bond and insurance. .

Construction Contingency was was jointly developed and assigned by the Project Delivery Team. The Contingency percentage at 25% reflects the possibility of changes in quantity estimates and unknowns associated with the unit price. The contingency factor used does not vary throughout the cost estimate. Even though ER 110-2-1302 identifies Contingencies at 20% for projects greater than $10,000,000 for recon/feasibility phase, it was determined and agreed upon by the Project Delivery Team that a high rate be used primarily due to risk, degree of confidence, and the project not being of the normal design.

Real Estate Cost (01 feature account) was prepared by the Savannah District COE.

Planning, Engineering & Design (30 feature account) was developed and assigned at 8% by the PDT. This is the percentage that has historically been used or these types of civil works projects. 8% was used in the Interim MsCIP projects which was reviewed and included in the Chief's Report.

BASIS of COST ESTIMATE and RATIONALE

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

Mississippi Coastal Improvements Program "MsCIP"

25-Jul-08

Joseph H. Ellsworth

Construction Management (31 feature account) was developed and assigned at 6% by the PDT. This is the percentage that has historically been used for these type of civil works projects. 6% was used in the Interim MsCIP projects which was reviewed and included in the Chief's Report.

Dredging Barrier Island Sand Borrow unit prices were derived from CEDEP and compared to Historical Data. Estimates were review and coordinated with Mobile District Operations Divison personnel. CEDEP estimates are available upon request. These estimates were not included in the Cost appendix.

Unit Prices, for such items as sitework, earthwork, stone protection, concrete, reinforcing, etc., were based on Historical Data, Recent Pricing, Estimator's Judgment, and Cost derivation using MCACES / MII estimating systems. Major Cost Items are listed below with an explanation as to unit price derivation:

POC's Listed are all Cost Engineering Personnel that worked on the report in the Cost Appendix.

Joseph H. Ellsworth	Lead Cost Engineer	CESAM	251-690-2628
Gary A. Payton	Cost Engineer	CESAM	251-694-3890
George F. Rush	Civil Engineer -Dredging	CESAM	251-694-3715
Michael A. McKown	Structural Engineer -GeoTech	CESAM	251-690-2681
Lloyd Oliver	Structural Engineer -Gates,Barriers	CESAM	251-694-3736
Richard W. Harvey	Mechical Engineer - Pump Stations	CESAM	251-694-3732
John R.Thomas	Real Estate Specialist	CESAS	912-652-5031
Donald A. Whitmore	Civil Engineer - Non-Structural Estimates	CELRH	304-399-6941
Jennifer L. Jacobson	Environmentalist	CESAM	251-690-2724

Beach & Dune Planting (Sea Oats & Grass) and **Fencing** are based on recent cost provided by the Local sponsor, Harrison County Public Works, Ms. Quantities were derived from using historical photographs of the barrier islands and estimating that beach & dune area. The Corps worked with the National Park Service and also the State of Mississippi, Department of Marine Resources in order to come up with this required acre estimates. Sea oats are typically concentrated on the top of the dune and some on the slopes; thus, the team estimated that only approximately 140 plants would be planted per acre.

Sea Grass Planting -The State of Mississippi, Department of Marine Resources estimated that the total historical seagrass beds coverage adjacent to the barrier islands possibly accounted for about 8,800 acres. The immediate areas surrounding the barriers islands have changed since that historical estimate in pre-1969; thus, in collaboration with the State of Mississippi, Department of Marine Resources, it was estimated that about 4,400 acres was now suitable for seagrass restoration.

Maritime Forest Planting cost at $10,000 per acre was derived from the spacings and cost of plants. It is estimated that the larger plants will be planted on between 40- and 50- foot centers while the smaller understory species will be planted at between 10- and 15-foot centers. The larger trees are estimated to cost between $100 and $150 per plant while the smaller species range from $3 to $15 per plant (prices include labor). Some of the species that will be planted within the coastal maritime forests include the following: live and laurel oaks, loblolly and slash pines, red bays, saw palmetto, sand live oak, cabbage palm, yaupon, sea grape, and prickly pear.

BASIS of COST ESTIMATE and RATIONALE

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

Mississippi Coastal Improvements Program "MsCIP"

25-Jul-08

Joseph H. Ellsworth

Structure Demolition is based on historical data updated to current price levels. Disposal Fees are based on current local disposal area charges.

Flap Gates & Cutoff Values cost are based on quotes from Waterman Industries Inc. including material and installation.

ATFP, Signage, Pavement Marking, Traffic Control is based on historical data and is estimated at 5 percentage of direct cost.

Anti-Terrorism / Force Protection for the Surge Barriers are based on historical data and is estimated at 3 percentage of direct cost.

Pump Stations were priced by the Mobile District Structural & Mechanical Engineers .

Structural Gates (Pass Thrus, Sector, Sluice, Roller) unit prices were provided by the New Orleans District, COE

Foundation Piles are based on quotes from Southern Prestress for piling and Jordan Piling for installation.

Riprap Stone was derived as follows ($45/ton in-place + 1.21 contractor markup + 1.65 tn/cy conversion = $90/cy in place) Unit cost based on recent construction projects along Gulf Coast are based on quotes from Southern Prestress for piling and Jordan Piling for installation.

EXCLUSIONS

COST RISK ANALYSIS for development of Contingency.
At this phase of the plan formulation process, there were no assessments made for HTRW investigations nor remediation costs based on the vast number of properties potentially involved and the uncertainties associated with project footprints. Also, the cost of escalation will be addressed as projects are selected to proceed to feasibility level of design. The identification of a major HTRW site within a project footprint could certainly have a cost impact, but none are known to exist at this time. Likewise, depending on the time that a project is funded for further study to feasibility level, the effects of escalation could be a major factor based on fuel costs or other items that can change drastically outside the usual inflation rate.
Estimate *Excludes* Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage. These are items which are not supported by the Project Policy (Federal or Non-Federal Cost).

Relocations (Cemeteries), Historical Preservation, & Recreation are items which are not supported by the Project Policy (Federal or Non-Federal Cost).

06 Account, Preservation - Mitigation-Tidal quantites were based on impacts of new footprint plus mitigated factor which was determined and coordinated by other agencies. Unit cost were derived and based on historical data.

LOD2 Beach Sand Dune Borrow is purchased washed Sand materials trucked from Upland Commerical Source, w/i 10 miles of project site. Unit price is based on recent cost from local suppliers for the Pascagoula, Ms. projects. Price represents sand material (beach quality) fob job site.

BASIS of COST ESTIMATE and RATIONALE

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

Mississippi Coastal Improvements Program "MsCIP"

25-Jul-08

Joseph H. Ellsworth

Miscellaneous Items represent cost where quantities were not available, such items as signage, construction site/staging restoration, silt fencing, site access, etc. These cost are derived within the estimate at .25 percent (.25%) of construction cost excluding Mob & Demob Cost

Mobilization & Demobilization (except dredging) are derived within the estimate at 2.5 % +- of construction cost excluding the Misc Items cost.

Pump Stations will be constructed in the dry and streamflow diversion quantities have been incorported into the various ring level estimates.

Operational & Maintenance Cost were based on Historical Lock & Dam records and protated for the size of subject barrier, which equates to approximately 2 percent. The PD Team agreed percentage used for the recon study is fair and reasonable. Subsequent estimate submitals will re-evaluate assumptions, percentage, and cost for O&M. LOD2 O & M cost were determined by the Economist, Jeremy LaDart. It reflects total O & M as 8 times the initial structural contract cost.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

(revised)

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			ESTIMATED AMOUNT
		MEASURES	
Line of Defense 1		***OffShore Barrier Islands***	
	Option "A"	***Restore Island Footprint***	$ 942,200,000
	Option "B"	***Replenish Sand in Littoral Zone*** *(River Sand Source)*	$ 1,013,800,000
	Option "C1 & C2"	***Replenish Sand in Littoral Zone*** *(Off-Shore & Inland River Sand Source)*	$ 147,400,000
	Option "D"	***Environmental Restoration*** *(2' Dune with Beach Sand)*	$ 14,200,000
	Option "E"	***Environmental Restoration*** *(6' Dune with Off-shore Sand)*	$ 39,200,000
	Option "F"	***Environmental Restoration*** *(Sea Grass Planting)*	$ 264,500,000
	Option "G"	***Restoration of Ship Island Breach***	$ 181,400,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

(revised)

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			ESTIMATED AMOUNT
Line of Defense 2		***Beach / Dune Construction***	
Options		***Hancock County***	
Option "A"	**elevation 10**	**with 40' Crest width**	$ 8,070,000
Option "B"	**elevation 8**	**with 50' Crest width**	$ 6,100,000
Option "C"	**elevation 10**	**with 20' Crest width**	$ 4,960,000
Option "D"	**elevation 8**	**with 30' Crest width**	$ 4,030,000
Option "E"	**elevation 10**	**with 40' Crest width with Planting & Fencing**	$ 8,400,000
Option "F"	**elevation 8**	**with 50' Crest width with Planting & Fencing**	$ 6,440,000
Option "G"	**elevation 10**	**with 20' Crest width with Planting & Fencing**	$ 5,300,000
Option "H"	**elevation 8**	**with 30' Crest width with Planting & Fencing**	$ 4,360,000
Option "I"	**elevation 10**	**with 55' Crest width with Fencing (Comparison Dune)**	$ 19,100,000
Option "J"	**elevation 10**	**with 55' Crest width with Planting & Fencing (Comparison Dune)**	$ 19,450,000
Option "K"		**60 foot wide by 2-foot berm with Plants & Fencing**	$ 4,640,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

(revised)

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			ESTIMATED AMOUNT
Line of Defense 2		***Beach / Dune Construction***	
Options		***Harrison County***	
Option "A"	**elevation 15**	**with 35' Crest width**	$ 21,840,000
Option "B"	**elevation 13**	**with 45' Crest width**	$ 18,600,000
Option "C"	**elevation 15**	**with 25' Crest width**	$ 18,100,000
Option "D"	**elevation 13**	**with 15' Crest width**	$ 10,400,000
Option "E"	**elevation 15**	**with 35' Crest width with Planting & Fencing**	$ 22,970,000
Option "F"	**elevation 13**	**with 45' Crest width with Planting & Fencing**	$ 19,760,000
Option "G"	**elevation 15**	**with 25' Crest width with Planting & Fencing**	$ 19,210,000
Option "H"	**elevation 13**	**with 15' Crest width with Planting & Fencing**	$ 11,520,000
Option "I"	**elevation 15**	**with 55' Crest width with Fencing (Comparison Dune)**	$ 40,290,000
Option "J"	**elevation 15**	**with 55' Crest width with Planting & Fencing (Comparison Dune)**	$ 41,460,000
Option "K"		**60 foot wide by 2-foot berm w / Plants & Fencing**	$ 9,680,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

(revised)

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08

LOCATION: **Mississippi** SHEET NO. 4 OF 8

PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton

WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team

FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			ESTIMATED AMOUNT
Line of Defense 2		***Beach / Dune Construction***	
Options		***Jackson County***	
Option "A"	**elevation 10**	**with 40' Crest width**	$ 1,910,000
Option "B"	**elevation 8**	**with 50' Crest width**	$ 1,450,000
Option "C"	**elevation 10**	**with 20' Crest width**	$ 1,180,000
Option "D"	**elevation 8**	**with 30' Crest width**	$ 960,000
Option "E"	**elevation 10**	**with 40' Crest width with Planting & Fencing**	$ 1,990,000
Option "F"	**elevation 8**	**with 50' Crest width with Planting & Fencing**	$ 1,530,000
Option "G"	**elevation 10**	**with 20' Crest width with Planting & Fencing**	$ 1,260,000
Option "H"	**elevation 8**	**with 30' Crest width with Planting & Fencing**	$ 1,040,000
Option "I"	**elevation 10**	**with 55' Crest width with Fencing (Comparison Dune)**	$ 4,490,000
Option "J"	**elevation 10**	**with 55' Crest width with Planting & Fencing (Comparison Dune)**	$ 4,570,000
Option "K"		**60 foot wide by 2-foot berm w / Plants & Fencing**	$ 1,110,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

(revised)

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION							ESTIMATED AMOUNT
Line of Defense 3		***Elevated Roadway, Seawalls, & Ring Levees***					
Jackson County		**Ring Levee** - elev. 20	Option "A"	**Pascagoula / Moss Point**			$ 699,000,000
"	"	**Ring Levee** - elev. 30	Option "B"	"	"	"	$ 916,000,000
"	"	**Ring Levee-Washington**- elev. 20	Option "C"	"	"	Alt Alignment	$ 671,600,000
"	"	**Ring Levee-Washington**- elev. 30	Option "D"	"	"	Alt Alignment	$ 849,900,000
"	"	**Ring Levee - Moss Pt.** - elev. 20	Option "E"	"	"	Alt Alignment	$ 874,400,000
"	"	**Ring Levee - Moss Pt.** - elev. 30	Option "F"	"	"	Alt Alignment	$ 1,013,200,000
"	"	**Ring Levee- Moss/Wash** - elev. 20	Option "G"	"	"	Alt Alignment	$ 921,400,000
"	"	**Ring Levee- Moss/Wash** - elev. 30	Option "H"	"	"	Alt Alignment	$ 1,057,700,000
"	"	**Ring Levee** - elev. 20	Option "A"	**Gautier**			$ 348,300,000
"	"	**Ring Levee** - elev. 30	Option "B"	"			$ 450,100,000
"	"	**Ring Levee** - elev. 20	Option "A"	**BelleFontaine**			$ 137,600,000
"	"	**Ring Levee** - elev. 30	Option "B"	"	"		$ 191,900,000
"	"	**Ring Levee** - elev. 20	Option "C"	"	"	Alt Alignment	$ 103,900,000
"	"	**Ring Levee** - elev. 30	Option "D"	"	"	Alt Alignment	$ 142,900,000
"	"	**Ring Levee** - elev. 20	Option "A"	**Gulf Park Estates**			$ 149,200,000
"	"	**Ring Levee** - elev. 30	Option "B"	"	"	"	$ 220,600,000
"	"	**Ring Levee** - elev. 20	Option "C"	"	"	" Alt Alignment	$ 158,900,000
"	"	**Ring Levee** - elev. 30	Option "D"	"	"	" Alt Alignment	$ 208,700,000
"	"	**Ring Levee** - elev. 20	Option "A"	**Ocean Springs**			$ 152,100,000
"	"	**Ring Level** - elev. 30	Option "B"	"	"		$ 327,000,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

(revised)

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			ESTIMATED AMOUNT
Line of Defense 3	***Elevated Roadway, Seawalls, & Ring Levees***		
Hancock County	**Ring Levee** - elev. 20 Option "A"	**Pearlington**	$ 104,800,000
" "	**Ring Levee** - elev. 30 Option "B"	**"**	$ 120,200,000
	Ring Levee - elev. 20 Option "A"	**Bay St. Louis**	$ 283,000,000
	Ring Levee - elev. 30 Option "B"	**"**	$ 382,900,000
Jackson County	**Rdwy-Seawall** - elev. 11	**Ocean Springs**	$ 67,500,000
Harrison County	**Rdwy-Seawall** - elev. 16	**Elevated US Hwy 90**	$ 1,989,200,000
Hancock County	**Rdwy-Seawall** - elev. 11 **& Saddle Dikes -**elev. 16	**Beach Blvd**	$ 328,000,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

(revised)

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08

LOCATION: **Mississippi** SHEET NO. 7 OF 8

PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton

WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team

FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			ESTIMATED AMOUNT
Line of Defense 4	***Inland Barrier & Surge Barrier***		
Jackson County	Inland Barrier - elev. 20 Option "A"		$ 126,900,000
" "	Inland Barrier - elev. 30 Option "B"		$ 224,800,000
" "	Inland Barrier - elev. 40 Option "C"		$ 266,000,000
Back Bay of Biloxi	Surge Barrier - elev. 20 Option "A"		$ 989,800,000
" " " "	Surge Barrier - elev. 30 Option "B"		$ 1,267,100,000
" " " "	Surge Barrier - elev. 40 Option "C"		$ 1,810,700,000
Harrison County	Inland Barrier - elev. 20 Option "A"		$ 435,800,000
" "	Inland Barrier - elev. 30 Option "B"		$ 731,600,000
" "	Inland Barrier - elev. 40 Option "C"		$ 947,100,000
" "	Levee for Roadway(75') - elev. 20 Option "D"		$ 205,400,000
" "	Levee for Roadway(75') - elev. 30 Option "E"		$ 768,300,000
" "	Menge Ave(15' +) - elev. 20 Option "F"	Alt Route	$ 140,400,000
" "	Menge Ave(15'+) - elev. 30 Option "G"	Alt Route	$ 317,100,000
" "	Menge Ave(15'+) - elev. 40 Option "H"	Alt Route	$ 506,300,000
"	Levee for Rdwy(75') with Menge Ave Alt - elev. 20 Option "I"	Alt Route	$ 178,600,000
"	Levee for Rdwy(75') with Menge Ave Alt - elev. 30 Option "J"	Alt Route	$ 462,900,000
St. Louis Bay	Surge Barrier - elev. 20 Option "A"		$ 1,628,000,000
" " "	Surge Barrier - elev. 30 Option "B"		$ 1,963,600,000
" " "	Surge Barrier - elev. 40 Option "C"		$ 2,362,200,000
Hancock County	Inland Barrier - elev. 20 Option "A"		$ 379,400,000
" "	Inland Barrier - elev. 30 Option "B"		$ 852,200,000
" "	Inland Barrier - elev. 40 Option "C"		$ 790,800,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

(revised)

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08

LOCATION: **Mississippi** SHEET NO. 8 OF 8

PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton

WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team

FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION					ESTIMATED AMOUNT
Line of Defense 5	***Retreat and / or Relocation of Critical Facilities***				N / A
Line of Defense 3	***Ring Levees***				
Harrison County	**Ring Levee** - elev. 17	Option "A"	**Forrest Heights**		$ 6,100,000
Harrison County	**Ring Levee** - elev. 21	Option "B"	**Forrest Heights**		$ 11,400,000
Line of Defense 1	***Emergency Beach Nourishment***				
Ship Island	**Fort Mass & French Warehouse**				$ 1,430,000
Line of Defense 3	***Buffer Zones***	***Jackson County***			
	Moss Point	Option "E"	elevation 20		$ 422,170,000
	" "	Option "F"	elevation 30		$ 419,000,000
	Washington Ave	Option "C"	elevation 20		$ 71,870,000
	" "	Option "D"	elevation 30		$ 63,770,000
	Moss Pt. - Washington Ave	Option "G"	elevation 20		$ 493,530,000
	" "	Option "H"	elevation 30		$ 482,550,000
	BelleFontaine	Option "C"	elevation 20		$ 3,120,000
	" "	Option "D"	elevation 30		$ 1,690,000
	Gulf Park Estates	Option "C"	elevation 20		$ 9,410,000
	" "	Option "D"	elevation 30		$ 7,610,000

Notes:

Price Level, Oct 07

Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment

Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"

Quantities listed within the Estimate represent Major Elements of the Project

Estimate Excludes: Project Escalation, Relocations, HTRW, & Historical Preservation

COMPREHENSIVE PLAN STRUCTURAL " Annual O & M " COST

PROJECT:	**Mississippi Coastal Improvements Program "MsCIP"**	ITEM NO.	DATE 25-Jul-08
LOCATION:	**Mississippi**	SHEET NO. 1	OF 7
		PREPARED Joseph H. Ellsworth	CHECKED: Gary A. Payton
WORK ITEM:	***Preliminary Concept Estimate***	BASIS of ESTIMATE:	info furnished per Project Delivery Team
		FILE NAME:	mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			ESTIMATED AMOUNT
		MEASURES	
Line of Defense 1		***OffShore Barrier Islands***	***Annual O & M Cost***
	Option "A"	***Restore Island Footprint***	N / A
	Option "B"	***Replenish Sand in Littoral Zone*** ***(River Sand Source)***	N / A
	Option "C1 & C2"	***Replenish Sand in Littoral Zone*** ***(Off-Shore & Inland River Sand Source)***	N / A
	Option "D"	***Environmental Restoration*** ***(2' Dune with Beach Sand)***	N / A
	Option "E"	***Environmental Restoration*** ***(6' Dune with Off-shore Sand)***	N / A
	Option "F"	***Environmental Restoration*** ***(Sea Grass Planting)***	N / A
	Option "G"	***Restoration of Ship Island Breach***	N / A

COMPREHENSIVE PLAN STRUCTURAL " Annual O & M " COST

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 7
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

Line of Defense 2 ***Beach / Dune Construction***

Options		***Hancock County***	***Annual O & M Cost***
Option "A"	**elevation 10**	**with 40' Crest width**	$ 2,167,694
Option "B"	**elevation 8**	**with 50' Crest width**	$ 1,638,530
Option "C"	**elevation 10**	**with 20' Crest width**	$ 1,332,313
Option "D"	**elevation 8**	**with 30' Crest width**	$ 1,082,504
Option "E"	**elevation 10**	**with 40' Crest width with Planting & Fencing**	$ 2,256,336
Option "F"	**elevation 8**	**with 50' Crest width with Planting & Fencing**	$ 1,729,857
Option "G"	**elevation 10**	**with 20' Crest width with Planting & Fencing**	$ 1,423,640
Option "H"	**elevation 8**	**with 30' Crest width with Planting & Fencing**	$ 1,171,146
Option "I"	**elevation 10**	**with 55' Crest width with Fencing (Comparison Dune)**	$ 5,130,478
Option "J"	**elevation 10**	**with 55' Crest width with Planting & Fencing (Comparison Dune)**	$ 5,224,492
Option "K"		**60 foot wide by 2-foot berm with Plants & Fencing**	N / A

COMPREHENSIVE PLAN STRUCTURAL " Annual O & M " COST

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 7
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

Line of Defense 2 ***Beach / Dune Construction***

Options		***Harrison County***	***Annual O & M Cost***
Option "A"	**elevation 15**	**with 35' Crest width**	$ 5,866,473
Option "B"	**elevation 13**	**with 45' Crest width**	$ 4,996,172
Option "C"	**elevation 15**	**with 25' Crest width**	$ 4,861,867
Option "D"	**elevation 13**	**with 15' Crest width**	$ 2,793,559
Option "E"	**elevation 15**	**with 35' Crest width with Planting & Fencing**	$ 6,170,004
Option "F"	**elevation 13**	**with 45' Crest width with Planting & Fencing**	$ 5,307,761
Option "G"	**elevation 15**	**with 25' Crest width with Planting & Fencing**	$ 5,160,025
Option "H"	**elevation 13**	**with 15' Crest width with Planting & Fencing**	$ 3,094,403
Option "I"	**elevation 15**	**with 55' Crest width with Fencing (Comparison Dune)**	$ 10,822,354
Option "J"	**elevation 15**	**with 55' Crest width with Planting & Fencing (Comparison Dune)**	$ 11,136,629
Option "K"		**60 foot wide by 2-foot berm w / Plants & Fencing**	N / A

COMPREHENSIVE PLAN STRUCTURAL " Annual O & M " COST

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 7
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

Line of Defense 2 ***Beach / Dune Construction***

Options		***Jackson County***	***Annual O & M Cost***
Option "A"	**elevation 10**	**with 40' Crest width**	$ 513,048
Option "B"	**elevation 8**	**with 50' Crest width**	$ 389,487
Option "C"	**elevation 10**	**with 20' Crest width**	$ 316,961
Option "D"	**elevation 8**	**with 30' Crest width**	$ 257,867
Option "E"	**elevation 10**	**with 40' Crest width with Planting & Fencing**	$ 534,537
Option "F"	**elevation 8**	**with 50' Crest width with Planting & Fencing**	$ 410,975
Option "G"	**elevation 10**	**with 20' Crest width with Planting & Fencing**	$ 338,450
Option "H"	**elevation 8**	**with 30' Crest width with Planting & Fencing**	$ 279,356
Option "I"	**elevation 10**	**with 55' Crest width with Fencing (Comparison Dune)**	$ 1,206,065
Option "J"	**elevation 10**	**with 55' Crest width with Planting & Fencing (Comparison Dune)**	$ 1,227,554
Option "K"		**60 foot wide by 2-foot berm w / Plants & Fencing**	N / A

(Beach O&M based on renourishment of the beach 5 times, annualied over a 50 year period of analysis)

COMPREHENSIVE PLAN STRUCTURAL " Annual O & M " COST

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 7
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME:
Elevated Roadway, Seawalls, & Ring Levees mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			Current Contract Cost	% of CCC	ESTIMATED AMOUNT Annual O & M Cost
Line of Defense 3					
Jackson County					
Ring Levee - elev. 20	Option "A"	**Pascagoula / Moss Pt**	$285,948,174	@ 2% =	$5,719,000
Ring Levee - elev. 30	Option "B"	" " "	$415,448,288	@ 2% =	$8,309,000
Ring Levee-Washington- elev. 20	Option "C"	" " Alt Alignment	$232,894,798	@ 2% =	$4,658,000
Ring Levee-Washington- elev. 30	Option "D"	" " Alt Alignment	$335,373,647	@ 2% =	$6,707,000
Ring Levee - Moss Pt. - elev. 20	Option "E"	" " Alt Alignment	$188,044,474	@ 2% =	$3,761,000
Ring Levee - Moss Pt. - elev. 30	Option "F"	" " Alt Alignment	$271,125,478	@ 2% =	$5,423,000
Ring Levee- Moss/Wash - elev. 20	Option "G"	" " Alt Alignment	$176,833,476	@ 2% =	$3,537,000
Ring Levee- Moss/Wash - elev. 30	Option "H"	" " Alt Alignment	$259,843,786	@ 2% =	$5,197,000
Ring Levee - elev. 20	Option "A"	**Gautier**	$ 187,184,083	@ 2% =	$3,744,000
Ring Levee - elev. 30	Option "B"	"	$ 245,193,309	@ 2% =	$4,904,000
Ring Levee - elev. 20	Option "A"	**BelleFontaine**	$ 68,568,586	@ 2% =	$1,371,000
Ring Levee - elev. 30	Option "B"	" "	$ 96,935,648	@ 2% =	$1,939,000
Ring Levee - elev. 20	Option "C"	" " Alt Alignment	$ 49,425,113	@ 2% =	$ 989,000
Ring Levee - elev. 30	Option "D"	" " Alt Alignment	$ 70,690,128	@ 2% =	$1,414,000
Ring Levee - elev. 20	Option "A"	**Gulf Park Estates**	$ 74,939,535	@ 2% =	$1,499,000
Ring Levee - elev. 30	Option "B"	" " "	$ 120,191,295	@ 2% =	$2,404,000
Ring Levee - elev. 20	Option "C"	" " " Alt Alignment	$ 64,751,081	@ 2% =	$1,295,000
Ring Levee - elev. 30	Option "D"	" " " Alt Alignment	$ 95,315,466	@ 2% =	$1,906,000
Ring Levee - elev. 20	Option "A"	**Ocean Springs**	$ 70,713,680	@ 2% =	$1,414,000
Ring Level - elev. 30	Option "B"	" "	$ 126,584,199	@ 2% =	$2,532,000

COMPREHENSIVE PLAN STRUCTURAL " Annual O & M " COST

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 7
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME:
Elevated Roadway, Seawalls, & Ring Levees mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			Current Contract Cost	% of CCC	Annual O & M Cost
Line of Defense 3					
Hancock County					
Ring Levee - elev. 20	Option "A"	Pearlington	$ 66,011,422	@ 2% =	$1,320,000
Ring Levee - elev. 30	Option "B"	"	$ 76,319,443	@ 2% =	$1,526,000
Ring Levee - elev. 20	Option "A"	Bay St. Louis	$ 100,079,223	@ 2% =	$2,002,000
Ring Levee - elev. 30	Option "B"	"	$ 140,170,843	@ 2% =	$2,803,000
Jackson County					
Rdwy-Seawall - elev. 11		**Ocean Springs**	$14,357,317	@ 2% =	$ 287,000
Harrison County					
Rdwy-Seawall - elev. 16		**Elevated US Hwy 90**	$979,288,421	@ 2% =	$ 19,586,000
Hancock County					
Rdwy-Seawall - elev. 11 **& Saddle Dikes -**elev. 16		**Beach Blvd**	$191,534,042	@ 2% =	$3,831,000
Harrison County					
Forrest Height Levee - elev 17			$ 2,080,512	@ 2% =	$ 42,000
Forrest Height Levee - elev 21			$ 5,681,732	@ 2% =	$ 114,000

COMPREHENSIVE PLAN STRUCTURAL " Annual O & M " COST

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 7 OF 7
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Preliminary Concept Estimate*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION				Current Contract Cost	% of CCC	ESTIMATED AMOUNT Annual O & M Cost
Line of Defense 4	***Inland Barrier & Surge Barrier***					
Jackson County	Inland Barrier - elev. 20	Option "A"		$ 40,932,861	@ 2% =	$ 819,000
" "	Inland Barrier - elev. 30	Option "B"		$ 101,393,987	@ 2% =	$2,028,000
" "	Inland Barrier - elev. 40	Option "C"		$ 121,881,692	@ 2% =	$2,438,000
Back Bay of Biloxi	Surge Barrier - elev. 20	Option "A"		$ 688,501,037	@ 2% =	$ 13,770,000
" " " "	Surge Barrier - elev. 30	Option "B"		$ 882,298,560	@ 2% =	$ 17,646,000
" " " "	Surge Barrier - elev. 40	Option "C"		$ 1,262,153,433	@ 2% =	$ 25,243,000
Harrison County	Inland Barrier - elev. 20	Option "A"		$ 100,337,751	@ 2% =	$2,007,000
" "	Inland Barrier - elev. 30	Option "B"		$ 290,259,173	@ 2% =	$5,805,000
" "	Inland Barrier - elev. 40	Option "C"		$ 417,147,087	@ 2% =	$8,343,000
" "	Levee for Roadway(75') - elev. 20	Option "D"		$ 93,388,290	@ 2% =	$1,868,000
" "	Levee for Roadway(75') - elev. 30	Option "E"		$ 293,549,934	@ 2% =	$5,871,000
" "	Menge Ave(15' +) - elev. 20	Option "F"	Alt Route	$ 90,015,267	@ 2% =	$1,800,000
" "	Menge Ave(15'+) - elev. 30	Option "G"	Alt Route	$ 202,610,598	@ 2% =	$4,052,000
" "	Menge Ave(15'+) - elev. 40	Option "H"	Alt Route	$ 328,203,779	@ 2% =	$6,564,000
"	Levee for Rdwy(75') with Menge Ave Alt - elev. 20	Option "I"	Alt Route	$ 103,651,509	@ 2% =	$2,073,000
"	Levee for Rdwy(75') with Menge Ave Alt - elev. 30	Option "J"	Alt Route	$ 300,794,161	@ 2% =	$6,016,000
St. Louis Bay	Surge Barrier - elev. 20	Option "A"		$ 1,133,702,062	@ 2% =	$ 22,674,000
" " "	Surge Barrier - elev. 30	Option "B"		$ 1,368,223,293	@ 2% =	$ 27,364,000
" " "	Surge Barrier - elev. 40	Option "C"		$ 1,646,791,696	@ 2% =	$ 32,936,000
Hancock County	Inland Barrier - elev. 20	Option "A"		$ 169,496,737	@ 2% =	$3,390,000
" "	Inland Barrier - elev. 30	Option "B"		$ 446,696,402	@ 2% =	$8,934,000
" "	Inland Barrier - elev. 40	Option "C"		$ 378,122,578	@ 2% =	$7,562,000
Line of Defense 5	***Retreat and / or Relocation of Critical Facilities***					N / A

Notes:

Price Level, Oct 07
Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment
Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"
Quantities listed within the Estimate represent Major Elements of the Project
Estimate Excludes: Project Escalation, Relocations, HTRW, & Historical Preservation Cost

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 1*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Option "A" FILE NAME: scip-comprehensive-study-compbined-cost-est-25jul08.xls
Restore Island Footprint ***(Horn, Petit Bois, Ship, & Cat Island)***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT

Off-Shore Borrow / *Access Channel & Storage Area*

Assumed Quantity		Off-Shore Borrow Quantity (cy)	Off-Shore Borrow Haul Distance, r/t (mi)		Access Channel & Storage Area Quantity (cy)	Access Channel & Storage Area Haul Distance, r/t (mi)	
14%	Petit Bois	9,300,000	90		2,000,000	20	
31%	Horn	21,240,000	84		4,650,000	5	
32%	Ship	21,240,000	90		4,800,000	20	
23%	Cat	14,600,000	114		3,450,000	30	
100%		66,380,000	93	miles rt, weighted a	14,900,000	18	miles rt, weighted avg

In-Place Material on Island

Quantity (cy)	Pumping Distance (avg lf)	Pumping Distance (max lf)		Island Surface Area Quantity (acr)
5,880,000	12,000	18000	Petit Bois	231
13,000,000	12,000	18000	Horn	535
13,500,000	15,000	25000	Ship	540
9,660,000	30,000	55000	Cat	390
42,040,000				1,696

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mob, Prep Work, Demob - Pipeline Dredge Plant with Booster, Initially		1	ea	1,750,000	$1,750,000
Intermediate Mob & Preparatory Work, Pipeline Dredge Plant		7	ea	150,000	1,050,000
Intermediate Mob & Preparatory Work, Pipeline Dredge Plant with Booster		7	ea	175,000	1,225,000
Mobilization, Preparatory Work, Demobilization - Hopper Dredge Plant		2	ea	750,000	1,500,000
Mobilization, Preparatory Work, Demobilization - Land Base Equipment		1	job	allow	1,000,000
Dredge Access Channels & Storage Area (by Hopper Dredge)		14,900,000	cy	2.90	43,210,000
Sand Borrow (by Hopper) (reference CEDEP for Cost Derivation)					
with allowed Overflow		66,380,000	cy	6.75	448,065,000
Assumed location of sand is St. Bernard Shoals					
Avg. Haul Distance approx. 94 miles r/t, weight avg.					
Average Water depth at Borrow Area, 60 ft.					
Sand Placement (by Pipeline Dredge from Storage Area, in-place)					
Petit Bois w/o Booster	12,000 lf avg	5,880,000	cy	1.50	8,820,000
Horn w/o Booster	12,000 lf avg	13,000,000	cy	1.50	19,500,000
Ship w/ Booster	15,000 lf avg	13,500,000	cy	2.50	33,750,000
Cat w/2ea Boosters	30,000 lf avg	9,660,000	cy	4.00	38,640,000
		42,040,000	cy		

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 1*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Option "A" FILE NAME: scip-comprehensive-study-compbined-cost-est-25jul08.xls
Restore Island Footprint ***(Horn, Petit Bois, Ship, & Cat Island)***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Maritime Forest Planting	340	acr	10,000	$3,400,000
Emerging Marsh Planting	644	acr	57,600	37,094,400
Beach & Dune Planting, Sea Oats, (figure 7,260 plants/acr @ 34 acr)	246,840	plants	1.50	370,260
Grading-Shaping - Land Base Equipment, Marshbuggies, dosers, etc.	1,696	acr	10,000	16,960,000
GIS Support During Construction	5	yrs	200,000	1,000,000
Control & Placement Surveys	5	yrs	200,000	1,000,000
		Current Contract Cost, Oct 07		$ 658,334,660
CONTINGENCY		@	**25.0%**	164,583,665
				$ 822,918,325
01 Account, Lands & Damage		PCA	**LS**	25,000
09 Account, Aids to Navigation			**LS**	100,000
				$ 823,043,325
30 Account, Plan, Engr.& Design		@	**8.0%**	65,843,466
				$ 888,886,791
31 Account, Constr. Management		@	**6.0%**	53,333,207
				$ 942,219,998
ESCALATION		@	**0.0%**	
				$ 942,219,998 rounded
		TOTAL PROJECT COST, Oct 07		$ 942,200,000

Notes: Dredging Cost Estimates derived using CEDEP
Estimates Excludes Permanent Intrastructure including Island Landings

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 1*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Option "B" FILE NAME:
Replenish Sand in Littoral Zone (River Sand Source) mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Sand Borrow, from Tenn-Tom Upland Disposals, by barge & crane	18,905,200	cy	23.31	$440,680,212
from BWT Upland Disposals, by barge & crane	12,675,000	cy	16.14	204,574,500
Barge Pump off / Dispersement	31,580,200	cy	2.00	63,160,400
Current Contract Cost, Oct 07				$ 708,415,112
CONTINGENCY		@	**25.0%**	177,103,778
				$ 885,518,890
01 Account, Lands & Damage		PCA	**LS**	25,000
				$ 885,543,890
30 Account, Plan, Engr.& Design		@	**8.0%**	70,843,511
				$ 956,387,401
31 Account, Constr. Management		@	**6.0%**	57,383,244
				$ 1,013,770,645
ESCALATION		@	**0.0%**	0
				$ 1,013,770,645 rounded
TOTAL PROJECT COST, FY- 07				$ 1,013,800,000

Notes: Sand Borrow Unit Cost furnished by Operations Division

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 1*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Option "C1 & C2" FILE NAME: scip-comprehensive-study-compbined-cost-est-25jul08.xls
Replenish Sand in Littoral Zone (Off-Shore & Inland River Sand Source)

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Option C1				
Placement Area / *Off-Shore Borrow Quantity (cy)* / *Haul Distance, r/t (miles), weighted avg.* / *Pumping Distance (avg lf)* / *Pumping Distance (max lf)*				
East End Ship Island — 5,000,000 — 90 — 5,000 — 6,000				
Mobilization, Preparatory Work, Demobilization - Hopper Dredge Plant	1	ea	750,000	750,000
Sand Borrow (by Hopper) (reference CEDEP for Cost Derivation) with allowed Overflow Assumed location of sand is St. Bernard Shoals Avg. Haul Distance approx. 90 miles r/t, weight avg. Average Water depth at Borrow Area, 60 ft. Dredge Pump-Off	5,000,000	cy	9.00	45,000,000
			Subtotal	$ 45,750,000
Option C2				
Placement Area / *Tombigbee River Borrow Quantity (cy)* / *Haul Distance, r/t (miles), weighted avg.*				
East End Petit Bois Island — 5,000,000 — 150				
Mobilization & Demobilization - Pump off / Spreader Barage Equip	1	job	allow	225,000
Sand Borrow, from Tenn-Tombigbee River Upland Disposals	4,000,000	cy	11.50	$46,000,000
Barge Pump off / Dispersement	4,000,000	cy	2.50	10,000,000
			Subtotal	$ 56,225,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 1*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Option "C1 & C2" FILE NAME: scip-comprehensive-study-compbined-cost-est-25jul08.xls
Replenish Sand in Littoral Zone (Off-Shore & Inland River Sand Source)

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
GIS Support During Construction	2.50	yrs	200,000	500,000
Control & Placement Surveys	2.50	yrs	200,000	500,000
			Current Contract Cost, Oct 07	$ 102,975,000
CONTINGENCY		@	**25.0%**	25,743,750
				$ 128,718,750
01 Account, Lands & Damage		PCA	**LS**	25,000
				$ 128,743,750
30 Account, Plan, Engr.& Design		@	**8.0%**	10,299,500
				$ 139,043,250
31 Account, Constr. Management		@	**6.0%**	8,342,595
				$ 147,385,845
ESCALATION		@	**0.0%**	0
				$ 147,385,845 rounded
			TOTAL PROJECT COST, Oct 07	$ 147,400,000

Notes: Sand Borrow Unit Cost furnished by Operations Division

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 1*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Option "D" FILE NAME: scip-comprehensive-study-compbined-cost-est-25jul08.xls
Environmental Restoration (2' Dune with Beach Sand)

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization - Land Base Equipment	1	job	allow	$20,000
Dredge Access Channels	30,000	cy	5.00	150,000
Construct 2' Dume with Beach Sand- Land Base Equipment, Marshbuggies, dosers, etc.	106,770	cy	15.00	1,601,550
Maritime Forest Planting	755	acr	10,000	7,550,000
Beach & Dune Planting, Sea Oats, (figure 7,260 plants/acr @ 51.3 acr)	372,440	plants	1.50	558,660

	Current Contract Cost, Oct 07			$ 9,880,210
	CONTINGENCY	@	**25.0%**	2,470,053
				$ 12,350,263
	01 Account, Lands & Damage	PCA	**LS**	25,000
				$ 12,375,263
	30 Account, Plan, Engr.& Design	@	**8.0%**	990,021
				$ 13,365,284
	31 Account, Constr. Management	@	**6.0%**	801,917
				$14,167,201
	ESCALATION	@	**0.0%**	0
				$ 14,167,201 rounded
	TOTAL PROJECT COST, Oct 07			$ 14,200,000

Notes: Planting Unit Cost furnished by Planning Division

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 7 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 1*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Option "E" FILE NAME: scip-comprehensive-study-compbined-cost-est-25jul08.xls
Environmental Restoration (6' Dune with Off-shore Sand)

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization - Hopper Dredge Plant	1	ea	allow	$750,000
Mobilization, Preparatory Work, Demobilization - Land Base Equipment	1	job	allow	20,000
Dredge Access Channels & Storage Area (by Hopper Dredge)	200,000	cy	5.00	1,000,000
Sand Borrow (by Hopper) (reference CEDEP for Cost Derivation) with allowed Overflow Assumed location of sand is St. Bernard Shoals Avg. Haul Distance approx. 94 miles r/t, weight avg. Average Water depth at Borrow Area, 60 ft.	640,500	cy	6.75	4,323,375
Barge Pump off / Dispersement	640,500	cy	2.00	1,281,000
Construct 6' Dune with Beach Sand- Land Base Equipment, Marshbuggies, dosers, trucks,etc.	640,500	cy	18.00	11,529,000
Maritime Forest Planting	755	acr	10,000	7,550,000
Beach & Dune Planting, Sea Oats, (figure 30 miles @ 21,120 plants / m	633,600	plants	1.50	950,400
Current Contract Cost, Oct 07				$27,403,775
CONTINGENCY		@	**25.0%**	6,850,944
				$ 34,254,719
01 Account, Lands & Damage		PCA	**LS**	25,000
				$ 34,279,719
30 Account, Plan, Engr.& Design		@	**8.0%**	2,742,378
				$ 37,022,096
31 Account, Constr. Management		@	**6.0%**	2,221,326
				$ 39,243,422
ESCALATION		@	**0.0%**	0
				$ 39,243,422 rounded
TOTAL PROJECT COST, Oct 07				$ 39,200,000

Notes: Planting Unit Cost furnished by Planning Division

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 8 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 1*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Option "F" FILE NAME: scip-comprehensive-study-compbined-cost-est-25jul08.xls
Environmental Restoration (Sea Grass Planting)

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Sea Grass Planting	4,400	acr	42,000	184,800,000
Current Contract Cost, Oct 07				$184,800,000
CONTINGENCY		@	**25.0%**	46,200,000
				$ 231,000,000
01 Account, Lands & Damage		PCA	**LS**	25,000
				$ 231,025,000
30 Account, Plan, Engr.& Design		@	**8.0%**	18,482,000
				$ 249,507,000
31 Account, Constr. Management		@	**6.0%**	14,970,420
				$ 264,477,420
ESCALATION		@	**0.0%**	0
				$ 264,477,420 rounded
TOTAL PROJECT COST, Oct 07				$ 264,500,000

Notes: Planting Unit Cost furnished by Planning Division

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 9 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 1*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Option "G" FILE NAME: scip-comprehensive-study-compbined-cost-est-25jul08.xls
Restoration of Ship Island Breach

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Off-Shore Borrow				
Assumed Quantity / *Quantity (cy)* / *Haul Distance, r/t (mi)*				
100% Ship — 13,000,000 — 90				
In-Place Material on Island				
Quantity (cy) / *Pumping Distance (avg lf)* / *(max lf)* / *Island Surface Area Quantity (acr)*				
13,000,000 — 5,000 — 6,000 — Ship Island Breach — 600				
Mobilization, Preparatory Work, Demobilization - Hopper Dredge Plant	2	ea	750,000	1,500,000
Mobilization, Preparatory Work, Demobilization - Land Base Equipment	1	job	allow	1,000,000
Sand Borrow (by Hopper) (reference CEDEP for Cost Derivation) with allowed Overflow Assumed location of sand is St. Bernard Shoals Avg. Haul Distance approx. 90 miles r/t, weight avg. Average Water depth at Borrow Area, 60 ft. Dredge Pump-Off	13,000,000	cy	9.00	117,000,000
Beach & Dune Planting (sea oats)	477,500	plants	1.50	716,250
Grading-Shaping - Land Base Equipment, Marshbuggies, dosers, etc.	600	acr	10,000	6,000,000
GIS Support During Construction	1.25	yrs	200,000	250,000
Control & Placement Surveys	1.25	yrs	200,000	250,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 10 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 1*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Option "G" FILE NAME: scip-comprehensive-study-compbined-cost-est-25jul08.xls
Restoration of Ship Island Breach

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Current Contract Cost, Oct 07		$126,716,250
CONTINGENCY		@	**25.0%**	31,679,063
				$158,395,313
01 Account, Lands & Damage		PCA	**LS**	25,000
				$ 158,420,313
30 Account, Plan, Engr.& Design		@	**8.0%**	12,673,625
				$ 171,093,938
31 Account, Constr. Management		@	**6.0%**	10,265,636
				$ 181,359,574
ESCALATION		@	**0.0%**	0
				$ 181,359,574 rounded
	TOTAL PROJECT COST, Oct 07			$ 181,400,000

Notes: Planting Unit Cost furnished by Planning Division

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Hancock County Option "A" elevation 10 with 40' Crest width				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$110,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	457,700	cy	8.00	3,661,600
Sand (dune) Construction, Grade & Shape	457,700	cy	4.00	1,830,800
Misc Site Items	1	ls	allow	13,700
		Current Contract Cost, Oct 07		$5,616,100
CONTINGENCY		@	**25.0%**	1,404,025
				$7,020,125
01 Account, Lands & Damage		PCA	**LS**	25,000
				7,045,125
				$7,045,125
30 Account, Plan, Engr.& Design		@	**8.0%**	563,610
				$7,608,735
31 Account, Constr. Management		@	**6.0%**	456,524
				$8,065,259
ESCALATION		@	**0.0%**	
				$8,065,259 rounded
TOTAL PROJECT COST, Oct 07				$ 8,070,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Hancock County Option "B" elevation 8 with 50' Crest width				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$83,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	345,671	cy	8.00	2,765,368
Sand (dune) Construction, Grade & Shape	345,671	cy	4.00	1,382,684
Misc Site Items	1	ls	allow	10,400
		Current Contract Cost, Oct 07		$4,241,452
CONTINGENCY		@	**25.0%**	1,060,363
				$5,301,815
01 Account, Lands & Damage		PCA	**LS**	25,000
				5,326,815
				$5,326,815
30 Account, Plan, Engr.& Design		@	**8.0%**	426,145
				$5,752,960
31 Account, Constr. Management		@	**6.0%**	345,178
				$6,098,138
ESCALATION		@	**0.0%**	
				$6,098,138 rounded
		TOTAL PROJECT COST, Oct 07		$ 6,100,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Hancock County Option "C" elevation 10 with 20' Crest width				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$67,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	280,812	cy	8.00	2,246,496
Sand (dune) Construction, Grade & Shape	280,812	cy	4.00	1,123,248
Misc Site Items	1	ls	allow	8,400
		Current Contract Cost, Oct 07		$3,445,144
CONTINGENCY		@	**25.0%**	861,286
				$4,306,430
01 Account, Lands & Damage		PCA	**LS**	25,000
				4,331,430
				$4,331,430
30 Account, Plan, Engr.& Design		@	**8.0%**	346,514
				$4,677,944
31 Account, Constr. Management		@	**6.0%**	280,677
				$4,958,621
ESCALATION		@	**0.0%**	
				$4,958,621
				rounded
TOTAL PROJECT COST, Oct 07			$	4,960,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Hancock County Option "D" elevation 8 with 30' Crest width				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$55,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	227,745	cy	8.00	1,821,960
Sand (dune) Construction, Grade & Shape	227,745	cy	4.00	910,980
Misc Site Items	1	ls	allow	6,800
		Current Contract Cost, Oct 07		$2,794,740
CONTINGENCY		@	**25.0%**	698,685
				$3,493,425
01 Account, Lands & Damage		PCA	**LS**	25,000
				3,518,425
				$3,518,425
30 Account, Plan, Engr.& Design		@	**8.0%**	281,474
				$3,799,899
31 Account, Constr. Management		@	**6.0%**	227,994
				$4,027,893
ESCALATION		@	**0.0%**	
				$4,027,893
				rounded
TOTAL PROJECT COST, Oct 07			$	4,030,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Hancock County Option "E" elevation 10 with 40' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$114,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	457,700	cy	8.00	3,661,600
Sand (dune) Construction, Grade & Shape	457,700	cy	4.00	1,830,800
Plants (sea oats on one toe, 3 rows of plants on 18" centers)	79,600	plants	1.50	119,400
Fencing (one toe)	39,800	lf	2.80	111,440
Misc Site Items	1	ls	allow	14,300
			Current Contract Cost, Oct 07	$5,851,540
CONTINGENCY		@	**25.0%**	1,462,885
				$7,314,425
01 Account, Lands & Damage		PCA	**LS**	25,000
				7,339,425
				$7,339,425
30 Account, Plan, Engr.& Design		@	**8.0%**	587,154
				$7,926,579
31 Account, Constr. Management		@	**6.0%**	475,595
				$8,402,174
ESCALATION		@	**0.0%**	
				$8,402,174
				rounded
TOTAL PROJECT COST, Oct 07				$ 8,400,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Hancock County Option "F" elevation 8 with 50' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$88,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	345,671	cy	8.00	2,765,368
Sand (dune) Construction, Grade & Shape	345,671	cy	4.00	1,382,684
Plants (sea oats on one toe, 3 rows on 18" centers)	79,600	plants	1.50	119,400
Fencing (one toe)	39,800	lf	2.80	111,440
Misc Site Items	1	ls	allow	10,900
		Current Contract Cost, Oct 07		$4,477,792
CONTINGENCY		@	**25.0%**	1,119,448
				$5,597,240
01 Account, Lands & Damage		PCA	**LS**	25,000
				5,622,240
				$5,622,240
30 Account, Plan, Engr.& Design		@	**8.0%**	449,779
				$6,072,019
31 Account, Constr. Management		@	**6.0%**	364,321
				$6,436,340
ESCALATION		@	**0.0%**	
				$6,436,340 rounded
TOTAL PROJECT COST, Oct 07			$	6,440,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 7 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Hancock County Option "G" elevation 10 with 20' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$72,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	280,812	cy	8.00	2,246,496
Sand (dune) Construction, Grade & Shape	280,812	cy	4.00	1,123,248
Plants (sea oats on one toe, 3 rows on 18" centers)	79,600	plants	1.50	119,400
Fencing (one toe)	39,800	lf	2.80	111,440
Misc Site Items	1	ls	allow	9,000
	Current Contract Cost, Oct 07			$3,681,584
CONTINGENCY		@	**25.0%**	920,396
				$4,601,980
01 Account, Lands & Damage		PCA	**LS**	25,000
				4,626,980
				$4,626,980
30 Account, Plan, Engr.& Design		@	**8.0%**	370,158
				$4,997,138
31 Account, Constr. Management		@	**6.0%**	299,828
				$5,296,967
ESCALATION		@	**0.0%**	
				$5,296,967
				rounded
	TOTAL PROJECT COST, Oct 07		$	5,300,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 8 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Hancock County Option "H" elevation 8 with 30' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$59,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	227,745	cy	8.00	1,821,960
Sand (dune) Construction, Grade & Shape	227,745	cy	4.00	910,980
Plants (sea oats on one toe, 3 rows on 18" centers)	79,600	plants	1.50	119,400
Fencing (one toe)	39,800	lf	2.80	111,440
Misc Site Items	1	ls	allow	7,400
Current Contract Cost, Oct 07				$3,030,180
CONTINGENCY		@	**25.0%**	757,545
				$3,787,725
01 Account, Lands & Damage		PCA	**LS**	25,000
				3,812,725
				$3,812,725
30 Account, Plan, Engr.& Design		@	**8.0%**	305,018
				$4,117,743
31 Account, Constr. Management		@	**6.0%**	247,065
				$4,364,808
ESCALATION		@	**0.0%**	
				$4,364,808
				rounded
TOTAL PROJECT COST, Oct 07			$	4,360,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 9 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Hancock County Option "I" elevation 10 with 55' Crest width with Fencing (Comparison Dune)				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$261,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	1,067,598	cy	8.00	8,540,784
Sand (dune) Construction, Grade & Shape	1,067,598	cy	4.00	4,270,392
Fencing (both toes+A37)	79,600	lf	2.80	222,880
Misc Site Items	1	ls	allow	32,600
		Current Contract Cost, Oct 07		$13,327,656
CONTINGENCY		@	**25.0%**	3,331,914
				$16,659,570
01 Account, Lands & Damage		PCA	**LS**	25,000
				16,684,570
				$16,684,570
30 Account, Plan, Engr.& Design		@	**8.0%**	1,334,766
				$18,019,336
31 Account, Constr. Management		@	**6.0%**	1,081,160
				$19,100,496
ESCALATION		@	**0.0%**	
				$19,100,496
				rounded
TOTAL PROJECT COST, Oct 07			$	19,100,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 10 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Hancock County Option "J" elevation 10 ***with 55' Crest width with Planting & Fencing (Comparison Dune)***				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$265,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	1,067,598	cy	8.00	8,540,784
Sand (dune) Construction, Grade & Shape	1,067,598	cy	4.00	4,270,392
Plants (sea oats on both toes, 3 rows on 18" centers)	159,200	plants	1.50	238,800
Fencing (both toes)	79,600	lf	2.80	222,880
Misc Site Items	1	ls	allow	33,200
Current Contract Cost, Oct 07				$13,571,056
CONTINGENCY		@	**25.0%**	3,392,764
				$16,963,820
01 Account, Lands & Damage		PCA	**LS**	25,000
				16,988,820
				$16,988,820
30 Account, Plan, Engr.& Design		@	**8.0%**	1,359,106
				$18,347,926
31 Account, Constr. Management		@	**6.0%**	1,100,876
				$19,448,801
ESCALATION		@	**0.0%**	
				$19,448,801
				rounded
TOTAL PROJECT COST, Oct 07			$	19,450,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 11 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Hancock County Option "K" 60 foot wide by 2-foot berm with Plants & Fencing				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$63,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	194,578	cy	8.00	1,556,624
Sand (dune) Construction, Grade & Shape	194,578	cy	4.00	778,312
Plants (sea oats on entire berm on 30" centers)	398,000	plants	1.50	597,000
Fencing (both toes)	79,600	lf	2.80	222,880
Misc Site Items	1	ls	allow	7,900
		Current Contract Cost, Oct 07		$3,225,716
CONTINGENCY		@	**25.0%**	806,429
				$4,032,145
01 Account, Lands & Damage		PCA	**LS**	25,000
				4,057,145
				$4,057,145
30 Account, Plan, Engr.& Design		@	**8.0%**	324,572
				$4,381,717
31 Account, Constr. Management		@	**6.0%**	262,903
				$4,644,620
ESCALATION		@	**0.0%**	
				$4,644,620
				rounded
TOTAL PROJECT COST, Oct 07			$	4,640,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 12 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Option "A" elevation 15 with 35' Crest width				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmer	1	job	allow	74,000
Construct Sand (dune), Dredged from near Shore Borrow Site	2,698,656	cy	5.50	14,842,608
Misc Site Items	1	ls	allow	37,100
	Current Contract Cost, Oct 07			$15,243,708
CONTINGENCY		@	**25.0%**	3,810,927
				$19,054,635
01 Account, Lands & Damage		PCA	**LS**	25,000
				$19,079,635
30 Account, Plan, Engr.& Design		@	**8.0%**	1,526,371
				$20,606,006
31 Account, Constr. Management		@	**6.0%**	1,236,360
				$21,842,366
ESCALATION		@	**0.0%**	
				$21,842,366
				rounded
TOTAL PROJECT COST, Oct 07			$	21,840,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 13 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Option "B" elevation 13 with 45' Crest width				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmei	1	job	allow	63,000
Construct Sand (dune), Dredged from near Shore Borrow Site	2,293,764	cy	5.50	12,615,702
Misc Site Items	1	ls	allow	31,500
			Current Contract Cost, Oct 07	$13,000,202
CONTINGENCY		@	**25.0%**	3,250,051
				$16,250,253
01 Account, Lands & Damage		PCA	**LS**	25,000
				$16,275,253
30 Account, Plan, Engr.& Design		@	**8.0%**	1,302,020
				$17,577,273
31 Account, Constr. Management		@	**6.0%**	1,054,636
				$18,631,909
ESCALATION		@	**0.0%**	
				$18,631,909
				rounded
TOTAL PROJECT COST, Oct 07			$	18,600,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 14 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Option "C" elevation 15 with 25' Crest width				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmei	1	job	allow	61,000
Construct Sand (dune), Dredged from near Shore Borrow Site	2,223,782	cy	5.50	12,230,801
Misc Site Items	1	ls	allow	30,600
		Current Contract Cost, Oct 07		$12,612,401
CONTINGENCY		@	**25.0%**	3,153,100
				$15,765,501
01 Account, Lands & Damage		PCA	**LS**	25,000
				$15,790,501
30 Account, Plan, Engr.& Design		@	**8.0%**	1,263,240
				$17,053,741
31 Account, Constr. Management		@	**6.0%**	1,023,224
				$18,076,966
ESCALATION		@	**0.0%**	0
				$18,076,966
				rounded
TOTAL PROJECT COST, Oct 07			$	18,100,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 15 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

Harrison County Option "D" elevation 13 with 15' Crest width

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmei	1	job	allow	34,000
Construct Sand (dune), Dredged from near Shore Borrow Site	1,254,041	cy	5.50	6,897,226
Misc Site Items	1	ls	allow	17,200
		Current Contract Cost, Oct 07		$7,238,426
CONTINGENCY		@	**25.0%**	1,809,606
				$9,048,032
01 Account, Lands & Damage		PCA	**LS**	25,000
				$9,073,032
30 Account, Plan, Engr.& Design		@	**8.0%**	725,843
				$9,798,874
31 Account, Constr. Management		@	**6.0%**	587,932
				$10,386,807
ESCALATION		@	**0.0%**	0
				$10,386,807
				rounded
TOTAL PROJECT COST, Oct 07			$	10,400,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 16 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Option "E" elevation 15 with 35' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmer	1	job	allow	78,000
Construct Sand (dune), Dredged from near Shore Borrow Site	2,698,656	cy	5.50	14,842,608
Plants (sea oats on one toe, 3 rows of plants on 18" centers)	269,928	plants	1.50	404,892
Fencing (one toe)	134,964	lf	2.80	377,899
Misc Site Items	1	ls	allow	39,100
Current Contract Cost, Oct 07				$16,032,499
CONTINGENCY		@	**25.0%**	4,008,125
				$20,040,624
01 Account, Lands & Damage		PCA	**LS**	25,000
				20,065,624
				$20,065,624
30 Account, Plan, Engr.& Design		@	**8.0%**	1,605,250
				$21,670,874
31 Account, Constr. Management		@	**6.0%**	1,300,252
				$22,971,126
ESCALATION		@	**0.0%**	
				$22,971,126
				rounded
TOTAL PROJECT COST, Oct 07			$	22,970,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 17 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Option "F" elevation 13 with 45' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmei	1	job	allow	67,000
Construct Sand (dune), Dredged from near Shore Borrow Site	2,293,764	cy	5.50	12,615,702
Plants (sea oats on one toe, 3 rows on 18" centers)	269,928	plants	1.50	404,892
Fencing (one toe)	134,964	lf	2.80	377,899
Misc Site Items	1	ls	allow	33,500
	Current Contract Cost, Oct 07			$13,788,993
CONTINGENCY		@	**25.0%**	3,447,248
				$17,236,242
01 Account, Lands & Damage		PCA	**LS**	25,000
				17,261,242
				$17,261,242
30 Account, Plan, Engr.& Design		@	**8.0%**	1,380,899
				$18,642,141
31 Account, Constr. Management		@	**6.0%**	1,118,528
				$19,760,669
ESCALATION		@	**0.0%**	
				$19,760,669
				rounded
TOTAL PROJECT COST, Oct 07			$	19,760,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 18 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Option "G" elevation 15 with 25' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmei	1	job	allow	65,000
Construct Sand (dune), Dredged from near Shore Borrow Site	2,223,782	cy	5.50	12,230,801
Plants (sea oats on one toe, 3 rows on 18" centers)	269,928	plants	1.50	404,892
Fencing (one toe)	134,964	lf	2.80	377,899
Misc Site Items	1	ls	allow	32,500
	Current Contract Cost, Oct 07			$13,401,092
CONTINGENCY		@	**25.0%**	3,350,273
				$16,751,365
01 Account, Lands & Damage		PCA	**LS**	25,000
				16,776,365
				$16,776,365
30 Account, Plan, Engr.& Design		@	**8.0%**	1,342,109
				$18,118,474
31 Account, Constr. Management		@	**6.0%**	1,087,108
				$19,205,583
ESCALATION		@	**0.0%**	
				$19,205,583
				rounded
	TOTAL PROJECT COST, Oct 07		$	19,210,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage
Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055
Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 19 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Option "H" elevation 13 with 15' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmei	1	job	allow	38,000
Construct Sand (dune), Dredged from near Shore Borrow Site	1,254,041	cy	5.50	6,897,226
Plants (sea oats on one toe, 3 rows on 18" centers)	269,928	plants	1.50	404,892
Fencing (one toe)	134,964	lf	2.80	377,899
Misc Site Items	1	ls	allow	19,200
	Current Contract Cost, Oct 07			$8,027,217
CONTINGENCY		@	**25.0%**	2,006,804
				$10,034,021
01 Account, Lands & Damage		PCA	**LS**	25,000
				10,059,021
				$10,059,021
30 Account, Plan, Engr.& Design		@	**8.0%**	804,722
				$10,863,743
31 Account, Constr. Management		@	**6.0%**	651,825
				$11,515,567
ESCALATION		@	**0.0%**	
				$11,515,567
				rounded
TOTAL PROJECT COST, Oct 07			$	11,520,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage
Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055
Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 20 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Option "I" elevation 15 with 55' Crest width with Fencing (Comparison Dune)				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmei	1	job	allow	138,000
Construct Sand (dune), Dredged from near Shore Borrow Site	4,888,008	cy	5.50	26,884,044
Fencing (both toes)	269,928	lf	2.80	755,798
Misc Site Items	1	ls	allow	69,100
			Current Contract Cost, Oct 07	$28,136,942
CONTINGENCY		@	**25.0%**	7,034,236
				$35,171,178
01 Account, Lands & Damage		PCA	**LS**	25,000
				35,196,178
				$35,196,178
30 Account, Plan, Engr.& Design		@	**8.0%**	2,815,694
				$38,011,872
31 Account, Constr. Management		@	**6.0%**	2,280,712
				$40,292,585
ESCALATION		@	**0.0%**	
				$40,292,585
				rounded
TOTAL PROJECT COST, Oct 07			$	40,290,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 21 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Option "J" elevation 15 ***with 55' Crest width with Planting & Fencing (Comparison Dune)***				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmei	1	job	allow	142,000
Construct Sand (dune), Dredged from near Shore Borrow Site	4,888,008	cy	5.50	26,884,044
Plants (sea oats on both toes, 3 rows on 18" centers)	539,856	plants	1.50	809,784
Fencing (both toes+A1155)	269,928	lf	2.80	755,798
Misc Site Items	1	ls	allow	71,100
	Current Contract Cost, Oct 07			$28,952,726
CONTINGENCY		@	**25.0%**	7,238,182
				$36,190,908
01 Account, Lands & Damage		PCA	**LS**	25,000
				36,215,908
				$36,215,908
30 Account, Plan, Engr.& Design		@	**8.0%**	2,897,273
				$39,113,181
31 Account, Constr. Management		@	**6.0%**	2,346,791
				$41,459,971
ESCALATION		@	**0.0%**	
				$41,459,971
				rounded
TOTAL PROJECT COST, Oct 07			$	41,460,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage
Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055
Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 22 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Option "K" 60 foot wide by 2-foot berm w / Plants & Fencing				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmei	1	job	allow	32,000
Construct Sand (dune), Dredged from near Shore Borrow Site	659,824	cy	5.50	3,629,032
Plants (sea oats on entire berm on 30" centers)	1,349,641	plants	1.50	2,024,462
Fencing (both toes)	269,928	lf	2.80	755,798
Misc Site Items	1	ls	allow	16,000
	Current Contract Cost, Oct 07			$6,747,292
CONTINGENCY		@	**25.0%**	1,686,823
				$8,434,115
01 Account, Lands & Damage		PCA	**LS**	25,000
				8,459,115
				$8,459,115
30 Account, Plan, Engr.& Design		@	**8.0%**	676,729
				$9,135,844
31 Account, Constr. Management		@	**6.0%**	548,151
				$9,683,995
ESCALATION		@	**0.0%**	
				$9,683,995
				rounded
TOTAL PROJECT COST, Oct 07			$	9,680,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage
Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055
Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 23 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Option "A" elevation 10 with 40' Crest width				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$26,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	107,019	cy	8.00	856,152
Sand (dune) Construction, Grade & Shape	107,019	cy	4.00	428,076
Misc Site Items	1	ls	allow	3,200
			Current Contract Cost, Oct 07	$1,313,428
CONTINGENCY		@	**25.0%**	328,357
				$1,641,785
01 Account, Lands & Damage		PCA	**LS**	25,000
				1,666,785
				$1,666,785
30 Account, Plan, Engr.& Design		@	**8.0%**	133,343
				$1,800,128
31 Account, Constr. Management		@	**6.0%**	108,008
				$1,908,135
ESCALATION		@	**0.0%**	
				$1,908,135
				rounded
TOTAL PROJECT COST, Oct 07			$	1,910,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 24 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Option "B" elevation 8 with 50' Crest width				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$19,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	80,824	cy	8.00	646,592
Sand (dune) Construction, Grade & Shape	80,824	cy	4.00	323,296
Misc Site Items	1	ls	allow	2,400
		Current Contract Cost, Oct 07		$991,288
CONTINGENCY		@	**25.0%**	247,822
				$1,239,110
01 Account, Lands & Damage		PCA	**LS**	25,000
				1,264,110
				$1,264,110
30 Account, Plan, Engr.& Design		@	**8.0%**	101,129
				$1,365,239
31 Account, Constr. Management		@	**6.0%**	81,914
				$1,447,153
ESCALATION		@	**0.0%**	
				$1,447,153
				rounded
TOTAL PROJECT COST, Oct 07			$	1,450,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 25 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Option "C" elevation 10 with 20' Crest width				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$16,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	65,659	cy	8.00	525,272
Sand (dune) Construction, Grade & Shape	65,659	cy	4.00	262,636
Misc Site Items	1	ls	allow	2,000
		Current Contract Cost, Oct 07		$805,908
CONTINGENCY		@	**25.0%**	201,477
				$1,007,385
01 Account, Lands & Damage		PCA	**LS**	25,000
				1,032,385
				$1,032,385
30 Account, Plan, Engr.& Design		@	**8.0%**	82,591
				$1,114,976
31 Account, Constr. Management		@	**6.0%**	66,899
				$1,181,874
ESCALATION		@	**0.0%**	
				$1,181,874
				rounded
TOTAL PROJECT COST, Oct 07			$	1,180,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 26 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Option "D" elevation 8 with 30' Crest width				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$13,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	53,251	cy	8.00	426,008
Sand (dune) Construction, Grade & Shape	53,251	cy	4.00	213,004
Misc Site Items	1	ls	allow	1,600
			Current Contract Cost, Oct 07	$653,612
CONTINGENCY		@	**25.0%**	163,403
				$817,015
01 Account, Lands & Damage		PCA	**LS**	25,000
				842,015
				$842,015
30 Account, Plan, Engr.& Design		@	**8.0%**	67,361
				$909,376
31 Account, Constr. Management		@	**6.0%**	54,563
				$963,939
ESCALATION		@	**0.0%**	
				$963,939
				rounded
TOTAL PROJECT COST, Oct 07			$	960,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 27 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Option "E" elevation 10 with 40' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$27,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	107,019	cy	8.00	856,152
Sand (dune) Construction, Grade & Shape	107,019	cy	4.00	428,076
Plants (sea oats on one toe, 3 rows of plants on 18" centers)	18,612	plants	1.50	27,918
Fencing (one toe)	9,306	lf	2.80	26,057
Misc Site Items	1	ls	allow	3,300
	Current Contract Cost, Oct 07			$1,368,503
CONTINGENCY		@	**25.0%**	342,126
				$1,710,629
01 Account, Lands & Damage		PCA	**LS**	25,000
				1,735,629
				$1,735,629
30 Account, Plan, Engr.& Design		@	**8.0%**	138,850
				$1,874,479
31 Account, Constr. Management		@	**6.0%**	112,469
				$1,986,948
ESCALATION		@	**0.0%**	
				$1,986,948
				rounded
TOTAL PROJECT COST, Oct 07			$	1,990,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 28 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Option "F" elevation 8 with 50' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$20,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	80,824	cy	8.00	646,592
Sand (dune) Construction, Grade & Shape	80,824	cy	4.00	323,296
Plants (sea oats on one toe, 3 rows on 18" centers)	18,612	plants	1.50	27,918
Fencing (one toe)	9,306	lf	2.80	26,057
Misc Site Items	1	ls	allow	2,600
Current Contract Cost, Oct 07				$1,046,463
CONTINGENCY		@	**25.0%**	261,616
				$1,308,079
01 Account, Lands & Damage		PCA	**LS**	25,000
				1,333,079
				$1,333,079
30 Account, Plan, Engr.& Design		@	**8.0%**	106,646
				$1,439,725
31 Account, Constr. Management		@	**6.0%**	86,383
				$1,526,108
ESCALATION		@	**0.0%**	
				$1,526,108
				rounded
TOTAL PROJECT COST, Oct 07				$ 1,530,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 29 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Option "G" elevation 10 with 20' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$17,000
Construct Sand (dune), Upland Borrow Site	65,659	cy	8.00	525,272
Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles				
Sand (dune) Construction, Grade & Shape	65,659	cy	4.00	262,636
Plants (sea oats on one toe, 3 rows on 18" centers)	18,612	plants	1.50	27,918
Fencing (one toe)	9,306	lf	2.80	26,057
Misc Site Items	1	ls	allow	2,100
Current Contract Cost, Oct 07				$860,983
CONTINGENCY		@	**25.0%**	215,246
				$1,076,229
01 Account, Lands & Damage		PCA	**LS**	25,000
				1,101,229
				$1,101,229
30 Account, Plan, Engr.& Design		@	**8.0%**	88,098
				$1,189,327
31 Account, Constr. Management		@	**6.0%**	71,360
				$1,260,686
ESCALATION		@	**0.0%**	
				$1,260,686
				rounded
TOTAL PROJECT COST, Oct 07			$	1,260,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 30 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Option "H" elevation 8 with 30' Crest width with Planting & Fencing				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$14,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	53,251	cy	8.00	426,008
Sand (dune) Construction, Grade & Shape	53,251	cy	4.00	213,004
Plants (sea oats on one toe, 3 rows on 18" centers)	18,612	plants	1.50	27,918
Fencing (one toe)	9,306	lf	2.80	26,057
Misc Site Items	1	ls	allow	1,700
	Current Contract Cost, Oct 07			$708,687
CONTINGENCY		@	**25.0%**	177,172
				$885,859
01 Account, Lands & Damage		PCA	**LS**	25,000
				910,859
				$910,859
30 Account, Plan, Engr.& Design		@	**8.0%**	72,869
				$983,727
31 Account, Constr. Management		@	**6.0%**	59,024
				$1,042,751
ESCALATION		@	**0.0%**	
				$1,042,751
				rounded
TOTAL PROJECT COST, Oct 07			$	1,040,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi Coastal Improvements Program "MsCIP** SHEET NO. 31 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Option "I" elevation 10 with 55' Crest width with Fencing (Comparison Dune)				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$61,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	249,625	cy	8.00	1,997,000
Sand (dune) Construction, Grade & Shape	249,625	cy	4.00	998,500
Fencing (both toes)	18,612	lf	2.80	52,114
Misc Site Items	1	ls	allow	7,600
			Current Contract Cost, Oct 07	$3,116,214
CONTINGENCY		@	**25.0%**	779,053
				$3,895,267
01 Account, Lands & Damage		PCA	**LS**	25,000
				3,920,267
				$3,920,267
30 Account, Plan, Engr.& Design		@	**8.0%**	313,621
				$4,233,888
31 Account, Constr. Management		@	**6.0%**	254,033
				$4,487,922
ESCALATION		@	**0.0%**	
				$4,487,922
				rounded
TOTAL PROJECT COST, Oct 07			$	4,490,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 32 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Option "J" elevation 10 ***with 55' Crest width with Planting & Fencing (Comparison Dune)***				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$62,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	249,625	cy	8.00	1,997,000
Sand (dune) Construction, Grade & Shape	249,625	cy	4.00	998,500
Plants (sea oats on both toes, 3 rows on 18" centers)	37,224	plants	1.50	55,836
Fencing (both toes)	18,612	lf	2.80	52,114
Misc Site Items	1	ls	allow	7,800
Current Contract Cost, Oct 07				$3,173,250
CONTINGENCY		@	**25.0%**	793,312
				$3,966,562
01 Account, Lands & Damage		PCA	**LS**	25,000
				3,991,562
				$3,991,562
30 Account, Plan, Engr.& Design		@	**8.0%**	319,325
				$4,310,887
31 Account, Constr. Management		@	**6.0%**	258,653
				$4,569,540
ESCALATION		@	**0.0%**	
				$4,569,540
				rounded
TOTAL PROJECT COST, Oct 07			$	4,570,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 33 OF 33
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 2*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Option "K" 60 foot wide by 2-foot berm w / Plants & Fencing				
Mobilization, Preparatory Work, Demobilization	1	job	allow	$15,000
Construct Sand (dune), Upland Borrow Site Sand, Washed, Trucked from Upland Commerical Source, w/i 10 miles	45,496	cy	8.00	363,968
Sand (dune) Construction, Grade & Shape	45,496	cy	4.00	181,984
Plants (sea oats on entire berm on 30" centers)	93,060	plants	1.50	139,590
Fencing (both toes)	18,612	lf	2.80	52,114
Misc Site Items	1	ls	allow	1,800
	Current Contract Cost, Oct 07			$754,456
CONTINGENCY		@	**25.0%**	188,614
				$943,070
01 Account, Lands & Damage		PCA	**LS**	25,000
				968,070
				$968,070
30 Account, Plan, Engr.& Design		@	**8.0%**	77,446
				$1,045,515
31 Account, Constr. Management		@	**6.0%**	62,731
				$1,108,246
ESCALATION		@	**0.0%**	
				$1,108,246
				rounded
TOTAL PROJECT COST, Oct 07			$	1,110,000

Notes:

Estimate Excludes Cost for Boardwalks, Seawalls, Comfort Stations, Parking Bays, Flag/Display/Recreational Areas, and Storm Drainage

Unit Cost for Fencing & Grassing furnish by Harrison County & Brown & Mitchel Inc. ("BMI"), Bobby Weaver 228-896-0055

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County ***Option "A"*** FILE NAME:
Ring Levee - elev. 20 ***Bay St. Louis*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,330,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	24,867	sy	4.50	111,902
8" Water line removal	6,480	lf	8.00	51,840
6" Sewer line removal	6,480	lf	8.00	51,840
2" Gas line removal	6,480	lf	3.00	19,440
Electrical line removal - 3 phase 1440v	6,480	lf	11.00	71,280
24" Storm Drain removal	6,480	lf	11.00	71,280
Demolished structures (avg. 1,500 sf/ea @ 123 ea)	184,500	sf	3.00	553,500
Disposal Fee - off site	6,833	cy	2.50	17,083
NEW WORK:				
Compacted Fill (levee)	442,170	cy	15.00	6,632,550
Compacted Fill (crossovers)	8,117	cy	15.00	121,755
New Asphalt 2" (Cross overs) 432 cy figure 2.0 tons/cy	864	tons	70.00	60,480
Base material 12" (cross overs)	2,588	cy	34.50	89,286
Riprap (24")	181,796	cy	90.00	16,361,640
24 " gabion mattress cages, galv-pvc type	299,963	sy	32.00	9,598,816
Filter Fabric	299,963	sy	2.00	599,926
Grassing (seeding)	23	acres	2,150	49,450
Clearing and Grubbing, off-site disposal	119	acres	5,000	595,000
Crushed Aggregate 6" Thick(Levee wearing surface)	9,214	cy	45.00	414,630
Guardrail	5,120	lf	21.00	107,520
New 8" Water line	3,000	lf	41	123,000
New 6" Sewer Line	3,000	lf	48	144,000
New 2"Gas Line	3,000	lf	20	60,000
New Electrical Line - 3 phase 1440v	3,000	lf	44.00	132,000
New 24" Storm Drain	3,000	lf	68.00	204,000
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	9	pass-thrus		3,186,197
Concrete Box Culverts	5,925	cy	700	4,147,500
#6 rebar (box culverts)	208	tons	925	192,400
			Subtotal	**$ 46,098,315**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County ***Option "A"*** FILE NAME:
Ring Levee - elev. 20 ***Bay St. Louis*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$ 46,098,315**
Flap Gates (12w x 4h)	30	ea	43,200	1,296,000
Flap Gates (8w x 4h)	20	ea	28,800	576,000
Flap Gates (10w x 4h)	8	ea	36,000	288,000
Flap Gates (7w x 4h)	7	ea	25,200	176,400
Flap Gates (7w x 3h)	18	ea	18,900	340,200
Cutoff valves (12w x4h)	30	ea	100,800	3,024,000
Cutoff valves (8w x4h)	20	ea	67,200	1,344,000
Cutoff valves (10w x4h)	8	ea	84,000	672,000
Cutoff valves (7w x4h)	7	ea	58,800	411,600
Cutoff valves (7w x3h)	18	ea	44,100	793,800
Pump stations, 42" to 60" pump size	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)			36,651,084
Ditch Excavation	313,152	cy	12.00	3,757,824
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	4,650,000
			Current Contract Cost, Oct 07	$ 100,079,223
CONTINGENCY		@	**25.0%**	25,019,806
				$ 125,099,029
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	120,246,000
06 Account, Preservation - Mitigation-Tidal (5 acr @ $200,000/acr)				1,000,000
06 Account, Preservation - Mitigation-Non-Tidal (152 acr @ $5,500/acr)				836,000
				$ 247,206,029
30 Account, Plan, Engr.& Design		@	**8.0%**	19,776,482
				$ 266,982,511
31 Account, Constr. Management		@	**6.0%**	16,018,951
				$ 283,001,462
ESCALATION		@	**0.0%**	0
				$ 283,001,462
				rounded
			TOTAL PROJECT COST, Oct 07	**$ 283,000,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County ***Option "B"*** FILE NAME:
Ring Levee - elev. 30 ***Bay St. Louis*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$3,260,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	36,060	sy	4.50	162,270
8" Water line removal	11,055	lf	8.00	88,440
6" Sewer line removal	11,055	lf	8.00	88,440
2" Gas line removal	11,055	lf	3.00	33,165
Electric line removal - 3 phase 1440v	11,055	lf	11.00	121,605
24" Storm Drain removal	11,055	lf	11.00	121,605
Demolished structures (avg. 1,500 sf/ea @ 186 ea)	279,000	sf	3.00	837,000
Disposal Fee - off site	10,333	cy	2.50	25,833
NEW WORK:				
Compacted Fill (levee)	2,104,864	cy	15.00	31,572,960
New Asphalt 2" (at Tunnels) 571 cy figure 2.0 tons/cy	1,142	tons	70.00	79,940
Base material 12" (cross overs)	3,423	cy	34.50	118,094
Riprap (12")	171,027	cy	90.00	15,392,430
24 " gabion mattress cages, galv-pvc type	564,388	sy	32.00	18,060,416
Filter Fabric	564,388	sy	2.00	1,128,776
Grassing (seeding)	64	acres	2,150	137,600
Clearing and Grubbing, off-site disposal	217	acres	5,000	1,085,000
Crushed Aggregate 6" Thick(Levee wearing surface)	11,379	cy	45.00	512,055
New 8" Water line	5,610	lf	41	230,010
New 6" Sewer Line	5,610	lf	48	269,280
New 2"Gas Line	5,610	lf	20	112,200
New Electrical Line - 3 phase 1440v	5,610	lf	44.00	246,840
New 24" Storm Drain	5,610	lf	68.00	381,480
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	9	pass-thrus		5,048,096
Concrete Box Culverts	5,925	cy	700	4,147,500
#6 rebar (box culverts)	208	tons	925	192,400
			Subtotal	**$ 83,453,435**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County ***Option "B"*** FILE NAME:
Ring Levee - elev. 30 ***Bay St. Louis*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$ 83,453,435**
Flap Gates (12w x 4h)	30	ea	43,200	1,296,000
Flap Gates (8w x 4h)	20	ea	28,800	576,000
Flap Gates (10w x 4h)	8	ea	36,000	288,000
Flap Gates (7w x 4h)	7	ea	25,200	176,400
Flap Gates (7w x 3h)	18	ea	18,900	340,200
Cutoff valves (12w x4h)	30	ea	100,800	3,024,000
Cutoff valves (8w x4h)	20	ea	67,200	1,344,000
Cutoff valves (10w x4h)	8	ea	84,000	672,000
Cutoff valves (7w x4h)	7	ea	58,800	411,600
Cutoff valves (7w x3h)	18	ea	44,100	793,800
Pump stations, 42" to 60" pump size	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)			37,517,584
Ditch Excavation	313,152	cy	12.00	3,757,824
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	6,520,000
			Current Contract Cost, Oct 07	$ 140,170,843
CONTINGENCY		@	**25.0%**	35,042,711
				$ 175,213,554
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	156,364,000
06 Account, Preservation - Mitigation-Tidal (7 acr @ $200,000/acr)				1,400,000
06 Account, Preservation - Mitigation-Non-Tidal (273 acr @ $5,500/acr)				1,501,500
				$ 334,504,054
30 Account, Plan, Engr.& Design		@	**8.0%**	26,760,324
				$ 361,264,378
31 Account, Constr. Management		@	**6.0%**	21,675,863
				$ 382,940,241
ESCALATION		@	**0.0%**	0
				$ 382,940,241
				rounded
			TOTAL PROJECT COST, Oct 07	**$ 382,900,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "A"*** FILE NAME:
Ring Levee - elev. 20 ***Gulf Park Estates*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$1,740,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	16,347	sy	4.50	73,562
8" Water line removal	5,600	lf	8.00	44,800
6" Sewer line removal	5,600	lf	8.00	44,800
2" Gas line removal	5,600	lf	3.00	16,800
Electrical line removal - 3 phase 1440v	5,600	lf	11.00	61,600
24" Storm Drain removal	5,600	lf	11.00	61,600
Demolished structures (avg. 1,500 sf/ea @ 60 ea)	90,000	sf	3.00	270,000
Disposal Fee - off site	3,333	cy	2.50	8,333
NEW WORK:				
Compacted Fill (levee)	796,003	cy	15.00	11,940,045
Compacted Fill (cross overs)	348	cy	15.00	5,225
New Asphalt 2" (Cross overs) 163 cy figure 2.0 tons/cy	326	tons	70.00	22,820
Base material 12" (cross overs)	1,212	cy	34.50	41,814
Riprap (24")	162,150	cy	90.00	14,593,500
24 " gabion mattress cages, galv-pvc type	267,548	sy	32.00	8,561,536
Filter Fabric	267,548	sy	2.00	535,096
Grassing (seeding)	27	acres	2,150	58,050
Clearing and Grubbing, off-site disposal	105	acres	5,000	525,000
Crushed Aggregate 6" Thick(Levee wearing surface)	6,311	cy	45.00	283,995
Guardrail	720	lf		
New 8" Water line	1,820	lf	41	74,620
New 6" Sewer Line	1,820	lf	48	87,360
New 2"Gas Line	1,820	lf	20	36,400
New Electrical Line - 3 phase 1440v	1,820	lf	44.00	80,080
New 24" Storm Drain	1,820	lf	68.00	123,760
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	11	pass-thrus		3,438,529
2-lane Gate (9ft height)	1	ea	32,000	32,000
Concrete Box Culverts	2,815	cy	700	1,970,500
#6 rebar (box culverts)	97	tons	925	89,725
			Subtotal	**$ 44,821,549**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "A"*** FILE NAME:
Ring Levee - elev. 20 ***Gulf Park Estates*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$**	**44,821,549**
Flap Gates (8w x 4h)		19	ea	28,800	547,200
Flap Gates (5w x 3h)		6	ea	13,500	81,000
Flap Gates (10w x 4h)		17	ea	36,000	612,000
Cutoff valves (8w x 4h)		19	ea	67,200	1,276,800
Cutoff valves (5w x 3h)		6	ea	31,500	189,000
Cutoff valves (10w x 4h)		17	ea	84,000	1,428,000
Pump stations, 42" to 60" pump size (8 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				21,071,378
Ditch Excavation		119,384	cy	12.00	1,432,608
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	3,480,000
		Current Contract Cost, Oct 07			$ 74,939,535
	CONTINGENCY		@	**25.0%**	18,734,884
					$ 93,674,419
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)				31,458,000
	06 Account, Preservation - Mitigation-Tidal (23 acr @ $200,000/acr)				4,600,000
	06 Account, Preservation - Mitigation-Non-Tidal (97 acr @ $5,500/acr)				533,500
					$ 130,290,919
	30 Account, Plan, Engr.& Design		@	**8.0%**	10,423,274
					$ 140,714,192
	31 Account, Constr. Management		@	**6.0%**	8,442,852
					$ 149,157,044
	ESCALATION		@	**0.0%**	0
					$ 149,157,044
					rounded
				TOTAL PROJECT COST, Oct 07	**$ 149,200,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "B"*** FILE NAME:
Ring Levee - elev. 30 ***Gulf Park Estates*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,800,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	23,054	sy	4.50	103,743
8" Water line removal	7,995	lf	8.00	63,960
6" Sewer line removal	7,995	lf	8.00	63,960
2" Gas line removal	7,995	lf	3.00	23,985
Electric line removal - 3 phase 1440v	7,995	lf	11.00	87,945
24" Storm Drain removal	7,995	lf	11.00	87,945
Demolished structures (avg. 1,500 sf/ea @ 64 ea)	96,000	sf	3.00	288,000
Disposal Fee - off site	3,556	cy	2.50	8,889
NEW WORK:				
Compacted Fill (levee)	2,254,986	cy	15.00	33,824,790
New Asphalt 2" (Cross overs) 193 cy figure 2.0 tons/cy	386	tons	70.00	27,020
Base material 12" (cross overs)	1,156	cy	34.50	39,882
Riprap (12")	125,876	cy	90.00	11,328,840
24 " gabion mattress cages, galv-pvc type	415,394	sy	32.00	13,292,608
Filter Fabric	415,394	sy	2.00	830,788
Grassing (seeding)	54	acres	2,150	116,100
Clearing and Grubbing, off-site disposal	155	acres	5,000	775,000
Crushed Aggregate 6" Thick(Levee wearing surface)	6,503	cy	45.00	292,635
New 8" Water line	2,535	lf	41	103,935
New 6" Sewer Line	2,535	lf	48	121,680
New 2"Gas Line	2,535	lf	20	50,700
New Electrical Line - 3 phase 1440v	2,535	lf	44.00	111,540
New 24" Storm Drain	2,535	lf	68.00	172,380
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	13	pass-thrus		6,925,159
Concrete Box Culverts	2,815	cy	700	1,970,500
#6 rebar (box culverts)	97	tons	925	89,725
			Subtotal	**$ 73,601,709**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "B"*** FILE NAME:
Ring Levee - elev. 30 ***Gulf Park Estates*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$**	**73,601,709**
Flap Gates (8w x 4h)		19	ea	28,800	547,200
Flap Gates (5w x 3h)		6	ea	13,500	81,000
Flap Gates (10w x 4h)		17	ea	36,000	612,000
Cutoff valves (8w x 4h)		19	ea	67,200	1,276,800
Cutoff valves (5w x 3h)		6	ea	31,500	189,000
Cutoff valves (10w x 4h)		17	ea	84,000	1,428,000
Pump stations, 42" to 60" pump size (8 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				35,432,978
Ditch Excavation		119,384	cy	12.00	1,432,608
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	5,590,000
		Current Contract Cost, Oct 07			$ 120,191,295
	CONTINGENCY		@	**25.0%**	30,047,824
					$ 150,239,119
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	34,051,000
	06 Account, Preservation - Mitigation-Tidal (38 acr @ $200,000/acr)				7,600,000
	06 Account, Preservation - Mitigation-Non-Tidal (136 acr @ $5,500/acr)				748,000
					$ 192,663,119
	30 Account, Plan, Engr.& Design		@	**8.0%**	15,413,049
					$ 208,076,168
	31 Account, Constr. Management		@	**6.0%**	12,484,570
					$ 220,560,738
	ESCALATION		@	**0.0%**	0
					$ 220,560,738
					rounded
				TOTAL PROJECT COST, Oct 07	**$ 220,600,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "C"*** FILE NAME:
Ring Levee - elev. 20 ***Gulf Park Estates*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization		1	job	allow	$1,510,000
REMOVALS:					
Asphalt removal 2" Thick(cross overs)		37,185	sy	4.50	167,333
8" Water line removal		6,160	lf	8.00	49,280
6" Sewer line removal		6,160	lf	8.00	49,280
2" Gas line removal		6,160	lf	3.00	18,480
Electrical line removal - 3 phase 1440v		6,160	lf	11.00	67,760
24" Storm Drain removal		6,160	lf	11.00	67,760
Demolished structures (avg. 1,500 sf/ea @ 152 ea)		228,000	sf	3.00	684,000
Disposal Fee - off site		8,444	cy	2.50	21,111
NEW WORK:					
Compacted Fill (levee)		473,133	cy	15.00	7,096,995
Compacted Fill (cross overs)		5,758	cy	15.00	86,370
New Asphalt 2" (Cross overs) 501 cy	figure 2.0 tons/cy	1,002	tons	70.00	70,140
Base material 12" (cross overs)		3,005	cy	34.50	103,673
Riprap (24")		135,841	cy	90.00	12,225,690
24 " gabion mattress cages, galv-pvc type		224,137	sy	32.00	7,172,384
Filter Fabric		224,137	sy	2.00	448,274
Grassing (seeding)		19	acres	2,150	40,850
Clearing and Grubbing, off-site disposal		89	acres	5,000	445,000
Crushed Aggregate 6" Thick(Levee wearing surface)		6,324	cy	45.00	284,580
Guardrail		4,560	lf	21.00	95,760
New 8" Water line		2,660	lf	41	109,060
New 6" Sewer Line		2,660	lf	48	127,680
New 2"Gas Line		2,660	lf	20	53,200
New Electrical Line - 3 phase 1440v		2,660	lf	44.00	117,040
New 24" Storm Drain		2,660	lf	68.00	180,880
Rdwy/RR Pass-Thrus	(reference backup file for cost derivation)	11	pass-thrus		2,887,747
Concrete Box Culverts		2,455	cy	700	1,718,500
#6 rebar (box culverts)		85	tons	925	78,625
				Subtotal	**$ 35,977,452**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "C"*** FILE NAME:
Ring Levee - elev. 20 ***Gulf Park Estates*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$**	**35,977,452**
Flap Gates (8w x 4h)		17	ea	28,800	489,600
Flap Gates (5w x 3h)		6	ea	13,500	81,000
Flap Gates (10w x 4h)		9	ea	36,000	324,000
Flap Gates (7w x 3h)		4	ea	18,900	75,600
Flap Gates (6w x 3h)		3	ea	16,200	48,600
Cutoff valves (8w x 4h)		17	ea	67,200	1,142,400
Cutoff valves (5w x 3h)		6	ea	31,500	189,000
Cutoff valves (10w x 4h)		9	ea	84,000	756,000
Cutoff valves (7w x 3h)		4	ea	44,100	176,400
Cutoff valves (6w x 3h)		3	ea	37,800	113,400
Pump stations, 42" to 60" pump size (9 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				21,742,146
Ditch Excavation		52,957	cy	12.00	635,484
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	3,000,000
			Current Contract Cost, Oct 07		$ 64,751,081
	CONTINGENCY		@	**25.0%**	16,187,770
					$ 80,938,851
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)				55,002,000
	06 Account, Preservation - Mitigation-Tidal (13 acr @ $200,000/acr)				2,600,000
	06 Account, Preservation - Mitigation-Non-Tidal (38 acr @ $5,500/acr)				209,000
					$ 138,774,851
	30 Account, Plan, Engr.& Design		@	**8.0%**	11,101,988
					$ 149,876,839
	31 Account, Constr. Management		@	**6.0%**	8,992,610
					$ 158,869,450
	ESCALATION		@	**0.0%**	0
					$ 158,869,450
					rounded
			TOTAL PROJECT COST, Oct 07		**$ 158,900,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 7 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "D"*** FILE NAME:
Ring Levee - elev. 30 ***Gulf Park Estates*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,220,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	40,813	sy	4.50	183,659
8" Water line removal	8,190	lf	8.00	65,520
6" Sewer line removal	8,190	lf	8.00	65,520
2" Gas line removal	8,190	lf	3.00	24,570
Electric line removal - 3 phase 1440v	8,190	lf	11.00	90,090
24" Storm Drain removal	8,190	lf	11.00	90,090
Demolished structures (avg. 1,500 sf/ea @ 169 ea)	253,500	sf	3.00	760,500
Disposal Fee - off site	9,389	cy	2.50	23,472
NEW WORK:				
Compacted Fill (levee)	1,663,941	cy	15.00	24,959,115
New Asphalt 2" (Cross overs) 208 cy figure 2.0 tons/cy	416	tons	70.00	29,120
Base material 12" (cross overs)	1,245	cy	34.50	42,953
Riprap (12")	107,785	cy	90.00	9,700,650
12 " gabion mattress cages	355,690	sy	32.00	11,382,080
Filter Fabric	355,690	sy	2.00	711,380
Grassing (seeding)	43	acres	2,150	92,450
Clearing and Grubbing, off-site disposal	138	acres	5,000	690,000
Crushed Aggregate 6" Thick(Levee wearing surface)	6,443	cy	45.00	289,935
New 8" Water line	2,730	lf	41	111,930
New 6" Sewer Line	2,730	lf	48	131,040
New 2"Gas Line	2,730	lf	20	54,600
New Electrical Line - 3 phase 1440v	2,730	lf	44.00	120,120
New 24" Storm Drain	2,730	lf	68.00	185,640
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	15	pass-thrus		6,817,897
Concrete Box Culverts	2,455	cy	700	1,718,500
#6 rebar (box culverts)	85	tons	925	78,625
			Subtotal	**$ 60,639,455**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 8 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "D"*** FILE NAME:
Ring Levee - elev. 30 ***Gulf Park Estates*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$**	**60,639,455**
Flap Gates (8w x 4h)		17	ea	28,800	489,600
Flap Gates (5w x 3h)		6	ea	13,500	81,000
Flap Gates (10w x 4h)		9	ea	36,000	324,000
Flap Gates (7w x 3h)		4	ea	18,900	75,600
Flap Gates (6w x 3h)		3	ea	16,200	48,600
Cutoff valves (8w x 4h)		17	ea	67,200	1,142,400
Cutoff valves (5w x 3h)		6	ea	31,500	189,000
Cutoff valves (10w x 4h)		9	ea	84,000	756,000
Cutoff valves (7w x 3h)		4	ea	44,100	176,400
Cutoff valves (6w x 3h)		3	ea	37,800	113,400
Pump stations, 42" to 60" pump size (9 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				26,214,528
Ditch Excavation		52,957	cy	12.00	635,484
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	4,430,000
			Current Contract Cost, Oct 07		$ 95,315,466
	CONTINGENCY		@	**25.0%**	23,828,867
					$ 119,144,333
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	58,603,000
	06 Account, Preservation - Mitigation-Tidal (21 acr @ $200,000/acr)				4,200,000
	06 Account, Preservation - Mitigation-Non-Tidal (59 acr @ $5,500/acr)				324,500
					$ 182,296,833
	30 Account, Plan, Engr.& Design		@	**8.0%**	14,583,747
					$ 196,880,580
	31 Account, Constr. Management		@	**6.0%**	11,812,835
					$ 208,693,415
	ESCALATION		@	**0.0%**	0
					$ 208,693,415
					rounded
			TOTAL PROJECT COST, Oct 07	**$**	**208,700,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "A"*** FILE NAME:
Ring Levee - elev. 20 ***BelleFontaine*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$1,590,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	12,587	sy	4.50	56,642
8" Water line removal	4,420	lf	8.00	35,360
6" Sewer line removal	4,420	lf	8.00	35,360
2" Gas line removal	4,420	lf	3.00	13,260
Electrical line removal - 3 phase 1440v	4,420	lf	11.00	48,620
24" Storm Drain removal	4,420	lf	11.00	48,620
Demolished structures (avg. 1,500 sf/ea @ 30 ea)	45,000	sf	3.00	135,000
Disposal Fee - off site	1,667	cy	2.50	4,167
NEW WORK:				
Compacted Fill (levee)	733,150	cy	15.00	10,997,250
New Asphalt 2" (Cross overs) 163 cy figure 2.0 tons/cy	326	tons	70.00	22,820
Base material 12" (cross overs)	978	cy	34.50	33,741
Riprap (24")	166,583	cy	90.00	14,992,470
24 " gabion mattress cages, galv-pvc type	249,875	sy	32.00	7,996,000
Filter Fabric	249,875	sy	2.00	499,750
Grassing (seeding)	27	acres	2,150	58,050
Clearing and Grubbing, off-site disposal	106	acres	5,000	530,000
Crushed Aggregate 6" Thick(Levee wearing surface)	6,674	cy	45.00	300,330
New 8" Water line	1,430	lf	41	58,630
New 6" Sewer Line	1,430	lf	48	68,640
New 2"Gas Line	1,430	lf	20	28,600
New Electrical Line - 3 phase 1440v	1,430	lf	44.00	62,920
New 24" Storm Drain	1,430	lf	68.00	97,240
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	10	pass-thrus		2,448,878
2-lane gate (5' height)	3	ea	18,000	54,000
2-lane gate (7' height)	2	ea	25,000	50,000
Concrete Box Culverts	2,608	cy	700	1,825,600
#6 rebar (box culverts)	90	tons	925	83,250
			Subtotal	**$ 42,175,197**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "A"*** FILE NAME:
Ring Levee - elev. 20 ***BelleFontaine*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 42,175,197**
Flap Gates (8w x 4h)		17	ea	28,800	489,600
Flap Gates (7w x 3h)		13	ea	18,900	245,700
Flap Gates (5w x 3h)		5	ea	13,500	67,500
Flap Gates (10w x 4h)		7	ea	36,000	252,000
Cutoff valves (8w x 4h)		17	ea	28,800	489,600
Cutoff valves (7w x 3h)		13	ea	44,100	573,300
Cutoff valves (5w x 3h)		5	ea	31,500	157,500
Cutoff valves (10w x 4h)		7	ea	84,000	588,000
Pump stations, 42" to 60" pump size (7 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				18,878,217
Ditch Excavation		121,831	cy	12.00	1,461,972
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	3,190,000
		Current Contract Cost, Oct 07			$ 68,568,586
	CONTINGENCY		@	**25.0%**	17,142,146
					$ 85,710,732
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)				19,365,886
	06 Account, Preservation - Mitigation-Tidal (71 acr @ $200,000/acr)				14,200,000
	06 Account, Preservation - Mitigation-Non-Tidal (164 acr @ $5,500/acr				902,000
					$ 120,203,618
	30 Account, Plan, Engr.& Design		@	**8.0%**	9,616,289
					$ 129,819,908
	31 Account, Constr. Management		@	**6.0%**	7,789,194
					$ 137,609,102
	ESCALATION		@	**0.0%**	0
					$ 137,609,102
					rounded
			TOTAL PROJECT COST, Oct 07		**$ 137,600,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "B"*** FILE NAME:
Ring Levee - elev. 30 ***BelleFontaine*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,250,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	18,560	sy	4.50	83,520
8" Water line removal	6,460	lf	8.00	51,680
6" Sewer line removal	6,460	lf	8.00	51,680
2" Gas line removal	6,460	lf	3.00	19,380
Electric line removal - 3 phase 1440v	6,460	lf	11.00	71,060
24" Storm Drain removal	6,460	lf	11.00	71,060
Demolished structures (avg. 1,500 sf/ea @ 38 ea)	57,000	sf	3.00	171,000
Disposal Fee - off site	2,111	cy	2.50	5,278
NEW WORK:				
Compacted Fill (levee)	2,172,884	cy	15.00	32,593,260
New Asphalt 2" (Cross overs) 326 cy figure 2.0 tons/cy	652	tons	70.00	45,640
Base material 12" (cross overs)	889	cy	34.50	30,671
Riprap (12")	124,299	cy	90.00	11,186,910
24 " gabion mattress cages, galv-pvc type	410,186	sy	32.00	13,125,952
Filter Fabric	410,186	sy	2.00	820,372
Grassing (seeding)	53	acres	2,150	113,950
Clearing and Grubbing, off-site disposal	156	acres	5,000	780,000
Crushed Aggregate 6" Thick(Levee wearing surface)	6,674	cy	45.00	300,330
New 8" Water line	1,900	lf	41	77,900
New 6" Sewer Line	1,900	lf	48	91,200
New 2"Gas Line	1,900	lf	20	38,000
New Electrical Line - 3 phase 1440v	1,900	lf	44.00	83,600
New 24" Storm Drain	1,900	lf	68.00	129,200
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	10	pass-thrus		4,723,764
Concrete Box Culverts	2,608	cy	700	1,825,600
#6 rebar (box culverts)	90	tons	925	83,250
			Subtotal	**$ 68,824,256**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "B"*** FILE NAME:
Ring Levee - elev. 30 ***BelleFontaine*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 68,824,256**
Flap Gates (8w x 4h)		17	ea	28,800	489,600
Flap Gates (5w x 3h)		5	ea	13,500	67,500
Flap Gates (10w x 4h)		7	ea	36,000	252,000
Flap Gates (7w x 3h)		13	ea	18,900	245,700
Cutoff valves (8w x 4h)		17	ea	67,200	1,142,400
Cutoff valves (5w x 3h)		5	ea	31,500	157,500
Cutoff valves (10w x 4h)		7	ea	84,000	588,000
Cutoff valves (7w x 3h)		13	ea	44,100	573,300
Pump stations, 42" to 60" pump size (7 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				18,623,420
Ditch Excavation		121,831	cy	12.00	1,461,972
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	4,510,000
		Current Contract Cost, Oct 07			$ 96,935,648
	CONTINGENCY		@	**25.0%**	24,233,912
					$ 121,169,560
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	25,773,853
	06 Account, Preservation - Mitigation-Tidal (97 acr @ $200,000/acr)				19,400,000
	06 Account, Preservation - Mitigation-Non-Tidal (233 acr @ $5,500/acr				1,281,500
					$ 167,649,913
	30 Account, Plan, Engr.& Design		@	**8.0%**	13,411,993
					$ 181,061,906
	31 Account, Constr. Management		@	**6.0%**	10,863,714
					$ 191,925,620
	ESCALATION		@	**0.0%**	0
					$ 191,925,620
					rounded
			TOTAL PROJECT COST, Oct 07		**$ 191,900,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "C"*** FILE NAME:
Ring Levee - elev. 20 ***BelleFontaine*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization		1	job	allow	$1,150,000
REMOVALS:					
Asphalt removal 2" Thick(cross overs)		25,281	sy	4.50	113,765
8" Water line removal		5,460	lf	8.00	43,680
6" Sewer line removal		5,460	lf	8.00	43,680
2" Gas line removal		5,460	lf	3.00	16,380
Electrical line removal - 3 phase 1440v		5,460	lf	11.00	60,060
24" Storm Drain removal		5,460	lf	11.00	60,060
Demolished structures (avg. 1,500 sf/ea @ 54 ea)		81,000	sf	3.00	243,000
Disposal Fee - off site		3,000	cy	2.50	7,500
NEW WORK:					
Compacted Fill (levee) 35,612LF		615,618	cy	15.00	9,234,270
Compacted Fill (crossovers)		902	cy	15.00	13,530
New Asphalt 2" (Cross overs) 255 cy	figure 2.0 tons/cy	510	tons	70.00	35,700
Base material 12" (cross overs)		1,530	cy	34.50	52,785
Riprap (24")		156,180	cy	90.00	14,056,200
24 " gabion mattress cages, galv-pvc type		257,696	sy	32.00	8,246,272
Filter Fabric		257,696	sy	2.00	515,392
Grassing (seeding)		24	acres	2,150	51,600
Clearing and Grubbing, off-site disposal		101	acres	5,000	505,000
Crushed Aggregate 6" Thick(Levee wearing surface)		6,595	cy	45.00	296,775
Guardrail		640	lf	21.00	13,440
New 8" Water line		1,950	lf	41	79,950
New 6" Sewer Line		1,950	lf	48	93,600
New 2"Gas Line		1,950	lf	20	39,000
New Electrical Line - 3 phase 1440v		1,950	lf	44.00	85,800
New 24" Storm Drain		1,950	lf	68.00	132,600
Rdwy/RR Pass-Thrus	(reference backup file for cost derivation)	13	pass-thrus		3,011,078
Concrete Box Culverts		2,476	cy	700	1,733,200
#6 rebar (box culverts)		86	tons	925	79,550
				Subtotal	**$ 40,013,867**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "C"*** FILE NAME:
Ring Levee - elev. 20 ***BelleFontaine*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 40,013,867**
Flap Gates (8w x 4h)		15	ea	28,800	432,000
Flap Gates (7w x 3h)		13	ea	18,900	245,700
Flap Gates (5w x 3h)		5	ea	13,500	67,500
Flap Gates (10w x 4h)		7	ea	36,000	252,000
Cutoff valves (8w x 4h)		15	ea	28,800	432,000
Cutoff valves (7w x 3h)		13	ea	44,100	573,300
Cutoff valves (5w x 3h)		5	ea	31,500	157,500
Cutoff valves (10w x 4h)		7	ea	84,000	588,000
Pump stations, 42" to 60" pump size (7 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				3,011,078
Ditch Excavation		113,514	cy	12.00	1,362,168
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	2,290,000
		Current Contract Cost, Oct 07			$ 49,425,113
	CONTINGENCY		@	**25.0%**	12,356,278
					$ 61,781,391
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)				26,711,082
	06 Account, Preservation - Mitigation-Tidal (7 acr @ $200,000/acr)				1,400,000
	06 Account, Preservation - Mitigation-Non-Tidal (158 acr @ $5,500/acr				869,000
					$ 90,786,473
	30 Account, Plan, Engr.& Design		@	**8.0%**	7,262,918
					$ 98,049,391
	31 Account, Constr. Management		@	**6.0%**	5,882,963
					$ 103,932,354
	ESCALATION		@	**0.0%**	0
					$ 103,932,354
					rounded
		TOTAL PROJECT COST, Oct 07			**$ 103,900,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 7 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "D"*** FILE NAME:
Ring Levee - elev. 30 ***BelleFontaine*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$1,640,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	32,561	sy	4.50	146,525
8" Water line removal	7,980	lf	8.00	63,840
6" Sewer line removal	7,980	lf	8.00	63,840
2" Gas line removal	7,980	lf	3.00	23,940
Electric line removal - 3 phase 1440v	7,980	lf	11.00	87,780
24" Storm Drain removal	7,980	lf	11.00	87,780
Demolished structures (avg. 1,500 sf/ea @ 68 ea)	102,000	sf	3.00	306,000
Disposal Fee - off site	3,778	cy	2.50	9,444
NEW WORK:				
Compacted Fill (levee)	1,960,375	cy	15.00	29,405,625
New Asphalt 2" (Cross overs) 193 cy figure 2.0 tons/cy	386	tons	70.00	27,020
Base material 12" (cross overs)	1,156	cy	34.50	39,882
Riprap (12")	117,962	cy	90.00	10,616,580
12 " gabion mattresses cages	389,274	sy	16.00	6,228,384
Filter Fabric	389,274	sy	2.00	778,548
Grassing (seeding)	49	acres	2,150	105,350
Clearing and Grubbing, off-site disposal	150	acres	5,000	750,000
Crushed Aggregate 6" Thick(Levee wearing surface)	6,595	cy	45.00	296,775
New 8" Water line	2,470	lf	41	101,270
New 6" Sewer Line	2,470	lf	48	118,560
New 2"Gas Line	2,470	lf	20	49,400
New Electrical Line - 3 phase 1440v	2,470	lf	44.00	108,680
New 24" Storm Drain	2,470	lf	68.00	167,960
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	11	pass-thrus		4,968,013
Concrete Box Culverts	2,476	cy	700	1,733,200
#6 rebar (box culverts)	86	tons	925	79,550
			Subtotal	**$ 58,003,946**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 8 OF 8
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "D"*** FILE NAME:
Ring Levee - elev. 30 ***BelleFontaine*** mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 58,003,946**
Flap Gates (8w x 4h)		15	ea	28,800	432,000
Flap Gates (5w x 3h)		13	ea	13,500	175,500
Flap Gates (10w x 4h)		5	ea	36,000	180,000
Flap Gates (7w x 3h)		7	ea	18,900	132,300
Cutoff valves (8w x 4h)		15	ea	67,200	1,008,000
Cutoff valves (5w x 3h)		13	ea	31,500	409,500
Cutoff valves (10w x 4h)		5	ea	84,000	420,000
Cutoff valves (7w x 3h)		7	ea	44,100	308,700
Pump stations, 42" to 60" pump size (7 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				4,968,013
Ditch Excavation		113,514	cy	12.00	1,362,168
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	3,290,000
		Current Contract Cost, Oct 07			$ 70,690,128
	CONTINGENCY		@	**25.0%**	17,672,532
					$ 88,362,660
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	33,260,332
	06 Account, Preservation - Mitigation-Tidal (10 acr @ $200,000/acr)				2,000,000
	06 Account, Preservation - Mitigation-Non-Tidal (213 acr @ $5,500/acr				1,171,500
					$ 124,819,492
	30 Account, Plan, Engr.& Design		@	**8.0%**	9,985,559
					$ 134,805,051
	31 Account, Constr. Management		@	**6.0%**	8,088,303
					$ 142,893,354
	ESCALATION		@	**0.0%**	0
					$ 142,893,354
					rounded
				TOTAL PROJECT COST, Oct 07	**$ 142,900,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "A"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 20 ***Pascagoula / Moss Point***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	6,650,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	62,668	sy	4.50	282,006
8" Water line removal	19,170	lf	8.00	153,360
6" Sewer line removal	19,170	lf	8.00	153,360
2" Gas line removal	19,170	lf	3.00	57,510
Electric line removal - 3 phase 1440v	19,170	lf	11.00	210,870
24" Storm Drain removal	19,170	lf	11.00	210,870
Demolished structures (avg. 1,500 sf/ea @ 474 ea)	711,000	sf	3.00	2,133,000
Disposal Fee - off site	26,333	cy	2.50	65,833
Misc Removal	1	job	allow	10,000
NEW WORK:				
Compacted Fill (levee)	2,734,259	cy	15.00	41,013,885
Compacted Fill (cross overs)	2,210	cy	15.00	33,150
New Asphalt 2" (Cross overs) 1,332 cy figure 2.0 tons/cy	2,664	ton	70.00	186,480
Base material 12" (cross overs)	7,993	cy	34.50	275,759
Riprap (24")	594,809	cy	90.00	53,532,810
24 " gabion mattress cages, galv-pvc type	981,435	sy	32.00	31,405,920
Filter Fabric	981,435	sy	2.00	1,962,870
Grassing (seeding)	97	acres	2,150	208,550
Clearing and Grubbing, off-site disposal	384	acres	5,000	1,920,000
Crushed Aggregate 6" Thick(Levee wearing surface)	23,632	cy	45.00	1,063,440
Guardrail	2,670	lf	21.00	56,070
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	68	pass-thrus		18,625,110
New 8" Water line	10,935	lf	41	448,335
New 6" Sewer Line	10,935	lf	48	524,880
New 2"Gas Line	10,935	lf	20	218,700
New Electrical Line - 3 phase 1440v	10,935	lf	44.00	481,140
New 24" Storm Drain	10,935	lf	68.00	743,580
Concrete Box Culverts	26,958	cy	700	18,870,600
#6 rebar (box culverts)	934	tons	925	863,950
Flap Gates (8w x 4h)	71	ea	28,800	2,044,800
Flap Gates (12w x 4h)	18	ea	43,200	777,600
Flap Gates (7w x 3h)	68	ea	18,900	1,285,200
Flap Gates (6w x 3h)	15	ea	16,200	243,000
			Subtotal	**$186,712,638**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "A"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 20 ***Pascagoula / Moss Point***

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$186,712,638**
Flap Gates (10w x 4h)		30	ea	36,000	1,080,000
Cutoff valves (8w x 4h)		71	ea	67,200	4,771,200
Cutoff valves (12w x 4h)		18	ea	100,800	1,814,400
Cutoff valves (7w x 3h)		68	ea	67,200	4,569,600
Cutoff valves (6w x 3h)		15	ea	37,800	567,000
Cutoff valves (10w x 4h)		30	ea	84,000	2,520,000
Pump stations, 42" to 60" pump size (28 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				55,189,536
Ditch Excavation		208,575	cy	12.00	2,502,900
Boat Gate, PG-1	(reference backup file for cost derivation)				12,920,900
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	13,300,000
		Current Contract Cost, Oct 07			$285,948,174
	CONTINGENCY		@	**25.0%**	71,487,043
					$357,435,217
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)				237,004,000
	06 Account, Preservation - Mitigation-Tidal (75 acr @ $200,000/acr)				15,000,000
	06 Account, Preservation - Mitigation-Non-Tidal (210 acr @ $5,500/acr)				1,155,000
					$610,619,217
	30 Account, Plan, Engr.& Design		@	**8.0%**	48,849,537
					$659,468,755
	31 Account, Constr. Management		@	**6.0%**	39,568,125
					$699,036,880
	ESCALATION		@	**0.0%**	0
					$ 699,036,880
					rounded
	TOTAL PROJECT COST, Oct 07				**$ 699,000,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "B"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 30 ***Pascagoula / Moss Point***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$9,660,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	91,281	sy	4.50	410,765
8" Water line removal	28,345	lf	8.00	226,760
6" Sewer line removal	28,345	lf	8.00	226,760
2" Gas line removal	28,345	lf	3.00	85,035
Electric line removal - 3 phase 1440v	28,345	lf	11.00	311,795
24" Storm Drain removal	28,345	lf	11.00	311,795
Demolished structures (avg. 1,500 sf/ea @ 557 ea)	835,500	cy	3.00	2,506,500
Disposal Fee - off site	30,944	cy	2.50	77,361
Misc Removal	1	job	allow	10,000
NEW WORK:				
Compacted Fill (levee) off-site borrow	7,997,069	cy	15.00	119,956,035
New Asphalt 2" (Cross overs) 1,349 cy figure 2.0 tons/cy	2,698	ton	70.00	188,860
Base material 12" (cross overs)	8,091	cy	34.50	279,140
Riprap (12")	516,876	cy	90.00	46,518,840
24 " gabion mattress cages, galv-pvc type	1,705,692	sy	32.00	54,582,144
Filter Fabric	1,705,692	sy	2.00	3,411,384
Grassing (seed, mulch, topsoil)	187	acres	2,150	402,050
Clearing and Grubbing, off-site disposal	562	acres	5,000	2,810,000
Crushed Aggregate 6" Thick(Levee wearing surface)	23,860	cy	45.00	1,073,700
New 8" Water line	15,135	lf	41	620,535
New 6" Sewer Line	15,135	lf	48	726,480
New 2"Gas Line	15,135	lf	20	302,700
New Electrical Line - 3 phase 1440v	15,135	lf	44.00	665,940
New 24" Storm Drain	15,135	lf	68.00	1,029,180
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	79	pass-thrus		38,767,028
Concrete Box Culverts	26,958	cy	700	18,870,600
#6 rebar (box culverts)	934	tons	925	863,950
Flap Gates (8w x 4h)	71	ea	28,800	2,044,800
Flap Gates (12w x 4h)	18	ea	43,200	777,600
Flap Gates (7w x 3h)	68	ea	18,900	1,285,200
Flap Gates (6w x 3h)	15	ea	16,200	243,000
Flap Gates (10w x 4h)	30	ea	36,000	1,080,000
Cutoff valves (8w x 4h)	71	ea	67,200	4,771,200
Cutoff valves (12w x 4h)	18	ea	100,800	1,814,400
			Subtotal	**$316,911,536**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT:	**Mississippi Coastal Improvements Program "MsCIP"**	ITEM NO.		DATE	25-Jul-08
LOCATION:	**Mississippi**	SHEET NO.	4	OF	16
		PREPARED:	Joseph H. Ellsworth	CHECKED:	Gary A. Payton
WORK ITEM:	***Line of Defense 3***	BASIS of ESTIMATE:	info furnished per Project Delivery Team		
	Jackson County ***Option "B"***	FILE NAME:	mscip-comprehensive-study-compbined-cost-est-25jul08.xls		
	Ring Levee - elev. 30 ***Pascagoula / Moss Point***				

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$316,911,536**
Cutoff valves (7w x 3h)		68	ea	44,100	2,998,800
Cutoff valves (6w x 3h)		15	ea	37,800	567,000
Cutoff valves (10w x 4h)		30	ea	84,000	2,520,000
Pump stations, 42" to 60" pump size (28 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				55,710,072
Ditch Excavation		208,575	cy	12.00	2,502,900
Boat Gate, PG-1	(reference backup file for cost derivation)				14,917,980
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	19,320,000
		Current Contract Cost, Oct 07			$415,448,288
	CONTINGENCY		@	**25.0%**	103,862,072
					$519,310,360
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)				256,517,000
	06 Account, Preservation - Mitigation-Tidal (113 acr @ $200,000/acr)				22,600,000
	06 Account, Preservation - Mitigation-Non-Tidal (308 acr @ $5,500/acr)				1,694,000
					$800,146,360
	30 Account, Plan, Engr.& Design		@	**8.0%**	64,011,709
					$864,158,068
	31 Account, Constr. Management		@	**6.0%**	51,849,484
					$916,007,552
	ESCALATION		@	**0.0%**	0
					$ 916,007,552 rounded
	TOTAL PROJECT COST, Oct 07				**$ 916,000,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "C"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee-Washington- elev. 20 ***Pascagoula / Moss Point***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	5,420,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	62,707	sy	4.50	282,182
8" Water line removal	19,035	lf	8.00	152,280
6" Sewer line removal	19,035	lf	8.00	152,280
2" Gas line removal	19,035	lf	3.00	57,105
Electric line removal - 3 phase 1440v	19,035	lf	11.00	209,385
24" Storm Drain removal	19,035	lf	11.00	209,385
Demolished structures (avg. 1,500 sf/ea @ 580 ea)	870,000	sf	3.00	2,610,000
Disposal Fee - off site	32,222	cy	2.50	80,556
Misc Removal	1	job	allow	10,000
NEW WORK:				
Compacted Fill (levee)	2,609,183	cy	15.00	39,137,745
Compacted Fill (cross overs)	2,210	cy	15.00	33,150
New Asphalt 2" (Cross overs) 1,421 cy figure 2.0 tons/cy	2,842	ton	70.00	198,940
Base material 12" (cross overs)	8,526	cy	34.50	294,147
Riprap (24")	581,405	cy	90.00	52,326,450
24 " gabion mattress cages, galv-pvc type	953,318	sy	32.00	30,506,176
Filter Fabric	959,318	sy	2.00	1,918,636
Grassing (seeding)	94	acres	2,150	202,100
Clearing and Grubbing, off-site disposal	377	acres	5,000	1,885,000
Crushed Aggregate 6" Thick(Levee wearing surface)	23,431	cy	45.00	1,054,395
Guardrail	2,670	lf	21.00	56,070
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	76	pass-thrus		19,908,310
New 8" Water line	10,935	lf	41	448,335
New 6" Sewer Line	10,935	lf	48	524,880
New 2"Gas Line	10,935	lf	20	218,700
New Electrical Line - 3 phase 1440v	10,935	lf	44.00	481,140
New 24" Storm Drain	10,935	lf	68.00	743,580
Concrete Box Culverts	26,415	cy	700	18,490,500
#6 rebar (box culverts)	913	tons	925	844,525
Flap Gates (8w x 4h)	48	ea	28,800	1,382,400
Flap Gates (12w x 4h)	38	ea	43,200	1,641,600
Flap Gates (7w x 3h)	63	ea	18,900	1,190,700
Flap Gates (6w x 3h)	3	ea	16,200	48,600
			Subtotal	**$182,719,252**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "C"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee-Washington- elev. 20 ***Pascagoula / Moss Point***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Subtotal, brought forward		**$182,719,252**
Flap Gates (10w x 4h)	32	ea	36,000	1,152,000
Cutoff valves (8w x 4h)	48	ea	67,200	3,225,600
Cutoff valves (12w x 4h)	38	ea	100,800	3,830,400
Cutoff valves (7w x 3h)	63	ea	67,200	4,233,600
Cutoff valves (6w x 3h)	3	ea	37,800	113,400
Cutoff valves (10w x 4h)	32	ea	84,000	2,688,000
Pump stations, 42" to 60" pump size (28 ea) (reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				21,725,635
Ditch Excavation	198,076	cy	12.00	2,376,912
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	10,830,000
		Current Contract Cost, Oct 07		$232,894,798
CONTINGENCY		@	**25.0%**	58,223,700
				$291,118,498
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				278,147,000
06 Account, Preservation - Mitigation-Tidal (81 acr @ $200,000/acr)				16,200,000
06 Account, Preservation - Mitigation-Non-Tidal (213 acr @ $5,500/acr)				1,171,500
				$586,661,998
30 Account, Plan, Engr.& Design		@	**8.0%**	46,932,960
				$633,594,957
31 Account, Constr. Management		@	**6.0%**	38,015,697
				$671,610,655
ESCALATION		@	**0.0%**	0
				$ 671,610,655
				rounded
TOTAL PROJECT COST, Oct 07				**$ 671,600,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT:	**Mississippi Coastal Improvements Program "MsCIP"**	ITEM NO.	DATE 25-Jul-08
LOCATION:	**Mississippi**	SHEET NO. 7	OF 16
		PREPARED: Joseph H. Ellsworth	CHECKED: Gary A. Payton
WORK ITEM:	***Line of Defense 3***	BASIS of ESTIMATE:	info furnished per Project Delivery Team
	Jackson County ***Option "D"***	FILE NAME:	mscip-comprehensive-study-compbined-cost-est-25jul08.xls
	Ring Levee-Washington- elev. 30	***Pascagoula / Moss Point***	

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	7,800,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	91,547	sy	4.50	411,962
8" Water line removal	28,145	lf	8.00	225,160
6" Sewer line removal	28,145	lf	8.00	225,160
2" Gas line removal	28,145	lf	3.00	84,435
Electric line removal - 3 phase 1440v	28,145	lf	11.00	309,595
24" Storm Drain removal	28,145	lf	11.00	309,595
Demolished structures (avg. 1,500 sf/ea @ 685 ea)	1,027,500	sf	3.00	3,082,500
Disposal Fee - off site	38,056	cy	2.50	95,139
Misc Removal	1	job	allow	10,000
NEW WORK:				
Compacted Fill (levee)	7,739,200	cy	15.00	116,088,000
New Asphalt 2" (Cross overs) 1,421 cy figure 2.0 tons/cy	2,876	ton	70.00	201,320
Base material 12" (cross overs)	8,628	cy	34.50	297,666
Riprap (24")	507,933	cy	90.00	45,713,970
12 " gabion mattress cages, galv-pvc type	1,676,179	sy	16.00	26,818,864
Filter Fabric	1,676,179	sy	2.00	3,352,358
Grassing (seeding)	183	acres	2,150	393,450
Clearing and Grubbing, off-site disposal	553	acres	5,000	2,765,000
Crushed Aggregate 6" Thick(Levee wearing surface)	23,658	cy	45.00	1,064,610
Guardrail	2,670	lf	21.00	56,070
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	87	pass-thrus		42,707,625
New 8" Water line	16,335	lf	41	669,735
New 6" Sewer Line	16,335	lf	48	784,080
New 2"Gas Line	16,335	lf	20	326,700
New Electrical Line - 3 phase 1440v	16,335	lf	44.00	718,740
New 24" Storm Drain	16,335	lf	68.00	1,110,780
Concrete Box Culverts	26,415	cy	700	18,490,500
#6 rebar (box culverts)	913	tons	925	844,525
Flap Gates (8w x 4h)	48	ea	28,800	1,382,400
Flap Gates (12w x 4h)	38	ea	43,200	1,641,600
Flap Gates (7w x 3h)	63	ea	18,900	1,190,700
Flap Gates (6w x 3h)	3	ea	16,200	48,600
			Subtotal	**$279,220,838**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 8 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "D"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee-Washington- elev. 30 ***Pascagoula / Moss Point***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Subtotal, brought forward		**$279,220,838**
Flap Gates (10w x 4h)	32	ea	36,000	1,152,000
Cutoff valves (8w x 4h)	48	ea	67,200	3,225,600
Cutoff valves (12w x 4h)	38	ea	100,800	3,830,400
Cutoff valves (7w x 3h)	63	ea	67,200	4,233,600
Cutoff valves (6w x 3h)	3	ea	37,800	113,400
Cutoff valves (10w x 4h)	32	ea	84,000	2,688,000
Pump stations, 42" to 60" pump size (28 ea) (reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				22,932,896
Ditch Excavation	198,076	cy	12.00	2,376,912
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	15,600,000
		Current Contract Cost, Oct 07		$335,373,647
CONTINGENCY		@	**25.0%**	83,843,412
				$419,217,058
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				297,899,000
06 Account, Preservation - Mitigation-Tidal (118 acr @ $200,000/acr)				23,600,000
06 Account, Preservation - Mitigation-Non-Tidal (308 acr @ $5,500/acr)				1,694,000
				$742,435,058
30 Account, Plan, Engr.& Design		@	**8.0%**	59,394,805
				$801,829,863
31 Account, Constr. Management		@	**6.0%**	48,109,792
				$849,939,655
ESCALATION		@	**0.0%**	0
				$ 849,939,655
				rounded
			TOTAL PROJECT COST, Oct 07	**$ 849,900,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 9 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "E"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - Moss Pt. - elev. 20 ***Pascagoula / Moss Point***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	4,370,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	67,895	sy	4.50	305,528
8" Water line removal	17,550	lf	8.00	140,400
6" Sewer line removal	17,550	lf	8.00	140,400
2" Gas line removal	17,550	lf	3.00	52,650
Electric line removal - 3 phase 1440v	17,550	lf	11.00	193,050
24" Storm Drain removal	17,550	lf	11.00	193,050
Demolished structures (avg. 1,500 sf/ea @ 482 ea)	723,000	sf	3.00	2,169,000
Disposal Fee - off site	26,778	cy	2.50	66,944
Misc Removal	1	job	allow	10,000
NEW WORK:				
Compacted Fill (levee) 105,085LF	1,694,854	cy	15.00	25,422,810
Compacted Fill (cross overs)	22,032	cy	15.00	330,480
New Asphalt 2" (Cross overs) 2148 cy figure 2.0 tons/cy	4,296	ton	70.00	300,720
Base material 12" (cross overs)	12,884	cy	34.50	444,498
Riprap (24")	440,512	cy	90.00	39,646,080
24" gabion mattress cages	726,844	sy	32.00	23,259,008
Filter Fabric	726,844	sy	2.00	1,453,688
Grassing (seeding)	65	acres	2,150	139,750
Clearing and Grubbing, off-site disposal	285	acres	5,000	1,425,000
Crushed Aggregate 6" Thick(Levee wearing surface)	19,318	cy	45.00	869,310
Guardrail	18,270	lf	21.00	383,670
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	43	pass-thrus		11,861,400
New 8" Water line	10,415	lf	41	427,015
New 6" Sewer Line	10,415	lf	48	499,920
New 2"Gas Line	10,415	lf	20	208,300
New Electrical Line - 3 phase 1440v	10,415	lf	44.00	458,260
New 24" Storm Drain	10,415	lf	68.00	708,220
Concrete Box Culverts	14,540	cy	700	10,178,000
#6 rebar (box culverts)	502	tons	925	464,350
Flap Gates (10w x 4h)	50	ea	36,000	1,800,000
Flap Gates (7w x 3h)	51	ea	18,900	963,900
Flap Gates 6w x 3h)	15	ea	16,200	243,000
Flap Gates (8w x 4h)	41	ea	28,800	1,180,800
			Subtotal	**$130,309,200**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 10 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "E"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - Moss Pt. - elev. 20 ***Pascagoula / Moss Point***

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$130,309,200**
Flap Gates (6w x 4h)		9	ea	21,600	194,400
Flap Gates (5w x 3h)		3	ea	13,500	40,500
Flap Gates (7w x 4h)		5	ea	58,800	294,000
Cutoff valves (10w x 4h)		50	ea	84,000	4,200,000
Cutoff valves (7w x 3h)		51	ea	44,100	2,249,100
Cutoff valves (6w x 3h)		15	ea	37,800	567,000
Cutoff valves (8w x4h)		41	ea	67,200	2,755,200
Cutoff valves (6w x 4h)		9	ea	50,400	453,600
Cutoff valves (5w x3h)		3	ea	31,500	94,500
Cutoff valves (7w x 4h)		5	ea	58,800	294,000
Pump stations, 42" to 60" pump size (28 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				$22,931,722
Ditch Excavation		166,696	cy	12.00	2,000,352
Boat Gate, PG-1	(reference backup file for cost derivation)				12,920,900
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	8,740,000
			Current Contract Cost, Oct 07		$188,044,474
	CONTINGENCY		@	**25.0%**	47,011,119
					$235,055,593
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)				520,145,000
	06 Account, Preservation - Mitigation-Tidal (40 acr @ $200,000/acr)				8,000,000
	06 Account, Preservation - Mitigation-Non-Tidal (100 acr @ $5,500/acr)				550,000
					$763,775,593
	30 Account, Plan, Engr.& Design		@	**8.0%**	61,102,047
					$824,877,640
	31 Account, Constr. Management		@	**6.0%**	49,492,658
					$874,370,298
	ESCALATION		@	**0.0%**	0
					$ 874,370,298
					rounded

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

TOTAL PROJECT COST, Oct 07 $ 874,400,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 11 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "F"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - Moss Pt. - elev. 30 ***Pascagoula / Moss Point***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	6,300,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	80,341	sy	4.50	361,535
8" Water line removal	24,130	lf	8.00	193,040
6" Sewer line removal	24,130	lf	8.00	193,040
2" Gas line removal	24,130	lf	3.00	72,390
Electric line removal - 3 phase 1440v	24,130	lf	11.00	265,430
24" Storm Drain removal	24,130	lf	11.00	265,430
Demolished structures (avg. 1,500 sf/ea @ 580 ea)	870,000	sf	3.00	2,610,000
Disposal Fee - off site	32,222	cy	2.50	80,556
Misc Removal	1	job	allow	10,000
NEW WORK:				
Compacted Fill (levee) 105,085LF	5,526,049	cy	15.00	82,890,735
New Asphalt 2" (Cross overs) 1223 cy figure 2.0 tons/cy	2,446	ton	70.00	171,220
Base material 12" (cross overs)	7,335	cy	34.50	253,058
Riprap (24")	340,971	cy	90.00	30,687,390
12 " gabion mattress cages	1,125,204	sy	16.00	18,003,264
Filter Fabric	1,125,204	sy	2.00	2,250,408
Grassing (seeding)	139	acres	2,150	298,850
Clearing and Grubbing, off-site disposal	431	acres	5,000	2,155,000
Crushed Aggregate 6" Thick(Levee wearing surface)	19,460	cy	45.00	875,704
		lf	21.00	0
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	75	pass-thrus		41,132,875
New 8" Water line	12,555	lf	41	514,755
New 6" Sewer Line	12,555	lf	48	602,640
New 2"Gas Line	12,555	lf	20	251,100
New Electrical Line - 3 phase 1440v	12,555	lf	44.00	552,420
New 24" Storm Drain	12,555	lf	68.00	853,740
Concrete Box Culverts	14,540	cy	700	10,178,000
#6 rebar (box culverts)	502	tons	925	464,350
Flap Gates (10w x 4h)	50	ea	36,000	1,800,000
Flap Gates (7w x 3h)	51	ea	18,900	963,900
Flap Gates 6w x 3h)	15	ea	16,200	243,000
Flap Gates (8w x 4h)	41	ea	28,800	1,180,800
			Subtotal	**$206,674,628**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi Coastal Improvements Program "MsCIP"** SHEET NO. 12 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "F"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - Moss Pt. - elev. 30 ***Pascagoula / Moss Point***

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$206,674,628**
Flap Gates (6w x 4h)		9	ea	21,600	194,400
Flap Gates (5w x 3h)		3	ea	13,500	40,500
Flap Gates (7w x 4h)		5	ea	58,800	294,000
Cutoff valves (10w x 4h)		50	ea	84,000	4,200,000
Cutoff valves (7w x 3h)		51	ea	44,100	2,249,100
Cutoff valves (6w x 3h)		15	ea	37,800	567,000
Cutoff valves (8w x4h)		41	ea	67,200	2,755,200
Cutoff valves (6w x 4h)		9	ea	50,400	453,600
Cutoff valves (5w x3h)		3	ea	31,500	94,500
Cutoff valves (7w x 4h)		5	ea	58,800	294,000
Pump stations, 42" to 60" pump size (28 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				23,790,218
Ditch Excavation		166,696	cy	12.00	2,000,352
Boat Gate, PG-1	(reference backup file for cost derivation)				14,917,980
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	12,600,000
			Current Contract Cost, Oct 07		$271,125,478
	CONTINGENCY		@	**25.0%**	67,781,369
					$338,906,847
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)				533,059,000
	06 Account, Preservation - Mitigation-Tidal (61 acr @ $200,000/acr)				12,200,000
	06 Account, Preservation - Mitigation-Non-Tidal (158 acr @ $5,500/acr)				869,000
					$885,059,847
	30 Account, Plan, Engr.& Design		@	**8.0%**	70,804,788
					$955,864,635
	31 Account, Constr. Management		@	**6.0%**	57,351,878
					$1,013,216,513
	ESCALATION		@	**0.0%**	0
					$ 1,013,216,513
					rounded
			TOTAL PROJECT COST, Oct 07		$ 1,013,200,000

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 13 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "G"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee- Moss/Wash - elev. 20 ***Pascagoula / Moss Point***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	4,110,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	67,800	sy	4.50	305,100
8" Water line removal	17,415	lf	8.00	139,320
6" Sewer line removal	17,415	lf	8.00	139,320
2" Gas line removal	17,415	lf	3.00	52,245
Electric line removal - 3 phase 1440v	17,415	lf	11.00	191,565
24" Storm Drain removal	17,415	lf	11.00	191,565
Demolished structures (avg. 1,500 sf/ea @ 482 ea)	870,000	sf	3.00	2,610,000
Disposal Fee - off site	32,222	cy	2.50	80,556
Misc Removal	1	job	allow	10,000
NEW WORK:				
Compacted Fill (levee) 105,085LF	1,561,061	cy	15.00	23,415,915
Compacted Fill (cross overs)	22,033	cy	15.00	330,495
New Asphalt 2" (Cross overs) 2222 cy figure 2.0 tons/cy	4,444	ton	70.00	311,080
Base material 12" (cross overs)	13,332	cy	34.50	459,954
Riprap (24")	427,490	cy	90.00	38,474,100
12 " gabion mattress cages	705,358	sy	16.00	11,285,728
Filter Fabric	705,358	sy	2.00	1,410,716
Grassing (seeding)	63	acres	2,150	135,450
Clearing and Grubbing, off-site disposal	274	acres	5,000	1,370,000
Crushed Aggregate 6" Thick(Levee wearing surface)	18,932	cy	45.00	851,940
Guardrail	18,270	lf	21.00	383,670
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	48	pass-thrus		14,130,550
New 8" Water line	10,415	lf	41	427,015
New 6" Sewer Line	10,415	lf	48	499,920
New 2"Gas Line	10,415	lf	20	208,300
New Electrical Line - 3 phase 1440v	10,415	lf	44.00	458,260
New 24" Storm Drain	10,415	lf	68.00	708,220
Concrete Box Culverts	14,326	cy	700	10,028,200
#6 rebar (box culverts)	493	tons	925	456,025
Flap Gates (10w x 4h)	35	ea	36,000	1,260,000
Flap Gates (7w x 3h)	46	ea	18,900	869,400
Flap Gates 7w x 4h)	5	ea	25,200	126,000
Flap Gates 6w x 3h)	5	ea	16,200	81,000
			Subtotal	**$115,511,608**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 14 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3***
Jackson County ***Option "G"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee- Moss/Wash - elev. 20 ***Pascagoula / Moss Point***
BASIS of ESTIMATE: info furnished per Project Delivery Team

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Subtotal, brought forward		**$115,511,608**
Flap Gates (6w x 4h)	9	ea	21,600	194,400
Flap Gates (8w x 4h)	41	ea	28,800	1,180,800
Flap Gates (12w x 4h)	20	ea	100,800	2,016,000
Flap Gates (5w x 3h)	3	ea	31,500	94,500
Cutoff valves (10w x 4h)	35	ea	84,000	2,940,000
Cutoff valves (7w x 3h)	46	ea	44,100	2,028,600
Cutoff valves (7w x 4h)	5	ea	58,800	294,000
Cutoff valves (6w x 3h)	5	ea	37,800	189,000
Cutoff valves (6w x 4h)	9	ea	50,400	453,600
Cutoff valves (8w x 4h)	41	ea	67,200	2,755,200
Cutoff valves (12w x 4h)	20	ea	100,800	2,016,000
Cutoff valves (5w x 3h)	3	ea	31,500	94,500
Pump stations, 42" to 60" pump size (28 ea) (reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				36,970,904
Ditch Excavation	156,197	cy	12.00	1,874,364
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	8,220,000
		Current Contract Cost, Oct 07		$176,833,476
CONTINGENCY		@	**25.0%**	44,208,369
				$221,041,845
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				574,040,000
06 Account, Preservation - Mitigation-Tidal (46 acr @ $200,000/acr)				9,200,000
06 Account, Preservation - Mitigation-Non-Tidal (106 acr @ $5,500/acr)				583,000
				$804,889,845
30 Account, Plan, Engr.& Design		@	**8.0%**	64,391,188
				$869,281,033
31 Account, Constr. Management		@	**6.0%**	52,156,862
				$921,437,894
ESCALATION		@	**0.0%**	0
				$ 921,437,894 rounded
TOTAL PROJECT COST, Oct 07				$ 921,400,000

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT:	**Mississippi Coastal Improvements Program "MsCIP"**	ITEM NO.	DATE 25-Jul-08
LOCATION:	**Mississippi**	SHEET NO. 15	OF 16
		PREPARED: Joseph H. Ellsworth	CHECKED: Gary A. Payton
WORK ITEM:	***Line of Defense 3***	BASIS of ESTIMATE:	info furnished per Project Delivery Team
	Jackson County ***Option "H"***	FILE NAME:	mscip-comprehensive-study-compbined-cost-est-25jul08.xls
	Ring Levee- Moss/Wash - elev. 30	***Pascagoula / Moss Point***	

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	6,040,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	80,608	sy	4.50	362,736
8" Water line removal	20,930	lf	8.00	167,440
6" Sewer line removal	20,930	lf	8.00	167,440
2" Gas line removal	20,930	lf	3.00	62,790
Electric line removal - 3 phase 1440v	20,930	lf	11.00	230,230
24" Storm Drain removal	20,930	lf	11.00	230,230
Demolished structures (avg. 1,500 sf/ea @ 584 ea)	870,000	sf	3.00	2,610,000
Disposal Fee - off site	32,222	cy	2.50	80,556
Misc Removal	1	job	allow	10,000
NEW WORK:				
Compacted Fill (levee) 105,085LF	5,227,529	cy	15.00	78,412,935
New Asphalt 2" (Cross overs) 1312 cy figure 2.0 tons/cy	2,624	ton	70.00	183,680
Base material 12" (cross overs)	7,869	cy	34.50	271,481
Riprap (24")	332,616	cy	90.00	29,935,440
12 " gabion mattress cages	1,097,633	sy	16.00	17,562,128
Filter Fabric	1,097,633	sy	2.00	2,195,266
Grassing (seeding)	136	acres	2,150	292,400
Clearing and Grubbing, off-site disposal	416	acres	5,000	2,080,000
Crushed Aggregate 6" Thick(Levee wearing surface)	19,075	cy	45.00	858,375
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	79	pass-thrus		36,085,597
New 8" Water line	12,500	lf	41	512,500
New 6" Sewer Line	12,500	lf	48	600,000
New 2"Gas Line	12,500	lf	20	250,000
New Electrical Line - 3 phase 1440v	12,500	lf	44.00	550,000
New 24" Storm Drain	12,500	lf	68.00	850,000
Concrete Box Culverts	14,326	cy	700	10,028,200
#6 rebar (box culverts)	493	tons	925	456,025
Flap Gates (10w x 4h)	35	ea	36,000	1,260,000
Flap Gates (7w x 3h)	46	ea	18,900	869,400
Flap Gates 7w x 4h)	5	ea	25,200	126,000
Flap Gates 6w x 3h)	5	ea	16,200	81,000
			Subtotal	**$193,421,848**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 16 OF 16
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3***
Jackson County ***Option "H"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee- Moss/Wash - elev. 30 ***Pascagoula / Moss Point***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Subtotal, brought forward		**$193,421,848**
Flap Gates (6w x 4h)	9	ea	21,600	194,400
Flap Gates (8w x 4h)	41	ea	28,800	1,180,800
Flap Gates (12w x 4h)	20	ea	100,800	2,016,000
Flap Gates (5w x 3h)	3	ea	31,500	94,500
Cutoff valves (10w x 4h)	35	ea	84,000	2,940,000
Cutoff valves (7w x 3h)	46	ea	44,100	2,028,600
Cutoff valves (7w x 4h)	5	ea	58,800	294,000
Cutoff valves (6w x 3h)	5	ea	37,800	189,000
Cutoff valves (6w x 4h)	9	ea	50,400	453,600
Cutoff valves (8w x 4h)	41	ea	67,200	2,755,200
Cutoff valves (12w x 4h)	20	ea	100,800	2,016,000
Cutoff valves (5w x 3h)	3	ea	31,500	94,500
Pump stations, 42" to 60" pump size (28 ea) (reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				38,210,974
Ditch Excavation	156,197	cy	12.00	1,874,364
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	12,080,000
		Current Contract Cost, Oct 07		$259,843,786
CONTINGENCY		@	**25.0%**	64,960,946
				$324,804,732
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				584,742,000
06 Account, Preservation - Mitigation-Tidal (67 acr @ $200,000/acr)				13,400,000
06 Account, Preservation - Mitigation-Non-Tidal (164 acr @ $5,500/acr)				902,000
				$923,873,732
30 Account, Plan, Engr.& Design		@	**8.0%**	73,909,899
				$997,783,631
31 Account, Constr. Management		@	**6.0%**	59,867,018
				$1,057,650,649
ESCALATION		@	**0.0%**	0
				$ 1,057,650,649
				rounded
TOTAL PROJECT COST, Oct 07				$ 1,057,700,000

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE STUDY " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***FORREST HEIGHTS LEVEE, EL 17***
Harrison County

ITEM NO.
SHEET NO. 1 OF 4
DATE 25-Jul-08
PREPARED: Joseph H. Ellsworth CHECKED: Mike Mckown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization			1	job	allow	$50,000
REMOVALS:						
Asphalt removal 2" Thick(cross overs)			500	sy	4.50	2,250
8" Water line removal			100	lf	8.00	800
6" Sewer line removal			100	lf	8.00	800
2" Gas line removal			100	lf	3.00	300
Electrical line removal - 3 phase 1440v			150	lf	11.00	1,650
24" Storm Drain removal			100	lf	11.00	1,100
Demolished structures (avg. 1,500 sf/ea @ 2 ea)			3,000	sf	3.00	9,000
Disposal Fee - off site			111	cy	2.50	278
NEW WORK:						
Compacted Fill (levee)			13,300	cy	15.00	199,500
New Asphalt 2" (Cross overs) 134 cy	figure 2.0 tons/cy		15	tons	70.00	1,050
Base material 12" (cross overs)			50	cy	34.50	1,725
Riprap (12")			170	cy	90.00	15,300
Grouted Riprap			125	cy	160.00	20,000
Filter Fabric			500	sy	2.00	1,000
Grassing (seeding)			10	acres	2,150	21,500
Clearing and Grubbing, off-site disposal			5	acres	5,000	25,000
Crushed Aggregate 6" Thick(Levee wearing surface)			1,000	cy	45.00	45,000
Selective Clearing and Snagging, soil removal and disposal			220	cy	20.00	4,400
Clearing and Snagging (from mouth of Turkey Creek upstream)			5	miles	25,000	112,500
New 8" Water line			100	lf	41	4,100
New 6" Sewer Line			100	lf	48	4,800
New 2"Gas Line			100	lf	20	2,000
New Electrical Line - 3 phase 1440v			150	lf	44.00	6,600
New 24" Storm Drain			100	lf	68.00	6,800
Pump Stations:						
Structural Concrete, complete all sites			194	cy	700	135,800
Form Work, complete all sites			4,996	sf	7	32,474
Steel Reinforcement, complete all sites			12	tons	925	11,141
Excavation			300	cy	15	4,500
Backfill			233	cy	5	1,165
Trash Screens and Miscellaneous metal items, All Sites			2	each	100,000	200,000
Pumps by Installation Site	P-1	Pumps	2	each	222,200	444,400
		Discharge Piping(42" Dia; 154 lf)	1	job	30,800	30,800
		Energy Dissipation	1	job	allow	90,000
		Electrical	2	ea	242,100	484,200
					Subtotal	**$ 1,971,932**

COMPREHENSIVE STUDY " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***FORREST HEIGHTS LEVEE, EL 17***
Harrison County

ITEM NO.
SHEET NO. 2 OF 4
DATE 25-Jul-08
PREPARED: Joseph H. Ellsworth CHECKED: Mike Mckown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$ 1,971,932**
Ditch Excavation	965	cy	12.00	11,580
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	97,000
			Current Contract Cost, Oct 07	$ 2,080,512
CONTINGENCY		@	**25.0%**	520,128
				$ 2,600,641
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	2,571,000
06 Account, Preservation - Mitigation-Non-Tidal (19.85 acr @ $5,500/acr+ admin+25% cont)				118,538
				$ 5,315,179
30 Account, Plan, Engr.& Design		@	**8.0%**	425,214
				$ 5,740,393
31 Account, Constr. Management		@	**6.0%**	344,424
				$ 6,084,816
ESCALATION		@	**0.0%**	0
				$ 6,084,816 rounded
			TOTAL PROJECT COST, Oct 07	**$ 6,100,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE STUDY " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***FORREST HEIGHTS LEVEE, EL 21***
Harrison County

ITEM NO.
SHEET NO. 3 OF 4
DATE 25-Jul-08
PREPARED: Joseph H. Ellsworth CHECKED: Mike Mckown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization			1	job	allow	$120,000
REMOVALS:						
Asphalt removal 2" Thick(cross overs)			700	sy	4.50	3,150
8" Water line removal			150	lf	8.00	1,200
6" Sewer line removal			150	lf	8.00	1,200
2" Gas line removal			150	lf	3.00	450
Electric line removal - 3 phase 1440v			175	lf	11.00	1,925
24" Storm Drain removal			125	lf	11.00	1,375
Demolished structures (avg. 1,500 sf/ea @ 2 ea)			3,000	sf	3.00	9,000
Disposal Fee - off site			111	cy	2.50	278
NEW WORK:						
Compacted Fill (levee)			51,000	cy	15.00	765,000
Vinyl Sheetpiling			39,550	sf	25.00	988,750
New Asphalt 2" (at Tunnels) 134 cy	figure 2.0 tons/cy		20	tons	70.00	1,400
Base material 12" (cross overs)			100	cy	34.50	3,450
Riprap (12")			170	cy	90.00	15,300
Grouted Riprap			125	cy	160.00	20,000
Filter Fabric			500	sy	2.00	1,000
Grassing (seeding)			10	acres	2,150	21,500
Clearing and Grubbing, off-site disposal			10	acres	5,000	50,000
Crushed Aggregate 6" Thick(Levee wearing surface)			2,000	cy	45.00	90,000
Selective Clearing and Snagging, soil removal and disposal			220	cy	20.00	4,400
Clearing and Snagging (from mouth of Turkey Creek upstream)			5	miles	25,000	112,500
New 8" Water line			150	lf	41	6,150
New 6" Sewer Line			150	lf	48	7,200
New 2"Gas Line			150	lf	20	3,000
New Electrical Line - 3 phase 1440v			175	lf	44.00	7,700
New 24" Storm Drain			125	lf	68.00	8,500
Pump Stations:						
Structural Concrete, complete all sites			194	cy	700	135,800
Form Work, complete all sites			4,996	sf	7	32,474
Steel Reinforcement, complete all sites			12	tons	925	11,141
Excavation			300	cy	15	4,500
Backfill			233	cy	5	1,165
Trash Screens and Miscellaneous metal items, All Sites			2	each	100,000	200,000
Pumps by Installation Site	P-1	Pumps	2	each	222,200	444,400
		Discharge Piping(42" Dia; 154 lf)	1	job	30,800	30,800
		Energy Dissipation	1	job	allow	90,000
		Electrical	2	ea	242,100	484,200
					Subtotal	**$ 3,678,907**

COMPREHENSIVE STUDY " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Mike Mckown
WORK ITEM: ***FORREST HEIGHTS LEVEE, EL 21*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Subtotal, brought forward		**$ 3,678,907**
Concrete Box Culvert (5 ea) 4'x3'	155	cy	900	139,500
Flap Gates (4w x 3h)	5	ea	13,500	67,500
Cutoff valves (4w x 3h)	5	ea	31,500	157,500
Ditch Excavation	2,500	cy	12.00	30,000
EAST WALL				
Concrete Wall	1,826	cy	700	1,278,200
Structural Steel Gates	6	tons	4,800	28,800
#6 rebar (box culverts)	49	tons	925	45,325
Misc. removals at Russell Blvd Entrance	1	job	allow	10,000
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	246,000
		Current Contract Cost, Oct 07		$ 5,681,732
CONTINGENCY		@	**25.0%**	1,420,433
				$ 7,102,166
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	2,649,000
06 Account, Preservation - Mitigation-Non-Tidal (19.85 acr @ $5,500/acr+ admin+25% cont)				220,844
				$ 9,997,010
30 Account, Plan, Engr.& Design		@	**8.0%**	799,761
				$ 10,796,770
31 Account, Constr. Management		@	**6.0%**	647,806
				$ 11,444,577
ESCALATION		@	**0.0%**	0
				$ 11,444,577
				rounded
		TOTAL PROJECT COST, Oct 07		**$ 11,400,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County ***Option "A"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 20 ***Pearlington***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$1,540,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	14,014	sy	4.50	63,063
8" Water line removal	4,960	lf	8.00	39,680
6" Sewer line removal	4,960	lf	8.00	39,680
2" Gas line removal	4,960	lf	3.00	14,880
Electrical line removal - 3 phase 1440v	4,960	lf	11.00	54,560
24" Storm Drain removal	4,960	lf	11.00	54,560
Demolished structures (avg. 1,500 sf/ea @ 28 ea)	42,000	sf	3.00	126,000
Disposal Fee - off site	1,556	cy	2.50	3,889
NEW WORK:				
Compacted Fill (levee)	786,911	cy	15.00	11,803,665
New Asphalt 2" (Cross overs) 134 cy figure 2.0 tons/cy	268	tons	70.00	18,760
Base material 12" (cross overs)	800	cy	34.50	27,600
Riprap (24")	147,330	cy	90.00	13,259,700
24 " gabion mattress cages, galv-pvc type	265,194	sy	32.00	8,486,208
Filter Fabric	265,194	sy	2.00	530,388
Grassing (seeding)	27	acres	2,150	58,050
Clearing and Grubbing, off-site disposal	93	acres	5,000	465,000
Crushed Aggregate 6" Thick(Levee wearing surface)	5,124	cy	45.00	230,580
New 8" Water line	1,395	lf	41	57,195
New 6" Sewer Line	1,395	lf	48	66,960
New 2"Gas Line	1,395	lf	20	27,900
New Electrical Line - 3 phase 1440v	1,395	lf	44.00	61,380
New 24" Storm Drain	1,395	lf	68.00	94,860
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	9	pass-thrus		3,186,197
Concrete Box Culverts	2,224	cy	700	1,556,800
#6 rebar (box culverts)	78	tons	925	72,150
			Subtotal	**$ 41,939,705**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County ***Option "A"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 20 ***Pearlington***

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 41,939,705**
Flap Gates (6w x 3h)		13	ea	16,200	210,600
Flap Gates (5w x 3h)		8	ea	13,500	108,000
Flap Gates (10w x 4h)		14	ea	36,000	504,000
Flap Gates (8w x 4h)		2	ea	28,800	57,600
Cutoff valves (6w x3h)		13	ea	37,800	491,400
Cutoff valves (5w x3h)		8	ea	31,500	252,000
Cutoff valves (10w x4h)		14	ea	84,000	1,176,000
Cutoff valves (8w x4h)		2	ea	67,200	134,400
Pump stations, 42" to 60" pump size (6 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				17,755,717
Ditch Excavation		26,000	cy	12.00	312,000
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	3,070,000
			Current Contract Cost, Oct 07		$ 66,011,422
	CONTINGENCY		@	**25.0%**	16,502,856
					$ 82,514,278
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	8,883,133
	06 Account, Preservation - Mitigation-Tidal (0 acr @ $200,000/acr)				0
	06 Account, Preservation - Mitigation-Non-Tidal (27 acr @ $5,500/acr)				148,500
					$ 91,570,911
	30 Account, Plan, Engr.& Design		@	**8.0%**	7,325,673
					$ 98,896,584
	31 Account, Constr. Management		@	**6.0%**	5,933,795
					$ 104,830,379
	ESCALATION		@	**0.0%**	0
					$ 104,830,379
					rounded
			TOTAL PROJECT COST, Oct 07		**$ 104,800,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County ***Option "B"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 30 ***Pearlington***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$1,770,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	18,974	sy	4.50	85,383
8" Water line removal	6,880	lf	8.00	55,040
6" Sewer line removal	6,880	lf	8.00	55,040
2" Gas line removal	6,880	lf	3.00	20,640
Electric line removal - 3 phase 1440v	6,880	lf	11.00	75,680
24" Storm Drain removal	6,880	lf	11.00	75,680
Demolished structures (avg. 1,500 sf/ea @ 30 ea)	45,000	sf	3.00	135,000
Disposal Fee - off site	1,667	cy	2.50	4,167
NEW WORK:				
Compacted Fill (levee)	1,266,791	cy	15.00	19,001,865
New Asphalt 2" (at Tunnels) 134 cy figure 2.0 tons/cy	268	tons	70.00	18,760
Base material 12" (cross overs)	800	cy	34.50	27,600
Riprap (12")	105,379	cy	90.00	9,484,110
24 " gabion mattress cages, galv-pvc type	347,750	sy	32.00	11,128,000
Filter Fabric	347,750	sy	2.00	695,500
Grassing (seeding)	47	acres	2,150	101,050
Clearing and Grubbing, off-site disposal	131	acres	5,000	655,000
Crushed Aggregate 6" Thick(Levee wearing surface)	5,124	cy	45.00	230,580
New 8" Water line	1,935	lf	41	79,335
New 6" Sewer Line	1,935	lf	48	92,880
New 2"Gas Line	1,935	lf	20	38,700
New Electrical Line - 3 phase 1440v	1,935	lf	44.00	85,140
New 24" Storm Drain	1,935	lf	68.00	131,580
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	9	pass-thrus		5,048,096
Concrete Box Culverts	2,224	cy	700	1,556,800
#6 rebar (box culverts)	78	tons	925	72,150
			Subtotal	**$ 50,723,776**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County ***Option "B"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 30 ***Pearlington***

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 50,723,776**
Flap Gates (6w x 3h)		13	ea	16,200	210,600
Flap Gates (5w x 3h)		8	ea	13,500	108,000
Flap Gates (10w x 4h)		14	ea	36,000	504,000
Flap Gates (8w x 4h)		2	ea	28,800	57,600
Cutoff valves (6w x 3h)		13	ea	37,800	491,400
Cutoff valves (5w x 3h)		8	ea	31,500	252,000
Cutoff valves (10w x 4h)		14	ea	84,000	1,176,000
Cutoff valves (8w x 4h)		2	ea	67,200	134,400
Pump stations, 42" to 60" pump size (6 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				18,799,667
Ditch Excavation		26,000	cy	12.00	312,000
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	3,550,000
			Current Contract Cost, Oct 07		$ 76,319,443
	CONTINGENCY		@	**25.0%**	19,079,861
					$ 95,399,304
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	9,340,242
	06 Account, Preservation - Mitigation-Tidal (0 acr @ $200,000/acr)				0
	06 Account, Preservation - Mitigation-Non-Tidal (40 acr @ $5,500/acr)				220,000
					$ 104,984,546
	30 Account, Plan, Engr.& Design		@	**8.0%**	8,398,764
					$ 113,383,310
	31 Account, Constr. Management		@	**6.0%**	6,802,999
					$ 120,186,308
	ESCALATION		@	**0.0%**	0
					$ 120,186,308
					rounded
			TOTAL PROJECT COST, Oct 07		**$ 120,200,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "A"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 20 ***Ocean Springs***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$1,640,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	11,795	sy	4.50	53,078
8" Water line removal	3,915	lf	8.00	31,320
6" Sewer line removal	3,915	lf	8.00	31,320
2" Gas line removal	3,915	lf	3.00	11,745
Electrical line removal - 3 phase 1440v	3,915	lf	11.00	43,065
24" Storm Drain removal	3,915	lf	11.00	43,065
Demolished structures (avg. 1,500 sf/ea @ 83 ea)	124,500	sf	3.00	373,500
Disposal Fee - off site	4,611	cy	2.50	11,528
NEW WORK:				
Compacted Fill (levee)	292,692	cy	15.00	4,390,380
Compacted Fill (cross overs)	755	cy	15.00	11,324
New Asphalt 2" (Cross overs) 296 cy figure 2.0 tons/cy	592	tons	70.00	41,440
Base material 12" (cross overs)	1,777	cy	34.50	61,307
Riprap (24")	79,047	cy	90.00	7,114,230
24 " gabion mattress cages, galv-pvc type	130,428	sy	32.00	4,173,696
Filter Fabric	130,428	sy	2.00	260,856
Grassing (seeding)	12	acres	2,150	25,800
Clearing and Grubbing, off-site disposal	52	acres	5,000	260,000
Crushed Aggregate 6" Thick(Levee wearing surface)	3,526	cy	45.00	158,670
Guardrail	1,396	lf	21.00	29,316
New 8" Water line	2,430	lf	41	99,630
New 6" Sewer Line	2,430	lf	48	116,640
New 2"Gas Line	2,430	lf	20	48,600
New Electrical Line - 3 phase 1440v	2,430	lf	44.00	106,920
New 24" Storm Drain	2,430	lf	68.00	165,240
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	13	pass-thrus		$3,666,357
Concrete Box Culverts	6,802	cy	700	4,761,400
#6 rebar (box culverts)	237	tons	925	219,225
			Subtotal	**$ 27,949,650**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3***
Jackson County ***Option "A"*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Ring Levee - elev. 20 ***Ocean Springs*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 27,949,650**
Flap Gates (8w x 4h)		30	ea	28,800	864,000
Flap Gates (6w x 3h)		19	ea	16,200	307,800
Flap Gates (10w x 4h)		5	ea	36,000	180,000
Flap Gates (7w x 3h)		18	ea	18,900	340,200
Cutoff valves (8w x 4h)		30	ea	67,200	2,016,000
Cutoff valves (6w x 3h)		19	ea	37,800	718,200
Cutoff valves (10w x 4h)		5	ea	84,000	420,000
Cutoff valves (7w x 3h)		18	ea	44,100	793,800
Pump stations, 42" to 60" pump size (14 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				33,461,226
Ditch Excavation		31,067	cy	12.00	372,804
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	3,290,000
			Current Contract Cost, Oct 07		$ 70,713,680
	CONTINGENCY		@	**25.0%**	17,678,420
					$ 88,392,101
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)				43,608,937
	06 Account, Preservation - Mitigation-Tidal (24 acr @ $200,000/acr)				800,000
	06 Account, Preservation - Mitigation-Non-Tidal (8 acr @ $5,500/acr)				44,000
					$ 132,870,038
	30 Account, Plan, Engr.& Design		@	**8.0%**	10,629,603
					$ 143,499,641
	31 Account, Constr. Management		@	**6.0%**	8,609,978
					$ 152,109,619
	ESCALATION		@	**0.0%**	0
					$ 152,109,619
					rounded
				TOTAL PROJECT COST, Oct 07	**$ 152,100,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "B"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Level - elev. 30 ***Ocean Springs***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,940,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	41,814	sy	4.50	188,163
8" Water line removal	12,800	lf	8.00	102,400
6" Sewer line removal	12,800	lf	8.00	102,400
2" Gas line removal	12,800	lf	3.00	38,400
Electric line removal - 3 phase 1440v	12,800	lf	11.00	140,800
24" Storm Drain removal	12,800	lf	11.00	140,800
Demolished structures (avg. 1,500 sf/ea @ 312 ea)	468,000	sf	3.00	1,404,000
Disposal Fee - off site	17,333	cy	2.50	43,333
NEW WORK:				
Compacted Fill (levee)	1,508,200	cy	15.00	22,623,000
New Asphalt 2" (Cross overs) 193 cy figure 2.0 tons/cy	578	tons	70.00	40,460
Base material 12" (cross overs)	3,467	cy	34.50	119,612
Riprap (12")	150,920	cy	90.00	13,582,800
24 " gabion mattress cages, galv-pvc type	498,037	sy	32.00	15,937,184
Filter Fabric	498,037	sy	2.00	996,074
Grassing (seeding)	54	acres	2,150	116,100
Clearing and Grubbing, off-site disposal	192	acres	5,000	960,000
Crushed Aggregate 6" Thick(Levee wearing surface)	10,671	cy	45.00	480,195
New 8" Water line	5,120	lf	41	209,920
New 6" Sewer Line	5,120	lf	48	245,760
New 2"Gas Line	5,120	lf	20	102,400
New Electrical Line - 3 phase 1440v	5,120	lf	44.00	225,280
New 24" Storm Drain	5,120	lf	68.00	348,160
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	33	pass-thrus		12,942,407
Concrete Box Culverts	6,802	cy	700	4,761,400
#6 rebar (box culverts)	237	tons	925	219,225
			Subtotal	**$ 79,010,272**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3***
Jackson County ***Option "B"*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Ring Level - elev. 30 ***Ocean Springs*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Subtotal, brought forward				**$ 79,010,272**
Flap Gates (8w x 4h)	30	ea	28,800	864,000
Flap Gates (6w x 3h)	19	ea	16,200	307,800
Flap Gates (10w x 4h)	5	ea	28,800	144,000
Flap Gates (7w x 3h)	18	ea	18,900	340,200
Cutoff valves (8w x 4h)	30	ea	67,200	2,016,000
Cutoff valves (6w x 3h)	19	ea	37,800	718,200
Cutoff valves (10w x 4h)	5	ea	84,000	420,000
Cutoff valves (7w x 3h)	18	ea	44,100	793,800
Pump stations, 42" to 60" pump size (14 ea) (reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				35,707,123
Ditch Excavation	31,067	cy	12.00	372,804
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	5,890,000
Current Contract Cost, Oct 07				$ 126,584,199
CONTINGENCY	@		**25.0%**	31,646,050
				$ 158,230,249
01 Account, Lands & Damage	PCA		**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	119,542,130
06 Account, Preservation - Mitigation-Tidal (38 acr @ $200,000/acr)				7,600,000
06 Account, Preservation - Mitigation-Tidal (38 acr @ $5,500/acr)				209,000
				$ 285,606,379
30 Account, Plan, Engr.& Design	@		**8.0%**	22,848,510
				$ 308,454,889
31 Account, Constr. Management	@		**6.0%**	18,507,293
				$ 326,962,182
ESCALATION	@		**0.0%**	0
				$ 326,962,182
				rounded
TOTAL PROJECT COST, Oct 07				**$ 327,000,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "A"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 20 ***Gautier***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$4,350,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	21,747	sy	4.50	97,862
8" Water line removal	7,000	lf	8.00	56,000
6" Sewer line removal	7,000	lf	8.00	56,000
2" Gas line removal	7,000	lf	3.00	21,000
Electrical line removal - 3 phase 1440v	7,000	lf	11.00	77,000
24" Storm Drain removal	7,000	lf	11.00	77,000
Demolished structures (avg. 1,500 sf/ea @ 139 ea)	208,500	sf	3.00	625,500
Disposal Fee - off site	7,722	cy	2.50	19,306
NEW WORK:				
Compacted Fill (levee)	821,665	cy	15.00	12,324,975
Compacted Fill (cross overs)	463	cy	15.00	6,945
New Asphalt 2" (Cross overs) 427 cy figure 2.0 tons/cy	854	tons	70.00	59,780
Base material 12" (cross overs)	2,561	cy	34.50	88,355
Riprap (24")	181,889	cy	90.00	16,370,010
24 " gabion mattress cages, galv-pvc type	300,117	sy	32.00	9,603,744
Filter Fabric	300,117	sy	2.00	600,234
Grassing (seeding)	32	acres	2,150	68,800
Clearing and Grubbing, off-site disposal	133	acres	5,000	665,000
Crushed Aggregate 6" Thick(Levee wearing surface)	8,377	cy	45.00	376,965
Guardrail	1,030	lf	21.00	21,630
New 8" Water line	2,750	lf	41	112,750
New 6" Sewer Line	2,750	lf	48	132,000
New 2"Gas Line	2,750	lf	20	55,000
New Electrical Line - 3 phase 1440v	2,750	lf	44.00	121,000
New 24" Storm Drain	2,750	lf	68.00	187,000
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	20	pass-thrus		5,051,370
Concrete Box Culverts	6,085	cy	700	4,259,500
#6 rebar (box culverts)	209	tons	925	193,325
			Subtotal	**$ 55,678,050**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "A"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 20 ***Gautier***

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$**	**55,678,050**
Flap Gates (8w x 4h)		27	ea	28,800	777,600
Flap Gates (12w x 4h)		23	ea	43,200	993,600
Flap Gates (7w x 3h)		32	ea	18,900	604,800
Flap Gates (6w x 3h)		8	ea	16,200	129,600
Flap Gates (5w x 3h)		3	ea	13,500	40,500
Cutoff valves (8w x 4h)		27	ea	67,200	1,814,400
Cutoff valves (12w x 4h)		23	ea	100,800	2,318,400
Cutoff valves (7w x 3h)		32	ea	44,100	1,411,200
Cutoff valves (6w x 3h)		8	ea	37,800	302,400
Cutoff valves (5w x 3h)		3	ea	31,500	94,500
Pump stations, 42" to 60" pump size (11 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				40,264,191
Ditch Excavation		95,652	cy	12.00	1,147,824
Boat Gate, G-1, G-2, G-3, G-4, G-5	(reference backup file for cost derivation)				72,907,018
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	8,700,000
			Current Contract Cost, Oct 07		$ 187,184,083
	CONTINGENCY		@	**25.0%**	46,796,021
					$ 233,980,103
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)				56,976,607
	06 Account, Preservation - Mitigation-Tidal (64 acr @ $200,000/acr)				12,800,000
	06 Account, Preservation - Mitigation-Non-Tidal (85 acr @ $5,500/acr)				467,500
					$ 304,249,210
	30 Account, Plan, Engr.& Design		@	**8.0%**	24,339,937
					$ 328,589,147
	31 Account, Constr. Management		@	**6.0%**	19,715,349
					$ 348,304,496
	ESCALATION		@	**0.0%**	0
					$ 348,304,496
					rounded
	TOTAL PROJECT COST, Oct 07			**$**	**348,300,000**

Notes:
Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "B"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 30 ***Gautier***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$5,750,000
REMOVALS:				
Asphalt removal 2" Thick(cross overs)	34,948	sy	4.50	157,266
8" Water line removal	10,915	lf	8.00	87,320
6" Sewer line removal	10,915	lf	8.00	87,320
2" Gas line removal	10,915	lf	3.00	32,745
Electric line removal - 3 phase 1440v	10,915	lf	11.00	120,065
24" Storm Drain removal	10,915	lf	11.00	120,065
Demolished structures (avg. 1,500 sf/ea @ 161 ea)	241,500	sf	3.00	724,500
Disposal Fee - off site	8,944	cy	2.50	22,361
NEW WORK:				
Compacted Fill (levee)	2,781,994	cy	15.00	41,729,910
New Asphalt 2" (Cross overs) 430 cy figure 2.0 tons/cy	860	tons	70.00	60,200
Base material 12" (cross overs)	2,578	cy	34.50	88,941
Riprap (12")	178,264	cy	90.00	16,043,760
24 " gabion mattress cages, galv-pvc type	588,272	sy	32.00	18,824,704
Filter Fabric	588,272	sy	2.00	1,176,544
Grassing (seeding)	72	acres	2,150	154,800
Clearing and Grubbing, off-site disposal	228	acres	5,000	1,140,000
Crushed Aggregate 6" Thick(Levee wearing surface)	10,587	cy	45.00	476,415
New 8" Water line	4,595	lf	41	188,395
New 6" Sewer Line	4,595	lf	48	220,560
New 2"Gas Line	4,595	lf	20	91,900
New Electrical Line - 3 phase 1440v	4,595	lf	44.00	202,180
New 24" Storm Drain	4,595	lf	68.00	312,460
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	23	pass-thrus		10,672,007
Concrete Box Culverts	6,085	cy	700	4,259,500
#6 rebar (box culverts)	209	tons	925	193,325
			Subtotal	**$ 102,937,244**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***Option "B"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Ring Levee - elev. 30 ***Gautier***

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$**	**102,937,244**
Flap Gates (8w x 4h)		27	ea	28,800	777,600
Flap Gates (12w x 4h)		23	ea	43,200	993,600
Flap Gates (7w x 3h)		32	ea	18,900	604,800
Flap Gates (6w x 3h)		8	ea	16,200	129,600
Flap Gates (5w x 3h)		3	ea	13,500	40,500
Cutoff valves (8w x 4h)		27	ea	67,200	1,814,400
Cutoff valves (12w x 4h)		23	ea	100,800	2,318,400
Cutoff valves (7w x 3h)		32	ea	44,100	1,411,200
Cutoff valves (6w x 3h)		8	ea	37,800	302,400
Cutoff valves (5w x 3h)		3	ea	31,500	94,500
Pump stations, 42" to 60" pump size (11 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				43,118,404
Ditch Excavation		95,652	cy	12.00	1,147,824
Boat Gate, G-1, G-2, G-3, G-4, G-5	(reference backup file for cost derivation)				80,248,938
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	11,800,000
			Current Contract Cost, Oct 07		$ 245,193,309
	CONTINGENCY		@	**25.0%**	61,298,327
					$ 306,491,636
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	66,585,077
	06 Account, Preservation - Mitigation-Tidal (95 acr @ $200,000/acr)				19,000,000
	06 Account, Preservation - Mitigation-Non-Tidal (188 acr @ $5,500/acr)				1,034,000
					$ 393,135,713
	30 Account, Plan, Engr.& Design		@	**8.0%**	31,450,857
					$ 424,586,570
	31 Account, Constr. Management		@	**6.0%**	25,475,194
					$ 450,061,764
	ESCALATION		@	**0.0%**	0
					$ 450,061,764
					rounded
	TOTAL PROJECT COST, Oct 07			**$**	**450,100,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Buffer Zones Jackson County***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Moss Point Option "E" elevation 20				
Demolished Structures, including Disposal (1,144 structures)	1	LS	allow	$30,440,402
Current Contract Cost, Oct 07				$30,440,402
CONTINGENCY		@	**25.0%**	7,610,101
				$38,050,503
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	330,695,519
				$368,771,022
30 Account, Plan, Engr.& Design		@	**8.0%**	29,501,682
				$398,272,703
31 Account, Constr. Management		@	**6.0%**	23,896,362
				$422,169,065
ESCALATION		@	**0.0%**	
				$422,169,065
				rounded
TOTAL PROJECT COST, Oct 07				$ 422,170,000

Notes:

The buffer zones for the alternate alignments will be used in combination with the cost estimates for the associated structural option. The Costs for the buffer zones will include acquisition of real estate and demolition of structures with contingencies and all administration and markups. Real Estate (01 feature account) & Demolition Cost furnished by the Savannah District COE, Belinda Estabrook, RE-RP, Realty Specialist.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Buffer Zones Jackson County***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Moss Point Option "F" elevation 30				
Demolished Structures, including Disposal (1,433 structures)	1	LS	allow	30,225,250
Current Contract Cost, Oct 07				$30,225,250
CONTINGENCY		@	**25.0%**	7,556,313
				$37,781,563
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	328,197,869
				$366,004,432
30 Account, Plan, Engr.& Design		@	**8.0%**	29,280,355
				$395,284,786
31 Account, Constr. Management		@	**6.0%**	23,717,087
				$419,001,873
ESCALATION		@	**0.0%**	
				$419,001,873
				rounded
TOTAL PROJECT COST, Oct 07				$ 419,000,000

Notes:

The buffer zones for the alternate alignments will be used in combination with the cost estimates for the associated structural option. The Costs for the buffer zones will include acquisition of real estate and demolition of structures with contingencies and all administration and markups. Real Estate (01 feature account) & Demolition Cost furnished by the Savannah District COE, Belinda Estabrook, RE-RP, Realty Specialist.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Buffer Zones Jackson County***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Washington Ave Option "C" elevation 20				
Demolished Structures, including Disposal (58 structures)	1	LS	allow	$1,160,076
Current Contract Cost, Oct 07				$1,160,076
CONTINGENCY		@	**25.0%**	290,019
				$1,450,095
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	61,306,156
				$62,781,251
30 Account, Plan, Engr.& Design		@	**8.0%**	5,022,500
				$67,803,751
31 Account, Constr. Management		@	**6.0%**	4,068,225
				$71,871,976
ESCALATION		@	**0.0%**	
				$71,871,976
				rounded
TOTAL PROJECT COST, Oct 07				$ 71,870,000

Notes:

The buffer zones for the alternate alignments will be used in combination with the cost estimates for the associated structural option. The Costs for the buffer zones will include acquisition of real estate and demolition of structures with contingencies and all administration and markups. Real Estate (01 feature account) & Demolition Cost furnished by the Savannah District COE, Belinda Estabrook, RE-RP, Realty Specialist.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Buffer Zones Jackson County***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Washington Ave Option "D" elevation 30				
Demolished Structures, including Disposal (47 structures)	1	LS	allow	$974,076
Current Contract Cost, Oct 07				$974,076
CONTINGENCY		@	**25.0%**	243,519
				$1,217,595
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	54,463,513
				$55,706,108
30 Account, Plan, Engr.& Design		@	**8.0%**	4,456,489
				$60,162,597
31 Account, Constr. Management		@	**6.0%**	3,609,756
				$63,772,352
ESCALATION		@	**0.0%**	
				$63,772,352
				rounded
TOTAL PROJECT COST, Oct 07				$ 63,770,000

Notes:

The buffer zones for the alternate alignments will be used in combination with the cost estimates for the associated structural option. The Costs for the buffer zones will include acquisition of real estate and demolition of structures with contingencies and all administration and markups. Real Estate (01 feature account) & Demolition Cost furnished by the Savannah District COE, Belinda Estabrook, RE-RP, Realty Specialist.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Buffer Zones Jackson County***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Moss Pt. - Washington Ave ***Option "G"*** ***elevation 20***				
Demolished Structures, including Disposal (1,502 structures)	1	LS	allow	$31,260,326
Current Contract Cost, Oct 07				$31,260,326
CONTINGENCY		@	**25.0%**	7,815,082
				$39,075,408
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	392,001,675
				$431,102,083
30 Account, Plan, Engr.& Design		@	**8.0%**	34,488,167
				$465,590,249
31 Account, Constr. Management		@	**6.0%**	27,935,415
				$493,525,664
ESCALATION		@	**0.0%**	
				$493,525,664
				rounded
TOTAL PROJECT COST, Oct 07				$ 493,530,000

Notes:

The buffer zones for the alternate alignments will be used in combination with the cost estimates for the associated structural option. The Costs for the buffer zones will include acquisition of real estate and demolition of structures with contingencies and all administration and markups. Real Estate (01 feature account) & Demolition Cost furnished by the Savannah District COE, Belinda Estabrook, RE-RP, Realty Specialist.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Buffer Zones Jackson County***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Moss Pt. - Washington Ave ***Option "H"*** ***elevation 30***				
Demolished Structures, including Disposal (1,473 structures)	1	LS	allow	$31,061,326
Current Contract Cost, Oct 07				$31,061,326
CONTINGENCY		@	**25.0%**	7,765,332
				$38,826,658
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	382,661,381
				$421,513,039
30 Account, Plan, Engr.& Design		@	**8.0%**	33,721,043
				$455,234,082
31 Account, Constr. Management		@	**6.0%**	27,314,045
				$482,548,126
ESCALATION		@	**0.0%**	
				$482,548,126
				rounded
TOTAL PROJECT COST, Oct 07				$ 482,550,000

Notes:

The buffer zones for the alternate alignments will be used in combination with the cost estimates for the associated structural option. The Costs for the buffer zones will include acquisition of real estate and demolition of structures with contingencies and all administration and markups. Real Estate (01 feature account) & Demolition Cost furnished by the Savannah District COE, Belinda Estabrook, RE-RP, Realty Specialist.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 7 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Buffer Zones Jackson County***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
BelleFontaine Option "C" elevation 20				
Demolished Structures, including Disposal (2 structures)	1	LS	allow	$143,076
Current Contract Cost, Oct 07				$143,076
CONTINGENCY		@	**25.0%**	35,769
				$178,845
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	2,519,063
				$2,722,908
30 Account, Plan, Engr.& Design		@	**8.0%**	217,833
				$2,940,741
31 Account, Constr. Management		@	**6.0%**	176,444
				$3,117,185
ESCALATION		@	**0.0%**	
				$3,117,185
				rounded
TOTAL PROJECT COST, Oct 07				$ 3,120,000

Notes:

The buffer zones for the alternate alignments will be used in combination with the cost estimates for the associated structural option. The Costs for the buffer zones will include acquisition of real estate and demolition of structures with contingencies and all administration and markups. Real Estate (01 feature account) & Demolition Cost furnished by the Savannah District COE, Belinda Estabrook, RE-RP, Realty Specialist.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 8 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Buffer Zones Jackson County***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
BelleFontaine Option "D" elevation 30				
Demolished Structures, including Disposal (0 structures)	1	LS	allow	$35,000
Current Contract Cost, Oct 07				$35,000
CONTINGENCY		@	**25.0%**	8,750
				$43,750
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	1,409,694
				$1,478,444
30 Account, Plan, Engr.& Design		@	**8.0%**	118,276
				$1,596,720
31 Account, Constr. Management		@	**6.0%**	95,803
				$1,692,523
ESCALATION		@	**0.0%**	
				$1,692,523
				rounded
TOTAL PROJECT COST, Oct 07				$ 1,690,000

Notes:

The buffer zones for the alternate alignments will be used in combination with the cost estimates for the associated structural option. The Costs for the buffer zones will include acquisition of real estate and demolition of structures with contingencies and all administration and markups. Real Estate (01 feature account) & Demolition Cost furnished by the Savannah District COE, Belinda Estabrook, RE-RP, Realty Specialist.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 9 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Buffer Zones Jackson County***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Gulf Park Estates Option "C" elevation 20				
Demolished Structures, including Disposal (11 structures)	1	LS	allow	$653,000
Current Contract Cost, Oct 07				$653,000
CONTINGENCY		@	**25.0%**	163,250
				$816,250
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	7,378,022
				$8,219,272
30 Account, Plan, Engr.& Design		@	**8.0%**	657,542
				$8,876,814
31 Account, Constr. Management		@	**6.0%**	532,609
				$9,409,423
ESCALATION		@	**0.0%**	
				$9,409,423
				rounded
TOTAL PROJECT COST, Oct 07				$ 9,410,000

Notes:

The buffer zones for the alternate alignments will be used in combination with the cost estimates for the associated structural option. The Costs for the buffer zones will include acquisition of real estate and demolition of structures with contingencies and all administration and markups. Real Estate (01 feature account) & Demolition Cost furnished by the Savannah District COE, Belinda Estabrook, RE-RP, Realty Specialist.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 10 OF 10
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Buffer Zones Jackson County***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Gulf Park Estates Option "D" elevation 30				
Demolished Structures, including Disposal (7 structures)	1	LS	allow	$531,000
Current Contract Cost, Oct 07				$531,000
CONTINGENCY		@	**25.0%**	132,750
				$663,750
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	5,962,259
				$6,651,009
30 Account, Plan, Engr.& Design		@	**8.0%**	532,081
				$7,183,090
31 Account, Constr. Management		@	**6.0%**	430,985
				$7,614,075
ESCALATION		@	**0.0%**	
				$7,614,075
				rounded
TOTAL PROJECT COST, Oct 07				$ 7,610,000

Notes:

The buffer zones for the alternate alignments will be used in combination with the cost estimates for the associated structural option. The Costs for the buffer zones will include acquisition of real estate and demolition of structures with contingencies and all administration and markups. Real Estate (01 feature account) & Demolition Cost furnished by the Savannah District COE, Belinda Estabrook, RE-RP, Realty Specialist.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 7
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Rdwy-Seawall - elev. 11 FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Jackson County Ocean Springs

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization		1	job	allow	$334,000
REMOVALS:					
Asphalt removal 2" Thick(Levee/Beach road)		26,445	sy	$4.50	119,003
Asphalt removal 2" Thick(cross overs)		13,314	sy	4.50	59,913
8" Water line removal		2,000	lf	8.00	16,000
6" Sewer line removal		2,000	lf	8.00	16,000
2" Gas line removal		2,000	lf	3.00	6,000
Electric line removal - 3 phase 1440v		2,000	lf	11.00	22,000
24" Storm Drain removal		2,000	lf	11.00	22,000
Demolished structures (avg. 1500 sf/ea @ 55ea)		82,500	sf	3.00	247,500
Disposal Fee		3,056	cy	2.50	7,639
Misc Removal		1	job	allow	10,000
NEW WORK"					
Compacted Fill (levee)		118,571	cy	15.00	1,778,565
Compacted Fill (cross overs)		15,314	cy	15.00	229,710
New Asphalt 2" (Levee/Beach road) 1,470 cy	figure 2.0 tons/cy	2,940	ton	70.00	205,800
New Asphalt 2" (Cross overs) 740 cy	figure 2.0 tons/cy	1,480	ton	70.00	103,600
Base material 12" (Levee/Beach road)		8,815	cy	34.50	304,118
Base material 12" (cross overs)		4,439	cy	34.50	153,146
Beach Dune fill (5' tall)		23,000	cy	12.00	276,000
Riprap (24")		31,254	cy	90.00	2,812,860
24 " gabion mattress cages, galv-pvc type		17,190	sy	32.00	550,080
Filter Fabric		17,190	sy	2.00	34,380
Grassing		7	acres	2,150	15,050
Clearing and Grubbing		34	acres	5,000	170,000
Crushed Aggregate 6" Thick(Levee wearing surface)		766	cy	45.00	34,470
Guardrail		9,985	lf	21.00	209,685
New 8" Water line		2,000	lf	41	82,000
New 6" Sewer Line		2,000	lf	48	96,000
New 2" Gas Line		2,000	lf	20	40,000
New Electric Line 3 phase 1440v		2,000	lf	44.00	88,000
New 24" Storm Drain		2,000	lf	68.00	136,000
Seawall (9917 LF x 25.0 sf/ft) A128		9,183	cy	600	5,509,800
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	$668,000
				Subtotal	**$14,357,317**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 7
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Rdwy-Seawall - elev. 11 FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Jackson County ***Ocean Springs***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Subtotal, brought forward				**$14,357,317**
Current Contract Cost, Oct 07				$14,357,317
CONTINGENCY		@	**25.0%**	3,589,329
				$17,946,647
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				39,005,114
06 Account, Preservation - Mitigation-Tidal (10 acr @ $200,000/acr)				2,000,000
06 Account, Preservation - Mitigation-Non-Tidal (4 acr @ $5,500/acr)				22,000
				$58,998,761
30 Account, Plan, Engr.& Design		@	**8.0%**	4,719,901
				$63,718,662
31 Account, Constr. Management		@	**6.0%**	3,823,120
				$67,541,781
ESCALATION		@	**0.0%**	0
				$ 67,541,781 rounded
TOTAL PROJECT COST, Oct 07				**$ 67,500,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 7
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Rdwy-Seawall - elev. 16 FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Harrison County ***Elevated US Hwy 90***

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization		1	job	allow	$22,770,000
REMOVALS:					
Asphalt removal 2" Thick(Levee/Beach road)		24,906,659	sy	4.50	112,079,966
Asphalt removal 2" Thick(cross overs)		166,582	sy	4.50	749,619
8" Water line removal		27,480	lf	8.00	219,840
6" Sewer line removal		27,480	lf	8.00	219,840
2" Gas line removal		27,480	lf	3.00	82,440
Electric line removal - 3 phase 1440v		27,480	lf	11.00	302,280
24" Storm Drain removal		113,515	lf	11.00	1,248,665
Storm Drain manhole/junction box removal		360	ea	500	180,000
Storm Drain curb inlet removal		984	ea	500	492,000
Storm Drain drop inlet removal		610	ea	500	305,000
Concrete sidewalk removal, including disposal		6,837	cy	82.00	560,634
Demolished structures (avg. 1500 sf/ea @ 80ea)		120,000	sf	3.00	360,000
Disposal Fee		4,444	cy	2.50	11,110
NEW WORK:					
Compacted Fill (levee)		4,689,128	cy	15.00	70,336,920
Compacted Fill (cross overs)		353,840	cy	15.00	5,307,600
Beach Dune Fill (10' tall)		600,000	cy	12.00	7,200,000
New Asphalt 2" (Levee/Beach road) 1,383,980 cy	figure 2.0 tons/cy	2,767,960	tons	70.00	193,757,200
New Asphalt 2" (Cross overs) 8,524 cy	figure 2.0 tons/cy	17,048	tons	70.00	1,193,360
Base material 12" (Levee/Beach road)		8,303,879	cy	34.50	286,483,826
Base material 12" (cross overs)		51,144	cy	34.50	1,764,468
Riprap (24")		458,544	cy	90.00	41,268,960
24 " gabion mattress cages, galv-pvc type		756,599	sy	32.00	24,211,168
Filter Fabric		756,599	sy	2.00	1,513,198
Grassing (seeding)		7	acres	2,150	15,050
Clearing and Grubbing, off-site disposal		486	acres	5,000	2,430,000
Crushed Aggregate 6" Thick(Levee wearing surface)		2,135	cy	45.00	96,075
Guardrail		80,340	lf	21	1,687,140
New 8" Water line		27,180	lf	41	1,114,380
New 6" Sewer Line		27,180	lf	48	1,304,640
New 2"Gas Line		27,180	lf	20	543,600
New Electrical Line - 3 phase 1440v		27,180	lf	44	1,195,920
New 24" Storm Drain		113,515	lf	68	7,719,020
New Storm Drain manhole/junction box		360	ea	1,800	648,000
New Storm Drain curb inlet		984	ea	1,400	1,377,600
New Storm Drain drop inlet		610	ea	1,600	976,000
Seawall (141,288 lf x 28.5 sf/ft) reinforced concrete		149,138	cy	600	89,482,800
Pump stations, 42" to 60" pump size (15 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				40,692,903
				Subtotal	**$921,901,221**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 7
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Rdwy-Seawall - elev. 16 FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Harrison County ***Elevated US Hwy 90***

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Subtotal, brought forward		**$921,901,221**
Concrete Box culverts	5,278	cy	700	3,694,600
#6 rebar (box culverts)	192	tons	925	177,600
Flap Gates (6w x 3h)	12	ea	16,200	194,400
Flap Gates (10w x 4h)	12	ea	36,000	432,000
Flap Gates (7w x 3h)	18	ea	18,900	340,200
Flap Gates (12w x 3h)	6	ea	32,400	194,400
Flap Gates (4w x 3h)	6	ea	10,800	64,800
Flap Gates (5w x 3h)	3	ea	13,500	40,500
Flap Gates (12w x 4h)	26	ea	43,200	1,123,200
Cutoff valves (12w x 4h)	26	ea	100,800	2,620,800
Cutoff valves (6w x 3h)	12	ea	37,800	453,600
Cutoff valves (10w x 4h)	12	ea	84,000	1,008,000
Cutoff valves (7w x 3h)	18	ea	44,100	793,800
Cutoff valves (12w x 3h)	6	ea	75,600	453,600
Cutoff valves (4w x 3h)	6	ea	25,200	151,200
Cutoff valves (5w x 3h)	3	ea	31,500	94,500
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	$45,550,000
		Current Contract Cost, Oct 07		**$979,288,421**
CONTINGENCY		@	**25.0%**	244,822,105
				$1,224,110,526
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	502,215,382
06 Account, Preservation - Mitigation-Tidal (56 acr @ $200,000/acr)				11,200,000
06 Account, Preservation - Mitigation-Non-Tidal (1 acr @ $5,500/acr)				5,500
				$1,737,556,408
30 Account, Plan, Engr.& Design		@	**8.0%**	139,004,513
				$1,876,560,920
31 Account, Constr. Management		@	**6.0%**	112,593,655
				$1,989,154,575
ESCALATION		@	**0.0%**	0
				$1,989,154,575
				rounded
TOTAL PROJECT COST, Oct 07				$1,989,200,000

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 7
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3***
Rdwy-Seawall - elev. 11 ***& Saddle Dikes -elev. 16***
Hancock County ***Beach Blvd***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Rdwy-Seawall - elev. 11					
Mobilization, Preparatory Work, Demobilization		1	job	allow	4,580,000
REMOVALS:					
Asphalt removal 2" Thick(Levee/Beach road)		2,862,597	sy	4.50	12,881,687
Asphalt removal 2" Thick(cross overs)		26,571	sy	4.50	119,570
8" Water line removal		4,900	lf	8.00	39,200
6" Sewer line removal		4,900	lf	8.00	39,200
2" Gas line removal		4,900	lf	3.00	14,700
Electric line removal - 3 phase 1440v		4,900	lf	11.00	53,900
24" Storm Drain removal		4,900	lf	11.00	53,900
Demolished structures (avg. 1500 sf/ea @ 66ea)		99,000	sf	3.00	297,000
Disposal Fee		3,667	cy	2.50	9,167
NEW WORK:					
Compacted Fill (levee)		382,017	cy	15.00	5,730,255
Compacted Fill (cross overs)		27,835	cy	15.00	417,525
Beach Dune fill (5' tall)		84,000	cy	12.00	1,008,000
New Asphalt 2" (Levee/Beach road) 159,065 cy	figure 2.0 tons/cy	318,130	tons	70.00	22,269,100
New Asphalt 2" (Cross overs) 1,432 cy	figure 2.0 tons/cy	2,864	tons	70.00	200,480
Base material 12" (Levee/Beach road)		954,388	cy	34.50	32,926,386
Base material 12" (cross overs)		8,592	cy	34.50	296,424
Riprap (24")		150,072	cy	90.00	13,506,480
24 " gabion mattress cages, galv-pvc type		247,619	sy	32.00	7,923,808
Filter Fabric		247,619	sy	2.00	495,238
Grassing (seeding)		2	acres	2,150.00	4,300
Clearing and Grubbing		93	acres	5,000	465,000
Crushed Aggregate 6" Thick(Levee wearing surface)		1,556	cy	45.00	70,020
Guardrail		15,370	lf	21.00	322,770
New 8" Water line		4,600	lf	41	188,600
New 6" Sewer Line		4,600	lf	48	220,800
New 2"Gas Line		4,600	lf	20	92,000
New Electri Line - 3 phase 1440v		4,600	lf	44.00	202,400
New 24" Storm Drain		4,810	lf	68.00	327,080
Rdwy/RR Pass-Thrus	(reference backup file for cost derivation)	4	pass-thrus		386,780
Box Culvert Extension (beach road)		114	cy	700	79,800
#6 rebar (box culverts extension beach road)		4	tons	925	3,700
Drop inlets		22	ea	1,600	35,200
Concrete seawall (39,782 LF x 25.0 sf/ft)		36,836	cy	600	22,101,600
Concrete Box culverts (pump stations)		7,490	cy	700	5,243,000
#6 rebar (box culverts)		254	tons	925	234,950
				Subtotal	**$132,840,018**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 7
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Rdwy-Seawall - elev. 11 & Saddle Dikes -elev. 16 Hancock County Beach Blvd***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
				Subtotal, brought forward	**$132,840,018**
Pump stations, 42" to 60" pump size (13 ea) (reference backup file for cost derivation)			lump sum	allow	26,763,616
Ditch excavation		35,358	cy	12.00	424,296
Flap Gates (8w x 4h)		19	ea	28,800	547,200
Flap Gates (12w x 4h)		33	ea	43,200	1,425,600
Flap Gates (7w x 3h)		11	ea	18,900	207,900
Flap Gates (4w x 2h)		2	ea	7,200	14,400
Flap Gates (10w x 4h)		36	ea	36,000	1,296,000
Cutoff valves (8w x 4h)		19	ea	67,200	1,276,800
Cutoff valves (12w x 4h)		33	ea	100,800	3,326,400
Cutoff valves (7w x 3h)		11	ea	44,100	485,100
Cutoff valves (4w x 2h)		2	ea	16,800	33,600
Cutoff valves (10w x 4h)		36	ea	84,000	3,024,000
Boat Gate- HK-1 (reference backup file for cost derivation)					13,587,948
Hancock County El. 16 Saddle Dikes					
REMOVALS:					
Asphalt removal 2" Thick(cross overs)		14,157	sy	4.50	63,707
8" Water line removal		600	lf	8.00	4,800
6" Sewer line removal		600	lf	8.00	4,800
2" Gas line removal		600	lf	3.00	1,800
Electric line removal - 3 phase 1440v		600	lf	11.00	6,600
24" Storm Drain removal		600	lf	11.00	6,600
NEW WORK:					
Compacted Fill (levee)		53,903	cy	15.00	808,545
Compacted Fill (cross overs)		19,927	cy	15.00	298,905
New Asphalt 2" (Cross overs) 787 cy	figure 2.0 tons/cy	1,574	tons	70.00	110,180
Base material 12" (cross overs) 4,720 cy	figure 2.0 tons/cy	9,440	tons	70.00	660,800
Grassing (seeding)		39	acres	2,150	83,850
Clearing and Grubbing		41	acres	5,000	205,000
Guardrail		10,618	lf	21.00	222,978
New 8" Water line		600	lf	41	24,600
New 6" Sewer Line		600	lf	48	28,800
New 2" Gas Line		600	lf	20	12,000
New Electric Line- 3 phase 1440v		600	lf	44.00	26,400
New 24" Storm Drain		600	lf	68.00	40,800
ATFP, Signage, Pavement Marking, Traffic Control, etc.		2	%	allow	3,670,000
				Subtotal	**$191,534,042**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 7 OF 7
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 Rdwy-Seawall - elev. 11 & Saddle Dikes -elev. 16 Hancock County Beach Blvd***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Current Contract Cost, Oct 07				**$191,534,042**
CONTINGENCY	@		**25.0%**	47,883,510
				$ 239,417,552
01 Account, Lands & Damage	PCA		**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				44,938,806
06 Account, Preservation - Mitigation-Tidal (9 acr @ $200,000/acr)				1,800,000
06 Account, Preservation - Mitigation-Tidal (62 acr @ $5,500/acr)				341,000
				$ 286,522,358
30 Account, Plan, Engr.& Design	@		**8.0%**	22,921,789
				$ 309,444,147
31 Account, Constr. Management	@		**6.0%**	18,566,649
				$328,010,796
ESCALATION	@		**0.0%**	0
				$ 328,010,796
				rounded
TOTAL PROJECT COST, Oct 07				**$328,000,000**

Notes:

Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 20 Option "A"

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$950,000
Levee System				
Length	67,780	lf		
Compacted Fill	215,340	cy	15.00	3,230,100
Grassing (seeding)	23	Ac	2,150	49,450
Crushed Aggregate 6" Thick(Levee wearing surface)	25,100	cy	45.00	1,129,500
Rock Levee	61,450	cy	90.00	5,530,500
Clearing & Grubbing	120	Ac	5,000	600,000
24" Rip Rap	61,450	cy	90.00	5,530,500
24 " Gabion Mattress Cages	92,180	sy	32.00	2,949,760
Filter Fabric	92,180	sy	2.00	184,360
Ramps & Tunnels				
Grassing (seeding)	5	ac	2,150	10,750
New Asphalt 2" (Cross overs) 82 cy figure 2.0 tons/cy	164	tons	70.00	11,480
Base material (12")	720	cy	34.50	24,840
Removal				
Asphalt	246	sy	4.50	1,107
8" Water line removal	800	lf	8.00	6,400
6" Sewer line removal	800	lf	8.00	6,400
2" Gas line removal	800	lf	3.00	2,400
24" Storm drain pipe removal	800	lf	11.00	8,800
Electric line removal - 3 phase 1440v	800	lf	11.00	8,800
Demolish Buildings (avg. 1500 sf/ea @ 200 ea)	300,000	sf	3.00	900,000
Demolish Buildings (multistory avg. 1500 sf/ea @ 41 ea)	61,500	sf	3.50	215,250
Disposal Fee - off site	13,389	cy	2.50	33,472
Water tanks	4	ea	125,000	500,000
New Work				
New 8" Water line	800	lf	41	32,800
New 6" Sewer Line	800	lf	48	38,400
New 2"Gas Line	800	lf	20	16,000
New Electric Line - 3 phase 1440v	800	lf	44.00	35,200
New 24" Storm drain pipe	800	lf	68.00	54,400
			Subtotal	**$ 22,060,669**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 20 Option "A"

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Subtotal, brought forward				**$ 22,060,669**
Concrete box culverts	1,248	cy	700	873,600
#6 rebar	42	tons	925	38,850
Flap Gates (7w x 3h)	7	ea	18,900	132,300
Flap Gates (10w x 4h)	11	ea	36,000	396,000
Cutoff valves (7w x 3h)	7	ea	44,100	308,700
Cutoff valves (10w x 4h)	11	ea	84,000	924,000
Pump stations, 42" to 60" pump size (2 ea) (reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				9,271,149
Ditch Excavation	418,966	cy	12.00	5,027,592
Anti-Terrorism/Force Protection, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	1,900,000
Current Contract Cost, Oct 07				$ 40,932,861
CONTINGENCY		@	**25.0%**	10,233,215
				$ 51,166,076
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	58,505,782
06 Account, Preservation - Mitigation-Tidal (4 acr @ $200,000/acr)				800,000
06 Account, Preservation - Mitigation-Non-Tidal (68 acr @ $5,500/acr)				374,000
				$ 110,870,858
30 Account, Plan, Engr.& Design		@	**8.0%**	8,869,669
				$ 119,740,526
31 Account, Constr. Management		@	**6.0%**	7,184,432
				$ 126,924,958
ESCALATION		@	**0.0%**	0
				$ 126,924,958
				rounded
TOTAL PROJECT COST, Oct 07				**$ 126,900,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 30 Option "B"

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization		1	job	allow	$2,360,000
Levee System					
Length		68,110	lf		
Compacted Fill		1,398,140	cy	15.00	20,972,100
Grassing (seeding)		13	Ac	2,150	27,950
Crushed Aggregate 6" Thick(Levee wearing surface)		37,840	cy	45.00	1,702,800
Rock Levee		56,380	cy	90.00	5,074,200
Clearing & Grubbing		135	Ac	5,000	675,000
24" Rip Rap		218,300	cy	90.00	19,647,000
24 " Gabion Mattress Cages		654,870	sy	32.00	20,955,840
Filter Fabric		654,870	sy	2.00	1,309,740
Ramps & Tunnels	same as elev 40				
Vehicle/RR Gate-two lane (24')	(reference backup file for cost derivation) (same cost as elev 40)				362,133
Ramps-two lane (24')	(included in above levee system quantities)				
Compacted Fill (ramps and tunnels)		61,670	cy	15.00	925,050
Grassing (seeding)		14	ac	2,150	30,100
New Asphalt 2" (Cross overs) 3984 cy	figure 2.0 tons/cy	7,968	tons	70.00	557,760
Base material (12")		9,400	cy	34.50	324,300
Guardrail		16,000	lf	21.00	336,000
Removal					
Asphalt		25,000	sy	4.50	112,500
8" Water line removal		8,000	lf	8.00	64,000
6" Sewer line removal		8,000	lf	8.00	64,000
2" Gas line removal		8,000	lf	3.00	24,000
24" Storm drain pipe removal		8,000	lf	11.00	88,000
Electric line removal - 3 phase 1440v		8,000	lf	11.00	88,000
Demolish Buildings (avg. 1500 sf/ea @ 200 ea)		300,000	sf	3.00	900,000
Demolish Buildings (multistory avg. 1500 sf/ea @ 41 ea)		61,500	sf	3.50	215,250
Disposal Fee - off site		13,389	cy	2.50	33,472
Water tanks		4	ea	125,000	500,000
New Work					
New 8" Water line		8,000	lf	41	328,000
New 6" Sewer Line		8,000	lf	48	384,000
New 2"Gas Line		8,000	lf	20	160,000
New Electric Line - 3 phase 1440v		8,000	lf	44.00	352,000
New 24" Storm drain pipe		8,000	lf	68.00	544,000
				Subtotal	**$ 79,117,195**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4***
Jackson County
Inland Barrier - elev. 30 Option "B"
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price		ESTIMATED AMOUNT
			Subtotal, brought forward		**$**	**79,117,195**
Concrete box culverts		1,248	cy	700		873,600
#6 rebar		42	tons	925		38,850
Flap Gates (7w x 3h)		7	ea	18,900		132,300
Flap Gates (10w x 4h)		11	ea	36,000		396,000
Cutoff valves (7w x 3h)		7	ea	44,100		308,700
Cutoff valves (10w x 4h)		11	ea	84,000		924,000
Pump stations, 42" to 60" pump size (2 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)					9,855,749
Ditch Excavation		418,966	cy	12.00		5,027,592
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow		4,720,000
			Current Contract Cost, Oct 07		$	101,393,987
	CONTINGENCY		@	**25.0%**		25,348,497
					$	126,742,483
	01 Account, Lands & Damage		PCA	**LS**		25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**		66,571,033
	06 Account, Preservation - Mitigation-Tidal (7 acr @ $200,000/acr)					1,400,000
	06 Account, Preservation - Mitigation-Non-Tidal (295 acr @ $5,500/acr)					1,622,500
					$	196,361,016
	30 Account, Plan, Engr.& Design		@	**8.0%**		15,708,881
					$	212,069,898
	31 Account, Constr. Management		@	**6.0%**		12,724,194
					$	224,794,092
	ESCALATION		@	**0.0%**		0
					$	224,794,092
						rounded
				TOTAL PROJECT COST, Oct 07	**$**	**224,800,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 40 Option "C"

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,900,000
Levee System				
Length	73,874	lf		
Compacted Fill	4,067,550	cy	15.00	61,013,250
Grassing (seeding)	206	Ac	2,150	442,900
Crushed Aggregate 6" Thick(Levee wearing surface)	41,050	cy	45.00	1,847,250
Rock Levee	208,240	cy	90.00	18,741,600
Clearing & Grubbing	317	Ac	5000	1,585,000
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	4	pass-thrus		362,133
Compacted Fill (ramps and tunnels)	238,960	cy	15.00	3,584,400
Grassing (seeding)	16	ac	2,150	34,400
New Asphalt 2" (Cross overs) 4620 cy figure 2.0 tons/cy	9,240	tons	70.00	646,800
Base material (12")	13,500	cy	34.50	465,750
Guardrail	7,200	lf	21.00	151,200
Removal				
Asphalt	29,400	sy	4.50	132,300
8" Water line removal	13,000	lf	41	533,000
6" Sewer line removal	13,000	lf	48	624,000
2" Gas line removal	13,000	lf	20	260,000
24" Storm drain pipe removal	13,000	lf	11.00	143,000
Electric line removal - 3 phase 1440v	13,000	lf	11.00	143,000
Demolish Buildings (avg. 1500 sf/ea @ 200 ea)	300,000	sf	3.00	900,000
Demolish Buildings (multistory avg. 1500 sf/ea @ 41 ea)	61,500	sf	3.50	215,250
Disposal Fee - off site	13,389	cy	2.50	33,472
Water tanks	4	ea	125,000	500,000
New Work				
New 8" Water line	13,000	lf	8.00	104,000
New 6" Sewer Line	13,000	lf	8.00	104,000
New 2"Gas Line	13,000	lf	3.00	39,000
New Electric Line - 3 phase 1440v	13,000	lf	44.00	572,000
New 24" Storm drain pipe	13,000	lf	68.00	884,000
			Subtotal	**$ 94,061,705**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 40 Option "C"

DESCRIPTION		Quantity	Unit	Unit Price		ESTIMATED AMOUNT
			Subtotal, brought forward		**$**	**94,061,705**
Concrete box culverts		1,248	cy	700		873,600
#6 rebar		42	tons	925		38,850
Flap Gates (7w x 3h)		7	ea	18,900		132,300
Flap Gates (10w x 4h)		11	ea	36,000		396,000
Cutoff valves (7w x 3h)		7	ea	44,100		308,700
Cutoff valves (10w x 4h)		11	ea	84,000		924,000
Pump stations, 42" to 60" pump size (2 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)					14,318,944
Ditch Excavation		418,966	cy	12.00		5,027,592
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow		5,800,000
			Current Contract Cost, Oct 07		$	121,881,692
	CONTINGENCY		@	**25.0%**		30,470,423
					$	152,352,115
	01 Account, Lands & Damage		PCA	**LS**		25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**		76,230,875
	06 Account, Preservation - Mitigation-Tidal (8 acr @ $200000/acr)					1,600,000
	06 Account, Preservation - Mitigation-Tidal (387 acr @ $5,500/acr)					2,128,500
					$	232,336,490
	30 Account, Plan, Engr.& Design		@	**8.0%**		18,586,919
					$	250,923,409
	31 Account, Constr. Management		@	**6.0%**		15,055,405
					$	265,978,813
	ESCALATION		@	**0.0%**		0
					$	265,978,813
						rounded
	TOTAL PROJECT COST, Oct 07				**$**	**266,000,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 7 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 20 Option "A"

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,390,000
Levee System				
Length	142,732	lf		
Compacted Fill	582,723	cy	15.00	8,740,845
Grassing (seeding)	67	Ac	2,150	144,050
Crushed Aggregate 6" Thick(Levee wearing surface)	52,864	cy	45.00	2,378,880
Rock Levee	207,205	cy	90.00	18,648,450
Clearing & Grubbing	260	Ac	5,000	1,300,000
24" Rip Rap	184,790	cy	90.00	16,631,100
24 " Gabion Mattress Cages	277,180	sy	32.00	8,869,760
Filter Fabric	277,180	sy	2.00	554,360
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	45	pass-thrus		11,369,882
New Asphalt 2" (Cross overs) 900 cy figure 2.0 tons/cy	1,800	tons	70.00	126,000
Base material (12")	24,300	cy	34.50	838,350
Removal				
Asphalt	4,050	sy	4.50	18,225
8" Water line removal	8,000	lf	41	328,000
6" Sewer line removal	8,000	lf	48	384,000
2" Gas line removal	8,000	lf	20	160,000
24" Storm drain pipe removal	8,000	lf	11.00	88,000
Electric line removal - 3 phase 1440v	8,000	lf	11.00	88,000
Demolish Buildings (avg. 1500 sf/ea @ 861 ea)	1,291,500	sf	3.00	3,874,500
Disposal Fee - off site	47,833	cy	2.50	119,583
New Work				
New 8" Water line	8,000	lf	8.00	64,000
New 6" Sewer Line	8,000	lf	8.00	64,000
New 2"Gas Line	8,000	lf	3.00	24,000
New Electric Line - 3 phase 1440v	8,000	lf	44.00	352,000
New 24" Storm drain pipe	8,000	lf	68.00	544,000
			Subtotal	**$ 75,709,985**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 8 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 20 Option "A"

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 75,709,985**
Concrete box culverts		3,656	cy	700	2,559,200
#6 rebar		119	tons	925	110,075
Flap Gates (12w x 4h)		28	ea	43,200	1,209,600
Flap Gates (10w x 4h)		15	ea	36,000	540,000
Cutoff valves (7w x 3h)		7	ea	44,100	308,700
Cutoff valves (10w x 4h)		11	ea	84,000	924,000
Pump stations, 42" to 60" pump size (1 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				3,727,691
Ditch Excavation		872,375	cy	12.00	10,468,500
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	4,780,000
			Current Contract Cost, Oct 07		$ 100,337,751
	CONTINGENCY		@	**25.0%**	25,084,438
					$ 125,422,189
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	253,268,000
	06 Account, Preservation - Mitigation-Tidal (8 acr @ $200,000/acr)				1,600,000
	06 Account, Preservation - Mitigation-Non-Tidal (68 acr @ $5,500/acr)				374,000
					$ 380,689,189
	30 Account, Plan, Engr.& Design		@	**8.0%**	30,455,135
					$ 411,144,324
	31 Account, Constr. Management		@	**6.0%**	24,668,659
					$ 435,812,983
	ESCALATION		@	**0.0%**	0
					$ 435,812,983
					rounded
	TOTAL PROJECT COST, Oct 07				**$ 435,800,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 9 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 30 Option "B"

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$6,610,000
Levee System				
Length	142,732	lf		
Compacted Fill	2,910,170	cy	15.00	43,652,550
Grassing (seeding)	45	Ac	2,150	96,750
Crushed Aggregate 6" Thick(Levee wearing surface)	79,295	cy	45.00	3,568,275
Rock Levee	202,280	cy	90.00	18,205,200
Clearing & Grubbing	340	Ac	5,000	1,700,000
12" Rip Rap	544,102	cy	90.00	48,969,180
12 " Gabion Matress Cages	1,632,305	sy	16.00	26,116,880
Filter Fabric	1,632,305	sy	2.00	3,264,610
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	158	pass-thrus		40,232,904
New Asphalt 2" (Cross overs) 18500 cy figure 2.0 tons/cy	37,000	tons	70.00	2,590,000
Base material (12")	22,220	cy	34.50	766,590
Guardrail	50,000	lf	21.00	1,050,000
Removal				
Asphalt	225,100	sy	4.50	1,012,950
8" Water line removal	85,000	lf	41	3,485,000
6" Sewer line removal	85,000	lf	48	4,080,000
2" Gas line removal	85,000	lf	20	1,700,000
24" Storm drain pipe removal	85,000	lf	11.00	935,000
Electric line removal - 3 phase 1440v	85,000	lf	11.00	935,000
Demolish Buildings (avg. 1500 sf/ea @ 935 ea)	1,291,500	sf	3.00	3,874,500
Disposal Fee - off site	47,833	cy	2.50	119,583
New Work				
New 8" Water line	75,000	lf	8.00	600,000
New 6" Sewer Line	75,000	lf	8.00	600,000
New 2"Gas Line	75,000	lf	3.00	225,000
New Electric Line - 3 phase 1440v	75,000	lf	44.00	3,300,000
New 24" Storm drain pipe	75,000	lf	68.00	5,100,000
			Subtotal	**$222,789,972**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 10 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 30 Option "B"

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$**	**222,789,972**
Concrete box culverts		3,656	cy	700	2,559,200
#6 rebar		119	tons	925	110,075
Flap Gates (12w x 4h)		28	ea	43,200	1,209,600
Flap Gates (10w x 4h)		15	ea	36,000	540,000
Cutoff valves (12w x 4h)		28	ea	100,800	2,822,400
Cutoff valves (10w x 4h)		15	ea	84,000	1,260,000
Pump stations, 42" to 60" pump size (7 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				23,568,446
Ditch Excavation		872,375	cy	12.00	10,468,500
Biloxi Courthous Flood Wall	(reference backup file for cost derivation)	1	Job	ls	5,639,400
Gulfport Courthouse Flood wall	(reference backup file for cost derivation)	1	Job	ls	6,071,580
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	13,220,000
			Current Contract Cost, Oct 07	$	290,259,173
	CONTINGENCY		@	**25.0%**	72,564,793
				$	362,823,967
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	271,796,962
	06 Account, Preservation - Mitigation-Tidal (17 acr @ $200,000/acr)				3,400,000
	06 Account, Preservation - Mitigation-Non-Tidal (180 acr @ $5,500/acr)				990,000
				$	639,035,929
	30 Account, Plan, Engr.& Design		@	**8.0%**	51,122,874
				$	690,158,803
	31 Account, Constr. Management		@	**6.0%**	41,409,528
				$	731,568,331
	ESCALATION		@	**0.0%**	0
				$	731,568,331
					rounded
	TOTAL PROJECT COST, Oct 07			**$**	**731,600,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 11 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 40 Option "C"

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$9,480,000
Levee System				
Length	142,732	lf		
Compacted Fill	8,186,158	cy	15.00	122,792,370
Grassing (seeding)	410	Ac	2,150	881,500
Crushed Aggregate 6" Thick(Levee wearing surface)	79,300	cy	45.00	3,568,500
Rock Levee	1,038,130	cy	90.00	93,431,700
Clearing & Grubbing	625	Ac	5,000	3,125,000
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	161	pass-thrus		78,715,972
Grassing (seeding)	245	Ac	2,150	526,750
New Asphalt 2" (Cross overs) 2400 cy figure 2.0 tons/cy	4,800	tons	70.00	336,000
Base material (12")	15,000	cy	34.50	517,500
Removal				
Asphalt	225,100	sy	4.50	1,012,950
8" Water line removal	85,000	lf	41	3,485,000
6" Sewer line removal	85,000	lf	48	4,080,000
2" Gas line removal	85,000	lf	20	1,700,000
24" Storm drain pipe removal	85,000	lf	11.00	935,000
Electric line removal - 3 phase 1440v	85,000	lf	11.00	935,000
Demolish Buildings (avg. 1500 sf/ea @ 925 ea)	1,291,500	sf	3.00	3,874,500
Demolish Buildings (multistory avg. 1500 sf/ea @ 41 ea)	132,000	sf	3.50	462,000
Disposal Fee - off site	52,722	cy	2.50	131,806
Water tanks	4	ea	125,000	500,000
New Work				
New 8" Water line	40,250	lf	8.00	322,000
New 6" Sewer Line	40,250	lf	8.00	322,000
New Electric Line - 3 phase 1440v	40,250	lf	44.00	1,771,000
New 24" Storm drain pipe	40,250	lf	68.00	2,737,000
			Subtotal	**$335,643,548**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 12 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 40 Option "C"

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$**	**335,643,548**
Concrete box culverts		3,656	cy	700	2,559,200
#6 rebar		119	tons	925	110,075
Flap Gates (12w x 4h)		28	ea	43,200	1,209,600
Flap Gates (10w x 4h)		15	ea	36,000	540,000
Cutoff valves (12w x 4h)		28	ea	100,800	2,822,400
Cutoff valves (10w x 4h)		15	ea	84,000	1,260,000
Pump stations, 42" to 60" pump size (7 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				25,449,584
Ditch Excavation		872,375	cy	12.00	10,468,500
Biloxi Courthous Flood Wall	(reference backup file for cost derivation)	1	Job	ls	8,765,200
Gulfport Courthouse Flood wall	(reference backup file for cost derivation)	1	Job	ls	9,348,980
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	18,970,000
			Current Contract Cost, Oct 07	$	417,147,087
	CONTINGENCY		@	**25.0%**	104,286,772
				$	521,433,858
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	300,446,455
	06 Account, Preservation - Mitigation-Tidal (21 acr @ $200,000/acr)				4,200,000
	06 Account, Preservation - Mitigation-Non-Tidal (216 acr @ $5,500/acr)				1,188,000
				$	827,293,313
	30 Account, Plan, Engr.& Design		@	**8.0%**	66,183,465
				$	893,476,778
	31 Account, Constr. Management		@	**6.0%**	53,608,607
				$	947,085,385
	ESCALATION		@	**0.0%**	0
				$	947,085,385
					rounded
	TOTAL PROJECT COST, Oct 07			**$**	**947,100,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 13 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County Option "D" FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Levee for Roadway(75') - elev. 20

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,170,000
Levee System				
Length	142,730	lf		
Compacted Fill	1,224,812	cy	15.00	18,372,180
Grassing (seeding)	84	Ac	2,150	180,600
Crushed Aggregate 6" Thick(Levee wearing surface)	3,251	cy	45.00	146,295
24" Rip Rap	148,140	cy	90.00	13,332,600
Filter Fabric	222,210	sy	2.00	444,420
24 " Gabion Matress Cages	222,210	sy	32.00	7,110,720
Clearing & Grubbing	142	Ac	5,000	710,000
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	42	pass-thrus		19,584,340
Grassing (seeding)	4	Ac	2,150	8,600
New Asphalt 2" (Cross overs) 12 cy figure 2.0 tons/cy	4	tons	70.00	280
Base material (12")	35	cy	34.50	1,208
Removal				
Asphalt	12,575	sy	4.50	56,588
8" Water line removal	4,700	lf	41	192,700
6" Sewer line removal	4,700	lf	48	225,600
2" Gas line removal	4,700	lf	20	94,000
24" Storm drain pipe removal	4,700	lf	11.00	51,700
Electric line removal - 3 phase 1440v	4,000	lf	11.00	44,000
Demolish Buildings (avg. 1500 sf/ea @ 140 ea)	210,000	sf	3.00	630,000
Disposal Fee - off site	7,778	cy	2.50	19,444
Water tanks	4	ea	125,000	500,000
New Work				
New 8" Water line	4,700	lf	8.00	37,600
New 6" Sewer Line	4,700	lf	8.00	37,600
New 2" Gas Line	4,700	lf	8.00	37,600
New Electric Line - 3 phase 1440v	4,000	lf	44.00	176,000
New 24" Storm drain pipe	4,700	lf	68.00	319,600
			Subtotal	**$64,483,674**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 14 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County Option "D" FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Levee for Roadway(75') - elev. 20

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$**	**64,483,674**
Concrete box culverts		6,215	cy	700	4,350,500
#6 rebar		201	tons	925	185,925
Flap Gates (12w x 4h)		28	ea	43,200	1,209,600
Flap Gates (10w x 4h)		15	ea	36,000	540,000
Cutoff valves (12w x 4h)		28	ea	100,800	2,822,400
Cutoff valves (10w x 4h)		15	ea	84,000	1,260,000
Pump stations, 42" to 60" pump size (1 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				3,727,691
Ditch Excavation		872,375	cy	12.00	10,468,500
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	4,340,000
			Current Contract Cost, Oct 07	$	93,388,290
	CONTINGENCY		@	**25.0%**	23,347,073
				$	116,735,363
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	58,265,920
	06 Account, Preservation - Mitigation-Tidal (17 acr @ $200,000/acr)				3,400,000
	06 Account, Preservation - Mitigation-Non-Tidal (180 acr @ $5,500/acr)				990,000
				$	179,416,283
	30 Account, Plan, Engr.& Design		@	**8.0%**	14,353,303
				$	193,769,585
	31 Account, Constr. Management		@	**6.0%**	11,626,175
				$	205,395,760
	ESCALATION		@	**0.0%**	0
				$	205,395,760
					rounded
	TOTAL PROJECT COST, Oct 07			**$**	**205,400,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 15 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County Option "E" FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Levee for Roadway(75') - elev. 30

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$6,830,000
Levee System				
Length	142,730	lf		
Compacted Fill	5,723,060	cy	15.00	85,845,900
Grassing (seeding)	350	Ac	2,150	752,500
Crushed Aggregate 6" Thick(Levee wearing surface)	13,027	cy	45.00	586,215
24" Rip Rap	304,200	cy	90.00	27,378,000
12 " Gabion Matress Cages	912,593	sy	16.00	14,601,488
Filter Fabric	912,593	sy	2.00	1,825,186
Clearing & Grubbing	587	Ac	5,000	2,935,000
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	140	pass-thrus		65,785,779
New Asphalt 2" (Cross overs) 2,384 cy figure 2.0 tons/cy	4,768	tons	70.00	333,760
Base material (12")	14,311	cy	34.50	493,730
Removal				
Asphalt	225,100	sy	4.50	1,012,950
8" Water line removal	85,000	lf	41	3,485,000
6" Sewer line removal	85,000	lf	48	4,080,000
2" Gas line removal	85,000	lf	20	1,700,000
24" Storm drain pipe removal	85,000	lf	11.00	935,000
Electric line removal - 3 phase 1440v	85,000	lf	11.00	935,000
Demolish Buildings (avg. 1500 sf/ea @ 1,138 ea)	1,707,000	sf	3.00	5,121,000
Disposal Fee - off site	63,222	cy	2.50	158,056
Water tanks	4	ea	125,000	500,000
New Work				
New 8" Water line	75,000	lf	8.00	600,000
New 6" Sewer Line	75,000	lf	8.00	600,000
New 2" Gas Line	75,000	lf	8.00	600,000
New Electric Line - 3 phase 1440v	75,000	lf	44.00	3,300,000
New 24" Storm drain pipe	75,000	lf	68.00	5,100,000
			Subtotal	**$235,494,563**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 16 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County Option "E" FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Levee for Roadway(75') - elev. 30

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$**	**235,494,563**
Concrete box culverts		6,215	cy	700	4,350,500
#6 rebar		201	tons	925	185,925
Flap Gates (12w x 4h)		28	ea	43,200	1,209,600
Flap Gates (10w x 4h)		15	ea	36,000	540,000
Cutoff valves (12w x 4h)		28	ea	100,800	2,822,400
Cutoff valves (10w x 4h)		15	ea	84,000	1,260,000
Pump stations, 42" to 60" pump size (7 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				23,568,446
Ditch Excavation		872,375	cy	12.00	10,468,500
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	13,650,000
			Current Contract Cost, Oct 07	$	293,549,934
	CONTINGENCY		@	**25.0%**	73,387,484
				$	366,937,418
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	298,748,055
	06 Account, Preservation - Mitigation-Tidal (21 acr @ $200,000/acr)				4,200,000
	06 Account, Preservation - Mitigation-Non-Tidal (217 acr @ $5,500/acr)				1,193,500
				$	671,103,973
	30 Account, Plan, Engr.& Design		@	**8.0%**	53,688,318
				$	724,792,291
	31 Account, Constr. Management		@	**6.0%**	43,487,537
				$	768,279,828
	ESCALATION		@	**0.0%**	0
				$	768,279,828
					rounded
	TOTAL PROJECT COST, Oct 07			**$**	**768,300,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 17 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County ***Option "F"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Menge Ave(15' +) - elev. 20

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,090,000
Levee System				
Length	47,730	lf		
Compacted Fill	463,777	cy	15.00	6,956,655
Grassing (seeding)	47	Ac	2,150	101,050
Crushed Aggregate 6" Thick(Levee wearing surface)	34,700	cy	45.00	1,561,500
24" Rip Rap	132,600	cy	90.00	11,934,000
24 " Gabion Matress Cages	155,130	sy	32.00	4,964,160
Filter Fabric	155,130	sy	2.00	310,260
Clearing & Grubbing	184	Ac	5,000	920,000
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	21	pass-thrus		4,081,549
Compacted Fill (ramps and tunnels)	161,856	cy	15.00	2,427,840
Grassing (seeding)	4	Ac	2,150	8,600
New Asphalt 2" (Cross overs) 1,150 cy figure 2.0 tons/cy	2,300	tons	70.00	161,000
Base material (12")	20,348	cy	34.50	702,006
Guardrail	9,430	lf	21.00	198,030
Removal				
Asphalt	14,576	sy	4.50	65,592
8" Water line removal	8,350	lf	41	342,350
6" Sewer line removal	8,350	lf	48	400,800
2" Gas line removal	8,350	lf	20	167,000
24" Storm drain pipe removal	8,350	lf	11.00	91,850
Electric line removal - 3 phase 1440v	8,350	lf	11.00	91,850
Demolish Buildings (avg. 1500 sf/ea @ 469 ea)	703,500	sf	3.00	2,110,500
Disposal Fee - off site	26,056	cy	2.50	65,139
New Work				
New 8" Water line	8,350	lf	8.00	66,800
New 6" Sewer Line	8,350	lf	8.00	66,800
New 2" Gas Line	8,350	lf	8.00	66,800
New Electric Line - 3 phase 1440v	8,350	lf	44.00	367,400
New 24" Storm drain pipe	8,350	lf	68.00	567,800
			Subtotal	**$40,887,331**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 18 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4 Harrison County Option "F" Menge Ave(15' +) - elev. 20***
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$**	**40,887,331**
Concrete box culverts		3,705	cy	700	2,593,500
#6 rebar		232	tons	925	214,600
Flap Gates (12w x 4h)		55	ea	43,200	2,376,000
Flap Gates (10w x 4h)		4	ea	36,000	144,000
Flap Gates (7w x 4h)		5	ea	25,200	126,000
Flap Gates (6w x 3h)		4	ea	16,200	64,800
Flap Gates (8w x 4h)		4	ea	28,800	115,200
Flap Gates (10w x 4h)		19	ea	36,000	684,000
Cutoff valves (12w x 4h)		55	ea	100,800	5,544,000
Cutoff valves (10w x 4h)		19	ea	84,000	1,596,000
Cuttoff valves (7w x 4h)		5	ea	58,800	294,000
Cuttoff valves (6w x 3h)		4	ea	37,800	151,200
Cuttoff valves (8w x 4h)		4	ea	67,200	268,800
Cuttoff valves (10w x 4h)		4	ea	84,000	336,000
Pump stations, 42" to 60" pump size (3 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				19,548,152
Ditch Excavation		906,807	cy	12.00	10,881,684
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	4,190,000
			Current Contract Cost, Oct 07	$	90,015,267
	CONTINGENCY		@ **25.0%**		22,503,817
				$	112,519,084
	01 Account, Lands & Damage		PCA **LS**		25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)		**LS**		8,916,948
	06 Account, Preservation - Mitigation-Tidal (4 acr @ $200,000/acr)				800,000
	06 Account, Preservation - Mitigation-Non-Tidal (76 acr @ $5,500/acr)				418,000
				$	122,679,032
	30 Account, Plan, Engr.& Design		@ **8.0%**		9,814,323
				$	132,493,354
	31 Account, Constr. Management		@ **6.0%**		7,949,601
				$	140,442,955
	ESCALATION		@ **0.0%**		0
				$	140,442,955
					rounded
	TOTAL PROJECT COST, Oct 07			**$**	**140,400,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 19 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County ***Option "G"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Menge Ave(15'+) - elev. 30

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$4,710,000
Levee System				
Length	187,490	lf		
Compacted Fill	2,128,830	cy	15.00	31,932,450
Grassing (seeding)	76	Ac	2,150	163,400
Crushed Aggregate 6" Thick(Levee wearing surface)	61,400	cy	45.00	2,763,000
12" Rip Rap	381	cy	90.00	34,290
12 " Gabion Matress Cages	1,042,870	sy	16.00	16,685,920
Filter Fabric	1,042,870	sy	2.00	2,085,740
Clearing & Grubbing	343	Ac	5,000	1,715,000
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	125	pass-thrus		30,124,860
Compacted Fill (ramps and tunnels)	7,200	cy	15.00	108,000
Grassing (seeding)	2	Ac	2,150	4,300
New Asphalt 2" (Cross overs) 9,645 cy figure 2.0 tons/cy	19,290	tons	70.00	1,350,300
Base material (12")	12,270	cy	34.50	423,315
Guardrail	34,800	lf	21.00	730,800
Removal				
Asphalt	154,500	sy	4.50	695,250
8" Water line removal	44,900	lf	41	1,840,900
6" Sewer line removal	44,900	lf	48	2,155,200
2" Gas line removal	44,900	lf	20	898,000
24" Storm drain pipe removal	44,900	lf	11.00	493,900
Electric line removal - 3 phase 1440v	44,900	lf	11.00	493,900
Demolish Buildings (avg. 1500 sf/ea @ 505 ea)	757,500	sf	3.00	2,272,500
Disposal Fee - off site	28,056	cy	2.50	70,139
New Work				
New 8" Water line	44,900	lf	8.00	359,200
New 6" Sewer Line	44,900	lf	8.00	359,200
New 2" Gas Line	44,900	lf	8.00	359,200
New Electric Line - 3 phase 1440v	44,900	lf	44.00	1,975,600
New 24" Storm drain pipe	44,900	lf	68.00	3,053,200
			Subtotal	**$107,857,563**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 20 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County ***Option "G"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Menge Ave(15'+) - elev. 30

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 107,857,563**
Concrete box culverts		3,705	cy	700	2,593,500
#6 rebar		233	tons	925	215,525
Flap Gates (12w x 4h)		55	ea	43,200	2,376,000
Flap Gates (10w x 4h)		5	ea	36,000	180,000
Flap Gates (7w x 4h)		5	ea	25,200	126,000
Flap Gates (6w x 3h)		4	ea	16,200	64,800
Flap Gates (8w x 4h)		4	ea	28,800	115,200
Flap Gates (10w x 4h)		19	ea	36,000	684,000
Cutoff valves (12w x 4h)		55	ea	100,800	5,544,000
Cutoff valves (10w x 4h)		19	ea	84,000	1,596,000
Cuttoff valves (7w x 4h)		5	ea	58,800	294,000
Cuttoff valves (6w x 3h)		4	ea	37,800	151,200
Cuttoff valves (8w x 4h)		4	ea	67,200	268,800
Cuttoff valves (10w x 4h)		4	ea	84,000	336,000
Pump stations, 42" to 60" pump size (9 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				41,792,146
Ditch Excavation		906,807	cy	12.00	10,881,684
Biloxi Courthous Flood Wall	(reference backup file for cost derivation)	1	Job	ls	8,765,200
Gulfport Courthouse Flood wall	(reference backup file for cost derivation)	1	Job	ls	9,348,980
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	9,420,000

	Current Contract Cost, Oct 07			$ 202,610,598
CONTINGENCY		@	**25.0%**	50,652,650
				$ 253,263,248
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage	(land + admin + 25% contingency)		**LS**	20,801,338
06 Account, Preservation - Mitigation-Tidal (9 acr @ $200,000/acr)				1,800,000
06 Account, Preservation - Mitigation-Non-Tidal (201 acr @ $5,500/acr)				1,105,500
				$ 276,995,086
30 Account, Plan, Engr.& Design		@	**8.0%**	22,159,607
				$ 299,154,693
31 Account, Constr. Management		@	**6.0%**	17,949,282
				$ 317,103,974
ESCALATION		@	**0.0%**	0
				$ 317,103,974
				rounded
	TOTAL PROJECT COST, Oct 07			**$ 317,100,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 21 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County ***Option "H"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Menge Ave(15'+) - elev. 40

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$7,630,000
Levee System				
Length	187,490	lf		
Compacted Fill	7,485,500	cy	15.00	112,282,500
Grassing (seeding)	420	Ac	2,150	903,000
Crushed Aggregate 6" Thick(Levee wearing surface)	62,235	cy	45.00	2,800,575
Clearing & Grubbing	407	Ac	5,000	2,035,000
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	157	pass-thrus		67,603,699
Grassing (seeding)	7	Ac	2,150	15,050
New Asphalt 2" (Cross overs) 712 cy figure 2.0 tons/cy	1,424	tons	70.00	99,680
Base material (12")	4,275	cy	34.50	147,488
Removal				
Asphalt	91,882	sy	4.50	413,469
8" Water line removal	75,000	lf	8.00	600,000
6" Sewer line removal	75,000	lf	8.00	600,000
2" Gas line removal	75,000	lf	3.00	225,000
24" Storm drain pipe removal	75,000	lf	11.00	825,000
Electric line removal - 3 phase 1440v	75,000	lf	11.00	825,000
Demolish Buildings (avg. 1500 sf/ea @ 585 ea)	877,500	sf	3.00	2,632,500
Disposal Fee - off site	32,500	cy	2.50	81,250
New Work				
New 8" Water line	75,000	lf	41	3,075,000
New 6" Sewer Line	75,000	lf	48	3,600,000
New 2" Gas Line	75,000	lf	20	1,500,000
New Electric Line - 3 phase 1440v	75,000	lf	44.00	3,300,000
New 24" Storm drain pipe	75,000	lf	68.00	5,100,000
			Subtotal	**$216,294,210**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 22 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County ***Option "H"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Menge Ave(15'+) - elev. 40

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 216,294,210**
Concrete box culverts		3,705	cy	700	2,593,500
#6 rebar		232	tons	925	214,600
Flap Gates (12w x 4h)		55	ea	43,200	2,376,000
Flap Gates (10w x 4h)		4	ea	36,000	144,000
Flap Gates (7w x 4h)		5	ea	25,200	126,000
Flap Gates (6w x 3h)		4	ea	16,200	64,800
Flap Gates (8w x 4h)		4	ea	28,800	115,200
Flap Gates (10w x 4h)		19	ea	36,000	684,000
Cutoff valves (12w x 4h)		55	ea	100,800	5,544,000
Cutoff valves (10w x 4h)		19	ea	84,000	1,596,000
Cuttoff valves (7w x 4h)		5	ea	58,800	294,000
Cuttoff valves (6w x 3h)		4	ea	37,800	151,200
Cuttoff valves (8w x 4h)		4	ea	67,200	268,800
Cuttoff valves (10w x 4h)		4	ea	84,000	336,000
Pump stations, 42" to 60" pump size (14 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				53,135,605
Ditch Excavation		906,807	cy	12.00	10,881,684
Biloxi Courthous Flood Wall	(reference backup file for cost derivation)	1	Job	ls	8,765,200
Gulfport Courthouse Flood wall	(reference backup file for cost derivation)	1	Job	ls	9,348,980
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	15,270,000

Current Contract Cost, Oct 07			$	328,203,779
CONTINGENCY	@	**25.0%**		82,050,945
			$	410,254,724
01 Account, Lands & Damage	PCA	**LS**		25,000
01 Account, Lands & Damage (land + admin + 25% contingency)		**LS**		28,270,865
06 Account, Preservation - Mitigation-Tidal (11 acr @ $200,000/acr)				2,200,000
06 Account, Preservation - Mitigation-Non-Tidal (277 acr @ $5,500/acr)				1,523,500
			$	442,274,089
30 Account, Plan, Engr.& Design	@	**8.0%**		35,381,927
			$	477,656,016
31 Account, Constr. Management	@	**6.0%**		28,659,361
			$	506,315,377
ESCALATION	@	**0.0%**		0
			$	506,315,377
				rounded
TOTAL PROJECT COST, Oct 07			**$**	**506,300,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 23 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County ***Option "I"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
" Levee for Rdwy(75') with Menge Ave Alt - elev. 20

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,410,000
Levee System				
Length	12,453	lf		
Compacted Fill	464,210	cy	15.00	6,963,150
Grassing (seeding)	13	Ac	2,150	27,950
Crushed Aggregate 6" Thick(Levee wearing surface)	2,623	cy	45.00	118,035
12" Rip Rap	226,488	cy	90.00	20,383,920
24 " Gabion Matress Cages	277,749	sy	32.00	8,887,968
Filter Fabric	277,749	sy	2.00	555,498
Clearing & Grubbing	69	Ac	5,000	345,000
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	20	pass-thrus		5,057,133
Compacted Fill (ramps and tunnels)	7,200	cy	15.00	108,000
Grassing (seeding)	2	Ac	2,150	4,300
New Asphalt 2" (Cross overs) 1,000 cy figure 2.0 tons/cy	2,000	tons	70.00	140,000
Base material (12")	11,000	cy	34.50	379,500
Guardrail	8,900	lf	21.00	186,900
Removal				
Asphalt	70,000	sy	4.50	315,000
8" Water line removal	14,900	lf	8.00	119,200
6" Sewer line removal	14,900	lf	8.00	119,200
2" Gas line removal	14,900	lf	3.00	44,700
24" Storm drain pipe removal	14,900	lf	11.00	163,900
Electric line removal - 3 phase 1440v	14,900	lf	11.00	163,900
Demolish Buildings (avg. 1500 sf/ea @ 122 ea)	183,000	sf	3.00	549,000
Disposal Fee - off site	6,778	cy	2.50	16,944
New Work				
New 8" Water line	14,900	lf	41	610,900
New 6" Sewer Line	14,900	lf	48	715,200
New 2" Gas Line	14,900	lf	20	298,000
New Electric Line - 3 phase 1440v	14,900	lf	44.00	655,600
New 24" Storm drain pipe	14,900	lf	68.00	1,013,200
			Subtotal	**$50,352,098**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 24 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County Option "I" FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
" Levee for Rdwy(75') with Menge Ave Alt - elev. 20

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 50,352,098**
Concrete box culverts		9,918	cy	700	6,942,600
#6 rebar		315	tons	925	291,375
Flap Gates (12w x 4h)		55	ea	43,200	2,376,000
Flap Gates (10w x 4h)		19	ea	36,000	684,000
Flap Gates (8w x 4h)		4	ea	28,800	115,200
Flap Gates (7w x 4h)		5	ea	25,200	126,000
Flap Gates (6w x 3h)		4	ea	16,200	64,800
Cutoff valves (12w x 4h)		55	ea	100,800	5,544,000
Cutoff valves (10w x 4h)		19	ea	84,000	1,596,000
Flap Gates (8w x 4h)		5	ea	28,800	144,000
Flap Gates (7w x 4h)		4	ea	25,200	100,800
Flap Gates (6w x 3h)		4	ea	16,200	64,800
Pump stations, 42" to 60" pump size (3 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				19,548,152
Ditch Excavation		906,807	cy	12.00	10,881,684
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	4,820,000
			Current Contract Cost, Oct 07		$ 103,651,509
	CONTINGENCY		@	**25.0%**	25,912,877
					$ 129,564,386
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	23,937,703
	06 Account, Preservation - Mitigation-Tidal (9 acr @ $200,000/acr)				1,800,000
	06 Account, Preservation - Mitigation-Non-Tidal (132 acr @ $5,500/acr)				726,000
					$ 156,053,089
	30 Account, Plan, Engr.& Design		@	**8.0%**	12,484,247
					$ 168,537,336
	31 Account, Constr. Management		@	**6.0%**	10,112,240
					$ 178,649,577
	ESCALATION		@	**0.0%**	0
					$ 178,649,577
					rounded
	TOTAL PROJECT COST, Oct 07				**$ 178,600,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 25 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County Option "J" FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
" Levee for Rdwy(75') with Menge Ave Alt - elev. 30

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$7,000,000
Levee System				
Length	159,365	lf		
Compacted Fill	4,107,957	cy	15.00	61,619,355
Grassing (seeding)	268	Ac	2,150	576,200
Crushed Aggregate 6" Thick(Levee wearing surface)	44,268	cy	45.00	1,992,060
12" Rip Rap	625,059	cy	90.00	56,255,310
12 " Gabion Matress Cages	1,875,176	sy	16.00	30,002,816
Filter Fabric	1,875,176	sy	2.00	3,750,352
Clearing & Grubbing	566	Ac	5,000	2,830,000
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	123	pass-thrus		46,593,985
Compacted Fill (ramps and tunnels)	7,200	cy	15.00	108,000
Grassing (seeding)	2	Ac	2,150	4,300
New Asphalt 2" (Cross overs) 1,000 cy figure 2.0 tons/cy	2,000	tons	70.00	140,000
Base material (12")	11,000	cy	34.50	379,500
Guardrail	8,900	lf	21.00	186,900
Removal				
Asphalt	70,000	sy	4.50	315,000
8" Water line removal	14,900	lf	8.00	119,200
6" Sewer line removal	14,900	lf	8.00	119,200
2" Gas line removal	14,900	lf	3.00	44,700
24" Storm drain pipe removal	14,900	lf	11.00	163,900
Electric line removal - 3 phase 1440v	14,900	lf	11.00	163,900
Demolish Buildings (avg. 1500 sf/ea @ 92 ea)	138,000	sf	3.00	414,000
Disposal Fee - off site	5,111	cy	2.50	12,778
New Work				
New 8" Water line	14,900	lf	41	610,900
New 6" Sewer Line	14,900	lf	48	715,200
New 2" Gas Line	14,900	lf	20	298,000
New Electric Line - 3 phase 1440v	14,900	lf	44.00	655,600
New 24" Storm drain pipe	14,900	lf	68.00	1,013,200
			Subtotal	**$216,084,356**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 26 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Harrison County ***Option "J"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
" Levee for Rdwy(75') with Menge Ave Alt - elev. 30

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 216,084,356**
Concrete box culverts		9,918	cy	700	6,942,600
#6 rebar		315	tons	925	291,375
Flap Gates (12w x 4h)		55	ea	43,200	2,376,000
Flap Gates (10w x 4h)		19	ea	36,000	684,000
Flap Gates (8w x 4h)		4	ea	28,800	115,200
Flap Gates (7w x 4h)		5	ea	25,200	126,000
Flap Gates (6w x 3h)		4	ea	16,200	64,800
Cutoff valves (12w x 4h)		55	ea	100,800	5,544,000
Cutoff valves (10w x 4h)		19	ea	84,000	1,596,000
Flap Gates (8w x 4h)		4	ea	28,800	115,200
Flap Gates (7w x 4h)		5	ea	25,200	126,000
Flap Gates (6w x 3h)		4	ea	16,200	64,800
Pump stations, 42" to 60" pump size (9 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				41,792,146
Ditch Excavation		906,807	cy	12.00	10,881,684
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	13,990,000
			Current Contract Cost, Oct 07		$ 300,794,161
	CONTINGENCY		@	**25.0%**	75,198,540
					$ 375,992,701
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	25,350,835
	06 Account, Preservation - Mitigation-Tidal (11 acr @ $200,000/acr)				2,200,000
	06 Account, Preservation - Mitigation-Non-Tidal (144 acr @ $5,500/acr)				792,000
					$ 404,360,536
	30 Account, Plan, Engr.& Design		@	**8.0%**	32,348,843
					$ 436,709,379
	31 Account, Constr. Management		@	**6.0%**	26,202,563
					$ 462,911,941
	ESCALATION		@	**0.0%**	0
					$ 462,911,941
					rounded
	TOTAL PROJECT COST, Oct 07				**$ 462,900,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 27 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 20 Option "A"

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$3,940,000
Levee System				
Length	153,091	lf		
Compacted Fill	1,948,860	cy	15.00	29,232,900
Grassing (seeding)	35	Ac	2,150	75,250
Crushed Aggregate 6" Thick(Levee wearing surface)	41,050	cy	45.00	1,847,250
Rock Levee	86,510	cy	90.00	7,785,900
Clearing & Grubbing	372	Ac	5,000	1,860,000
24" Rip Rap	493,710	cy	90.00	44,433,900
24 " Gabion Mattress Cages	740,570	sy	32.00	23,698,240
Filter Fabric	740,570	sy	2.00	1,481,140
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	10	pass-thrus		2,099,385
Compacted Fill (ramps and tunnels)	2,000	cy	15.00	30,000
Grassing (seeding)	2	acr	2,150	4,300
New Asphalt 2" (Cross overs) 4000 cy figure 2.0 tons/cy	8,000	tons	70.00	560,000
Base material (12")	600	cy	34.50	20,700
Guardrail	1,400	lf	21.00	29,400
Removal				
Asphalt	27,200	sy	4.50	122,400
8" Water line removal	4,400	lf	8.00	35,200
6" Sewer line removal	4,400	lf	8.00	35,200
2" Gas line removal	4,400	lf	3.00	13,200
24" Storm drain pipe removal	4,400	lf	11.00	48,400
Electric line removal - 3 phase 1440v	4,400	lf	11.00	48,400
Demolish Buildings (avg. 1500 sf/ea @ 150 ea)	1,291,500	sf	3.00	3,874,500
Demolish Buildings (multistory avg. 1500 sf/ea @ 13 ea)	132,000	sf	3.50	462,000
Disposal Fee - off site	52,722	cy	2.50	131,806
Water tanks	4	ea	125,000	500,000
Ball Field	2	acr	25,000	50,000
Trailer park (6 trailers/ac.) 2 acres	12	ea	3,000	36,000
New Work				
New 8" Water line	4,400	lf	41	180,400
New 6" Sewer Line	4,400	lf	48	211,200
New 2"Gas Line	4,400	lf	20	88,000
New Electric Line - 3 phase 1440v	4,400	lf	44.00	193,600
New 24" Storm drain pipe	4,400	lf	68.00	299,200
			Subtotal	**$123,427,871**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 28 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 20 Option "A"

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Subtotal, brought forward		**$123,427,871**
Concrete box culverts	7,964	cy	700	5,574,800
#6 rebar	200	tons	925	185,000
24" RCP	100	lf	45	4,500
20" RCP	100	lf	40	4,000
Flap Gates (10w x 8h)	20	ea	72,000	1,440,000
Flap Gates (12w x 8h)	7	ea	86,400	604,800
Flap Gates (12w x 4h)	32	ea	43,200	1,382,400
Flap Gates (7w x 4h)	5	ea	25,200	126,000
Flap Gates (7w x 3h)	4	ea	18,900	75,600
Flap Gates (4w x 2h)	2	ea	7,200	14,400
Flap Gates (24")	1	ea	7,200	7,200
Flap Gates (20")	1	ea	7,200	7,200
Cutoff valves (10w x 8h)	20	ea	168,000	3,360,000
Cutoff valves (12w x 8h)	7	ea	201,600	1,411,200
Cutoff valves (12w x 4h)	32	ea	100,800	3,225,600
Cutoff valves (7w x 4h)	5	ea	58,800	294,000
Cutoff valves (7w x 3h)	4	ea	44,100	176,400
Cutoff valves (4w x 2h)	2	ea	16,800	33,600
Cutoff valves (24")	1	ea	16,800	16,800
Cutoff valves (20")	1	ea	16,800	16,800
Pump stations, 42" to 60" pump size (3 ea) (reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				8,199,791
Ditch Excavation	1,002,398	cy	12.00	12,028,776
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	7,880,000
		Current Contract Cost, Oct 07		$ 169,496,737
CONTINGENCY		@	**25.0%**	42,374,184
				$ 211,870,922
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	66,177,149
06 Account, Preservation - Mitigation-Tidal (264 acr @ $200,000/acr)				52,800,000
06 Account, Preservation - Mitigation-Non-Tidal (95 acr @ $5,500/acr)				522,500
				$ 331,395,571
30 Account, Plan, Engr.& Design		@	**8.0%**	26,511,646
				$ 357,907,216
31 Account, Constr. Management		@	**6.0%**	21,474,433
				$ 379,381,649
ESCALATION		@	**0.0%**	0
				$ 379,381,649
				rounded
TOTAL PROJECT COST, Oct 07				**$ 379,400,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 29 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 30 Option "B"

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$10,390,000
Levee System				
Length	181,928	lf		
Compacted Fill	15,227,614	cy	15.00	228,414,210
Grassing (seeding)	72	Ac	2,150	154,800
Crushed Aggregate 6" Thick(Levee wearing surface)	101,070	cy	45.00	4,548,150
Rock Levee	184,935	cy	90.00	16,644,150
Clearing & Grubbing	409	Ac	5,000	2,045,000
12" Riprap	660,400	cy	90.00	59,436,000
12 " GABION MATRESS CAGES	1,981,200	sy	16.00	31,699,200
Filter Fabric	1,981,200	sy	2.00	3,962,400
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	20	pass-thrus		6,274,027
Compacted Fill (ramps and tunnels)	382,610	cy	15.00	5,739,150
Grassing (seeding)	45	acr	2,150	96,750
New Asphalt 2" (Cross overs) 3260 cy figure 2.0 tons/cy	6,520	tons	70.00	456,400
Base material (12")	19,200	cy	34.50	662,400
Guardrail	40,000	lf	21.00	840,000
Removal				
Asphalt	9,070	sy	4.50	40,815
8" Water line removal	40,000	lf	8.00	320,000
6" Sewer line removal	40,000	lf	8.00	320,000
2" Gas line removal	40,000	lf	3.00	120,000
24" Storm drain pipe removal	40,000	lf	11.00	440,000
Electric line removal - 3 phase 1440v	40,000	lf	11.00	440,000
Demolish Buildings (avg. 1500 sf/ea @ 175 ea)	262,500	sf	3.00	787,500
Demolish Buildings (multistory avg. 1500 sf/ea @ 13 ea)	132,000	sf	3.50	462,000
Disposal Fee - off site	14,611	cy	2.50	36,528
Water tanks	4	ea	125,000	500,000
Ball Field	2	acr	25,000	50,000
Trailer park (6 trailers/ac.) 2 acres	12	ea	3,000	36,000
New Work				
New 8" Water line	40,000	lf	41	1,640,000
New 6" Sewer Line	40,000	lf	48	1,920,000
New 2"Gas Line	40,000	lf	20	800,000
New Electric Line - 3 phase 1440v	40,000	lf	44.00	1,760,000
New 24" Storm drain pipe	40,000	lf	68.00	2,720,000
			Subtotal	**$383,755,480**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 30 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 30 Option "B"

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Subtotal, brought forward		**$ 383,755,480**
Concrete box culverts	7,964	cy	700	5,574,800
#6 rebar	200	tons	925	185,000
24" RCP	100	lf	45	4,500
20" RCP	100	lf	40	4,000
Flap Gates (10w x 8h)	20	ea	72,000	1,440,000
Flap Gates (12w x 8h)	7	ea	86,400	604,800
Flap Gates (12w x 4h)	32	ea	43,200	1,382,400
Flap Gates (7w x 4h)	5	ea	25,200	126,000
Flap Gates (7w x 3h)	4	ea	18,900	75,600
Flap Gates (4w x 2h)	2	ea	7,200	14,400
Flap Gates (24")	1	ea	7,200	7,200
Flap Gates (20")	1	ea	7,200	7,200
Cutoff valves (10w x 8h)	20	ea	168,000	3,360,000
Cutoff valves (12w x 8h)	7	ea	201,600	1,411,200
Cutoff valves (12w x 4h)	32	ea	100,800	3,225,600
Cutoff valves (7w x 4h)	5	ea	58,800	294,000
Cutoff valves (7w x 3h)	4	ea	44,100	176,400
Cutoff valves (4w x 2h)	2	ea	16,800	33,600
Cutoff valves (24")	1	ea	16,800	16,800
Cutoff valves (20")	1	ea	16,800	16,800
Pump stations, 42" to 60" pump size (3 ea) (reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				12,171,846
Ditch Excavation	1,002,398	cy	12.00	12,028,776
ATFP, Signage, Pavement Marking, Traffic Control, etc.	5	%	allow	20,780,000
		Current Contract Cost, Oct 07		$ 446,696,402
CONTINGENCY		@	**25.0%**	111,674,100
				$ 558,370,502
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	74,262,187
06 Account, Preservation - Mitigation-Tidal (546 acr @ $200,000/acr)				109,200,000
06 Account, Preservation - Mitigation-Non-Tidal (467 acr @ $5,500/acr)				2,568,500
				$ 744,426,189
30 Account, Plan, Engr.& Design		@	**8.0%**	59,554,095
				$ 803,980,284
31 Account, Constr. Management		@	**6.0%**	48,238,817
				$ 852,219,102
ESCALATION		@	**0.0%**	0
			rounded	$ 852,219,102
		TOTAL PROJECT COST, Oct 07		**$ 852,200,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 31 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: Line of Defense 4 BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Inland Barrier - elev. 40 Option "C"

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$8,790,000
Levee System				
Length	199,822	lf		
Compacted Fill	15,227,614	cy	15.00	228,414,210
Grassing (seeding)	655	Ac	2,150	1,408,250
Crushed Aggregate 6" Thick(Levee wearing surface)	9,053	cy	45.00	407,385
Rock Levee	468,635	cy	90.00	42,177,150
Clearing & Grubbing	953	Ac	5,000	4,765,000
Ramps & Tunnels				
Rdwy/RR Pass-Thrus (reference backup file for cost derivation)	20	pass-thrus		11,147,923
Compacted Fill (ramps and tunnels)	497,840	cy	15.00	7,467,600
Grassing (seeding)	50	acr	2,150	107,500
New Asphalt 2" (Cross overs) 4000 cy figure 2.0 tons/cy	8,000	tons	70.00	560,000
Base material (12")	25,000	cy	34.50	862,500
Guardrail	50,000	lf	21.00	1,050,000
Removal				
Asphalt	54,400	sy	4.50	244,800
8" Water line removal	30,000	lf	8.00	240,000
6" Sewer line removal	30,000	lf	8.00	240,000
2" Gas line removal	30,000	lf	3.00	90,000
24" Storm drain pipe removal	30,000	lf	11.00	330,000
Electric line removal - 3 phase 1440v	30,000	lf	11.00	330,000
Demolish Buildings (avg. 1500 sf/ea @ 200 ea)	300,000	sf	3.00	900,000
Demolish Buildings (multistory avg. 1500 sf/ea @ 13 ea)	132,000	sf	3.50	462,000
Disposal Fee - off site	16,000	cy	2.50	40,000
Water tanks	4	ea	125,000	500,000
Ball Field	2	acr	25,000	50,000
Trailer park (6 trailers/ac.) 2 acres	12	ea	3,000	36,000
New Work				
New 8" Water line	30,000	lf	41	1,230,000
New 6" Sewer Line	30,000	lf	48	1,440,000
New 2"Gas Line	30,000	lf	20	600,000
New Electric Line - 3 phase 1440v	30,000	lf	44.00	1,320,000
New 24" Storm drain pipe	30,000	lf	68.00	2,040,000
Concrete box culverts	7,964	cy	700	5,574,800
#6 rebar	200	tons	925	185,000
			Subtotal	**$323,010,118**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 32 OF 32
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4***
Hancock County
Inland Barrier - elev. 40 Option "C"
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward		**$ 323,010,118**
24" RCP		100	lf	45	4,500
20" RCP		100	lf	40	4,000
Flap Gates (10w x 8h)		20	ea	72,000	1,440,000
Flap Gates (12w x 8h)		7	ea	86,400	604,800
Flap Gates (12w x 4h)		32	ea	43,200	1,382,400
Flap Gates (7w x 4h)		5	ea	25,200	126,000
Flap Gates (7w x 3h)		4	ea	18,900	75,600
Flap Gates (4w x 2h)		2	ea	7,200	14,400
Flap Gates (24")		1	ea	7,200	7,200
Flap Gates (20")		1	ea	7,200	7,200
Cutoff valves (10w x 8h)		20	ea	168,000	3,360,000
Cutoff valves (12w x 8h)		7	ea	201,600	1,411,200
Cutoff valves (12w x 4h)		32	ea	100,800	3,225,600
Cutoff valves (7w x 4h)		5	ea	58,800	294,000
Cutoff valves (7w x 3h)		4	ea	44,100	176,400
Cutoff valves (4w x 2h)		2	ea	16,800	33,600
Cutoff valves (24")		1	ea	16,800	16,800
Cutoff valves (20")		1	ea	16,800	16,800
Pump stations, 42" to 60" pump size (3 ea)	(reference "Pumping Stations" estimate, pages 1-57 for cost derivation)				13,293,184
Ditch Excavation		1,002,398	cy	12.00	12,028,776
ATFP, Signage, Pavement Marking, Traffic Control, etc.		5	%	allow	17,590,000
			Current Contract Cost, Oct 07		$ 378,122,578
	CONTINGENCY		@	**25.0%**	94,530,644
					$ 472,653,222
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	81,106,793
	06 Account, Preservation - Mitigation-Tidal (662 acr @ $200,000/acr)				132,400,000
	06 Account, Preservation - Mitigation-Non-Tidal (834 acr @ $5,500/acr)				4,587,000
					$ 690,772,015
	30 Account, Plan, Engr.& Design		@	**8.0%**	55,261,761
					$ 746,033,776
	31 Account, Constr. Management		@	**6.0%**	44,762,027
					$ 790,795,803
	ESCALATION		@	**0.0%**	0
					$ 790,795,803
					rounded
	TOTAL PROJECT COST, Oct 07				**$ 790,800,000**

Notes: Gate/Valve Unit Cost from Waterman Industries Inc.

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
St. Louis Bay ***Option "A"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Surge Barrier - elev. 20

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$26,790,000
Surge Barrier				
Civil:				
Cofferdam and Dewatering:				
Cell Piling	38,008	Tons	2,200	83,617,600
Cell Excavation	484,505	C.Y.	20.00	9,690,100
Cell Fill (from required excavation)	892,806	C.Y.	10.00	8,928,060
Foundation Dewatering (84 months @ $45,000/mo.)	1	Job		3,780,000
Earthwork:				
Structural Excavation	590,100	C.Y.	20.00	11,802,000
Foundation Piling (20,856 Piles)	4,171,200	L.F.	35.00	145,992,000
Structural Fill (from required excavation)	226,500	C.Y.	10.00	2,265,000
Stone Protection	210,000	C.Y.	90	18,900,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	738,860	C.Y.	450	332,487,131
Forming	536,835	sf	6.50	3,489,428
Reinforcement	1,833	Tons	925	1,695,525
Abutment Walls				
Concrete	14,044	C.Y.	450	6,319,800
Forming	31,920	sf	6.50	207,480
Stilling Slab				
Concrete	11,900	C.Y.	450	5,355,000
Reinforcement	684	Tons	925	632,700
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	6,954	Tons	9,800	68,149,200
Stainless Steel	22,382	Tons	11,700	261,869,400
Low Level Culverts:				
Structural Concrete	14,072	C.Y.	450	6,332,524
Forming	625,738	sf	6.50	4,067,297
Reinforcement	900	Tons	925	832,117
Sluice Gates (6'x4'x $2100xn)	204	Each	50,400	10,281,600
Miscellaneous Metal	290	Tons	8,000	2,320,000
			Subtotal	**$1,015,803,962**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
St. Louis Bay ***Option "A"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Surge Barrier - elev. 20

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$1,015,803,962**
Control Building	3,000	sf	450	1,350,000
Maintenance Building	10,000	sf	200	2,000,000
Mechanical:				
Operator Arms and Linkages	7,510	Tons	10,000	75,100,000
Ancillary Operating Equipment	1	Job		600,000
Spare Parts	1	ls	allow	5,000,000
Electrical:	1	Job		1,708,100
Anti-Terrorism/Force Protection, etc.	3	%	allow	32,140,000
			Current Contract Cost, Oct 07	$1,133,702,062
CONTINGENCY		@	**25.0%**	283,425,515
				$1,417,127,577
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				1,109,966
06 Account, Preservation - Mitigation-Tidal (19 acr @ $200,000/acr)				3,800,000
06 Account, Preservation - Mitigation-Tidal (0 acr @ $5,500/acr)				0
				$1,422,062,543
30 Account, Plan, Engr.& Design		@	**8.0%**	113,765,003
				$1,535,827,546
31 Account, Constr. Management		@	**6.0%**	92,149,653
				$1,627,977,199
ESCALATION		@	**0.0%**	0
				$1,627,977,199
				rounded
			TOTAL PROJECT COST, Oct 07	$1,628,000,000

Notes: (reference backup files for mechanical & electrical cost derivation)

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
St. Louis Bay ***Option "B"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Surge Barrier - elev. 30

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$36,190,000
Surge Barrier				
Civil:				
Cofferdam and Dewatering:				
Cell Piling	47,511	Tons	2,200	104,524,200
Cell Excavation	484,505	C.Y.	20.00	9,690,100
Cell Fill (from required excavation)	1,174,394	C.Y.	10.00	11,743,940
Foundation Dewatering (84 months @ $45,000 /mo.)		Job		3,780,000
Earthwork:				
Structural Excavation	1,174,900	C.Y.	20.00	23,498,000
Foundation Piling (22,032 Piles)	4,406,400	L.F.	35.00	154,224,000
Structural Fill (from required excavation)	547,700	C.Y.	10.00	5,477,000
Stone Protection	210,000	C.Y.	90.00	18,900,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	792,302	C.Y.	450	239,878,026
Forming	688,272	sf	6.50	3,463,304
Reinforcement	1,638	Tons	925	981,425
Abutment Walls				
Concrete	20,400	C.Y.	450	10,645,200
Forming	39,600	sf	6.50	279,825
Stilling Slab				
Concrete	11,900	C.Y.	450	5,355,000
Reinforcement	684	tons	925	632,700
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	16,953	Tons	9,800	193,942,250
Stainless Steel	19,456	Tons	11,700	396,255,600
Low Level Culverts:				
Structural Concrete	20,883	C.Y.	450	36,605,437
Forming	928,541	sf	6.50	4,472,687
Reinforcement	1,335	Tons	925	673,140
Sluice Gates (6'x4'x $2100xn)	204	Each	50,400	10,281,600
Miscellaneous Metal	360	Tons	8,000	3,200,000
			Subtotal	**$1,112,545,193**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
St. Louis Bay ***Option "B"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Surge Barrier - elev. 30

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
			Subtotal, brought forward	**$1,112,545,193**
Control Building	3,000	sf	450	1,350,000
Maintenance Building	10,000	sf	200	2,000,000
Mechanical:				
Operator Arms and Linkages	9,350	Tons	10,000	201,600,000
Ancillary Operating Equipment	1	Job		600,000
Spare Parts	1	ls	allow	5,000,000
Electrical:	1	Job		1,708,100
Anti-Terrorism/Force Protection, etc.	3	%	allow	43,420,000
			Current Contract Cost, Oct 07	$1,368,223,293
CONTINGENCY		@	**25.0%**	342,055,823
				$1,710,279,117
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				1,109,966
06 Account, Preservation - Mitigation-Tidal (19 acr @ $200,000/acr)				3,800,000
06 Account, Preservation - Mitigation-Non-Tidal (0 acr @ $5,500/acr)				0
				$1,715,214,083
30 Account, Plan, Engr.& Design		@	**8.0%**	137,217,127
				$1,852,431,209
31 Account, Constr. Management		@	**6.0%**	111,145,873
				$1,963,577,082
ESCALATION		@	**0.0%**	0
				$1,963,577,082
				rounded
			TOTAL PROJECT COST, Oct 07	$1,963,600,000

Notes: (reference backup files for mechanical & electrical cost derivation)

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
St. Louis Bay ***Option "C"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Surge Barrier - elev. 40

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$38,940,000
Surge Barrier				
Civil:				
Cofferdam and Dewatering:				
Cell Piling	47,511	Tons	2,200	104,524,200
Cell Excavation	484,505	C.Y.	20.00	9,690,100
Cell Fill	1,455,982	C.Y.	10.00	14,559,820
Foundation Dewatering (84 Months @ $45,000 /mo.)		Job		3,780,000
Earthwork:				
Structural Excavation	1,144,000	C.Y.	20.00	22,880,000
Foundation Piling (21,060)	4,212,000	L.F.	35.00	147,420,000
Structural Fill	544,800	C.Y.	10.00	5,448,000
Stone Protection	210,000	C.Y.	90	18,900,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	782,501	C.Y.	450	352,125,617
Forming	784,095	sf	6.50	5,096,618
Reinforcement	1,560	Tons	925	1,443,000
Abutment Walls				
Concrete	23,656	C.Y.	450	10,645,200
Forming	43,050	sf	6.50	279,825
Stilling Slab				
Concrete	11,900	C.Y.	450	5,355,000
Reinforcement	684	tons	925	632,700
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	22,382	Tons	9,800	219,343,600
Stainless Steel	37,430	Tons	11,700	437,931,000
Low Level Culverts				
Structural Concrete	27,724	C.Y.	450	12,475,633
Forming	1,232,668	sf	6.50	8,012,345
Reinforcement	1,772	Tons	925	1,639,340
Sluice Gates (4x6x$2100xn)	204	Each	50,400	10,281,600
Miscellaneous Metal	600	Tons	8,000	4,800,000
			Subtotal	$1,436,203,596

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
St. Louis Bay ***Option "C"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Surge Barrier - elev. 40

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Subtotal, brought forward		$1,436,203,596
Control Building	3,000	sf	450	1,350,000
Maintenance Building	10,000	sf	200	2,000,000
Mechanical:				
Operator Arms and Linkages	15,320	Tons	10,000	153,200,000
Ancillary Operating Equipment	1	Job		600,000
Spare Parts	1	ls	allow	5,000,000
Electrical:	1	Job		1,708,100
Anti-Terrorism/Force Protection, etc.	3	%	allow	46,730,000
	Current Contract Cost, Oct 07			$1,646,791,696
CONTINGENCY		@	**25.0%**	411,697,924
				$2,058,489,620
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				1,109,966
06 Account, Preservation - Mitigation-Tidal (19 acr @ $200,000/acr)				3,800,000
06 Account, Preservation - Mitigation-Non-Tidal (0 acr @ $5,500/acr)				0
				$2,063,424,586
30 Account, Plan, Engr.& Design		@	**8.0%**	165,073,967
				$2,228,498,553
31 Account, Constr. Management		@	**6.0%**	133,709,913
				$2,362,208,467
ESCALATION		@	**0.0%**	0
				$2,362,208,467
				rounded
TOTAL PROJECT COST, Oct 07				$2,362,200,000

Notes: (reference backup files for mechanical & electrical cost derivation)

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4***
Back Bay of Biloxi ***Option "A"***
Surge Barrier - elev. 20
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$16,110,000
Surge Gates				
Civil:				
Cofferdam and Dewatering:				
Cell Piling	23,294	Tons	2200	51,246,800
Cell Excavation	279,846	C.Y.	20	5,596,920
Cell Fill	754,770	C.Y.	10	7,547,700
Foundation Dewatering (60 month duration, 45,000/month)	1	Job		2,700,000
Earthwork:				
Structural Excavation	23,294	C.Y.	20	465,880
Foundation Piling (13,836 Piles)	279,846	L.F.	35	9,794,610
Structural Fill	754,770	C.Y.	10	7,547,700
Stone Protection	210,000	C.Y.	90	18,900,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	480,239	C.Y.	450	216,107,726
Forming	356,663	sf	6.50	2,318,310
Reinforcement	1,210	Tons	925	1,119,250
Abutment Walls				
Concrete	12,188	C.Y.	450	5,484,600
Forming	30,900	sf	6.50	200,850
Stilling Structure				
Concrete	11,900	C.Y.	450	5,355,000
Reinforcement	684	Tons	925	632,700
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	4,686	Tons	9,800	45,922,800
Stainless Steel	15,061	Tons	11,700	176,213,700
Low Level Culverts:				
Structural Concrete	5,596	C.Y.	450	2,518,086
Forming	241,637	sf	6.50	1,570,641
Reinforcement	357	Tons	925	330,565
Sluice Gates (4x6x $2100xn)	85	Each	50,400	4,284,000
Miscellaneous Metal	200	Tons	8,000	1,600,000
			Subtotal	**$ 583,567,837**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Back Bay of Biloxi ***Option "A"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Surge Barrier - elev. 20

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Subtotal, brought forward	**$**	**583,567,837**
Control Building	3,000	sf	450	1,350,000
Maintenance Building	10,000	sf	200	2,000,000
Mechanical:				
Operator Arms and Linkages	7,510	Tons	10,000	75,100,000
Ancillary Operating Equipment	1	Job		600,000
Electrical:	1	Job		1,393,200
Spare Parts	1	ls	allow	5,000,000
Anti-Terrorism/Force Protection, etc.	3	%	allow	19,490,000
	Current Contract Cost, Oct 07			$ 688,501,037
CONTINGENCY		@	**25.0%**	172,125,259
				$ 860,626,296
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				1,767,353
06 Account, Preservation - Mitigation-Tidal (11 acr @ $200,000/acr)				2,200,000
06 Account, Preservation - Mitigation-Tidal (0 acr @ $5,500/acr)				0
				$ 864,618,649
30 Account, Plan, Engr.& Design		@	**8.0%**	69,169,492
				$ 933,788,141
31 Account, Constr. Management		@	**6.0%**	56,027,288
				$ 989,815,430
ESCALATION		@	**0.0%**	0
				$ 989,815,430
				rounded
TOTAL PROJECT COST, Oct 07			**$**	**989,800,000**

Notes: (reference backup files for mechanical & electrical cost derivation)

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4***
Back Bay of Biloxi ***Option "B"***
Surge Barrier - elev. 30
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$20,810,000
Surge Barrier				
Civil:				
Cell Piling	31,837	Tons	2200	70,041,400
Cell Excavation	279,846	C.Y.	20	5,596,920
Cell Fill (from required excavation)	754,770	C.Y.	10	7,547,700
Foundation Dewatering (60Mo. @ $45,000 / Mo.)	1	Job		2,700,000
Earthwork:				
Structural Excavation	881,900	C.Y.	20	17,638,000
Foundation Piling (14,538 Piles)	1,134,024	L.F.	35	39,690,840
Structural Fill (from required excavation)	414,500	C.Y.	10	4,145,000
Stone Protection	210000	C.Y.	90	18,900,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	540,621	C.Y.	450	243,279,522
Forming	351,575	sf	6.50	2,285,238
Reinforcement	1,083	Tons	925	1,001,775
Abutment Walls				
Concrete	12,188	C.Y.	450	5,484,600
Forming	30,900	sf	6.50	200,850
Stilling Slab				
Concrete	11900	C.Y.	450	5,355,000
Reinforcement	684	Tons	925	632,700
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	11238	Tons	9,800	110,132,400
Stainless Steel	13024	Tons	11,700	152,380,800
Low Level Culverts:				
Structural Concrete	41,300	C.Y.	450	18,584,795
Forming	468,061	sf	6.50	3,042,394
Reinforcement	542	Tons	925	501,427
Sluice Gates (6'x4'x $2100xn)	85	Each	50,400	4,284,000
Miscellaneous Metal	240	Tons	8,000	1,920,000
			Subtotal	**$ 736,155,360**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Back Bay of Biloxi ***Option "B"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Surge Barrier - elev. 30

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
		Subtotal, brought forward		**$ 736,155,360**
Control Building	3,000	sf	450	1,350,000
Maintenance Building	10,000	sf	200	2,000,000
Mechanical:				
Gate Arms	11,020	Tons	10,000	110,200,000
Operating Equipment	1	Job	600,000	600,000
Spare Parts	1	ls	allow	5,000,000
Electrical:	1	Job	1,393,200	1,393,200
Anti-Terrorism/Force Protection, etc.	3	%	allow	25,600,000
		Current Contract Cost, Oct 07		$ 882,298,560
CONTINGENCY		@	**25.0%**	220,574,640
				$ 1,102,873,200
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				1,767,353
06 Account, Preservation - Mitigation-Tidal (11 acr @ $200,000/acr)				2,200,000
06 Account, Preservation - Mitigation-Tidal (0 acr @ $5,500/acr)				0
				$ 1,106,865,553
30 Account, Plan, Engr.& Design		@	**8.0%**	88,549,244
				$ 1,195,414,797
31 Account, Constr. Management		@	**6.0%**	71,724,888
				$ 1,267,139,685
ESCALATION		@	**0.0%**	0
				$ 1,267,139,685
				rounded
TOTAL PROJECT COST, Oct 07				$ 1,267,100,000

Notes: (reference backup files for mechanical & electrical cost derivation)

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Back Bay of Biloxi ***Option "C"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Surge Barrier - elev. 40

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$29,810,000
Surge Barrier				
Civil:				
Cofferdam and Dewatering:				
Cell Piling	31,837	Tons	2,200	70,041,400
Cell Excavation	279,846	C.Y.	20	5,596,920
Cell Fill	1,075,547	C.Y.	10	10,755,470
Foundation Dewatering (60 month duration, 45,000/month)	1	Job		2,700,000
Earthwork:				
Structural Excavation	903,200	C.Y.	20	18,064,000
Foundation Piling (14,250 Piles)	2,850,000	L.F.	35	99,750,000
Structural Fill (from required excavation)	434,800	C.Y.	10	4,348,000
Stone Protection	210000	C.Y.	90	18,900,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	533,062	C.Y.	450	239,878,026
Forming	532,816	sf	6.50	3,463,304
Reinforcement	1,061	Tons	925	981,425
Abutment Walls				
Concrete	23,656	C.Y.	450	10,645,200
Forming	43,050	sf	6.50	279,825
Stilling Slab				
Concrete	11900	C.Y.	450	5,355,000
Reinforcement	684	Tons	925	632,700
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	14890	Tons	9,800	145,922,000
Stainless Steel	25401	Tons	11,700	297,191,700
Low Level Culverts:				
Structural Concrete	81,345	C.Y.	450	36,605,437
Forming	688,106	sf	6.50	4,472,687
Reinforcement	728	Tons	925	673,140
Sluice Gates (4x6x $2100xn)	85	Each	50,400	4,284,000
Miscellaneous Metal	400	Tons	8,000	3,200,000
			Subtotal	$ 1,013,550,233

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 6
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Back Bay of Biloxi ***Option "C"*** FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
Surge Barrier - elev. 40

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Subtotal, brought forward				**$ 1,013,550,233**
Control Building	3,000	sf	450	1,350,000
Maintenance Building	10,000	sf	200	2,000,000
Mechanical:				
Gate Arms	20,160	Tons	10,000	201,600,000
Operating Equipment	1	Job		600,000
Electrical:	1	Job		1,393,200
Spare Parts	1	ls	allow	5,000,000
Anti-Terrorism/Force Protection, etc.	3.00	%	allow	36,660,000
Current Contract Cost, Oct 07				$ 1,262,153,433
CONTINGENCY		@	**25.0%**	315,538,358
				$ 1,577,691,792
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				1,767,353
06 Account, Preservation - Mitigation-Tidal (11 acr @ $200,000/acr)				2,200,000
06 Account, Preservation - Mitigation-Tidal (0 acr @ $5,500/acr)				0
				$ 1,581,684,145
30 Account, Plan, Engr.& Design		@	**8.0%**	126,534,732
				$ 1,708,218,876
31 Account, Constr. Management		@	**6.0%**	102,493,133
				$ 1,810,712,009
ESCALATION		@	**0.0%**	0
				$ 1,810,712,009 rounded
TOTAL PROJECT COST, Oct 07				$ 1,810,700,000

Notes: (reference backup files for mechanical & electrical cost derivation)

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project "MsCIP'** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Llyod Oliver
WORK ITEM: ***Harrison County - Line of Defense 4 Biloxi Courthouse- Elevation 30*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Tee Wall				
Earthwork:				
Structural Excavation	11,750	C.Y.	20	$235,000
Foundation Piling	1540	Tons	1,500	2,310,000
Cutoff Wall Piling	635	Tons	2,200	1,395,900
Structural Fill	11,050	C.Y.	10	110,500
Structural:				
Concrete:				
Structural Concrete (Add Reinf. At 130 #/C.Y.)	1960	C.Y.	700	1,372,000
Structural Steel:				
Roadway Closure Gates (Including Miscellaneous Metal)	4	Each	54,000	216,000
Current Contract Cost, Oct 07				**$5,639,400**

Notes: (Gate unit cost based on similar projects provided by New Orleans COE District)

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project "MsCIP'** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Llyod Oliver
WORK ITEM: ***Harrison County - Line of Defense 4 Biloxi Courthouse- Elevation 40*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Tee Wall				
Earthwork:				
Structural Excavation	18,100	C.Y.	20	$362,000
Foundation Piling	1540	Tons	1,500	2,310,000
Cutoff Wall Piling	635	Tons	2,200	1,395,900
Structural Fill	15,730	C.Y.	10	157,300
Structural:				
Concrete:				
Structural Concrete (Add Reinf. At 130 #/C.Y.)	5,800	C.Y.	700	4,060,000
Structural Steel:				
Roadway Closure Gates (Including Miscellaneous Metal)	4	Each	120,000	480,000
Current Contract Cost, Oct 07				**$8,765,200**

Notes: (Gate unit cost based on similar projects provided by New Orleans COE District)

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project "MsCIP'** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Llyod Oliver
WORK ITEM: ***Harrison County - Line of Defense 4 Gulfport Courthouse- Elevation 30*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Tee Wall				
Earthwork:				
Structural Excavation	12,930	C.Y.	20	$258,600
Foundation Piling	1690	Tons	1,500	2,535,000
Cutoff Wall Piling	698	Tons	2,200	1,536,480
Structural Fill	12,150	C.Y.	10	121,500
Structural:				
Concrete:				
Structural Concrete (Add Reinf. At 130 #/C.Y.)	2160	C.Y.	700	1,512,000
Structural Steel:				
Roadway Closure Gates (Including Miscellaneous Metal)	2	Each	54,000	108,000
Current Contract Cost, Oct 07				**$6,071,580**

Notes: (Gate unit cost based on similar projects provided by New Orleans COE District)

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project "MsCIP'** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 4
PREPARED: Joseph H. Ellsworth CHECKED: Llyod Oliver
WORK ITEM: ***Harrison County - Line of Defense 4 Gulfport Courthouse- Elevation 40*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Tee Wall				
Earthwork:				
Structural Excavation	19,920	C.Y.	20	$398,400
Foundation Piling	1690	Tons	1,500	2,535,000
Cutoff Wall Piling	698	Tons	2,200	1,536,480
Structural Fill	17,310	C.Y.	10	173,100
Structural:				
Concrete:				
Structural Concrete (Add Reinf. At 130 #/C.Y.)	6,380	C.Y.	700	4,466,000
Structural Steel:				
Roadway Closure Gates (Including Miscellaneous Metal)	2	Each	120,000	240,000
			Current Contract Cost, Oct 07	**$9,348,980**

Notes: (Gate unit cost based on similar projects provided by New Orleans COE District)

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

NO GATE STRUCTURES

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 1 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4 - Inland Barrier Jackson County - Elevation 20 Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Jackson_Lod4_Inland Barrier_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County				
Structural Concrete, complete	0	cy		0
Form Work	0	sf		0
Steel Reinforcement	0	tons		0
11.5' wide x 16' high Swing Gates (railroad)	0	each		0
16.75' wide x 14' high Swing Gates	0	each		0
3' high x 31.5' wide Roller Gates	0	each		0
4' high x 31.5' wide Roller Gates	0	each		0
5' high x 31.5' wide Roller Gates	0	each		0
6' high x 31.5' wide Roller Gates	0	each		0
7' high x 31.5' wide Roller Gates	0	each		0
8' high x 31.5' wide Roller Gates	0	each		0
9' high x 31.5' wide Roller Gates	0	each		0

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District;
25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07 $0

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

NO GATE STRUCTURES

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 2 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4 - Inland Barrier Jackson County - Elevation 30 Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Jackson_Lod4_Inland Barrier_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County				
Structural Concrete, complete	0	cy		0
Form Work	0	sf		0
Steel Reinforcement	0	tons		0
11.5' wide x 6' high Swing Gates (railroad)	0	each		0
16.75' wide x 14' high Swing Gates	0	each		0
3' high x 31.5' wide Roller Gates	0	each		0
4' high x 31.5' wide Roller Gates	0	each		0
5' high x 31.5' wide Roller Gates	0	each		0
6' high x 31.5' wide Roller Gates	0	each		0
7' high x 31.5' wide Roller Gates	0	each		0
8' high x 31.5' wide Roller Gates	0	each		0
9' high x 31.5' wide Roller Gates	0	each		0

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07 $0

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 3 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4 - Inland Barrier Jackson County - Elevation 40 Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Jackson_Lod4_Inland Barrier_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County				
Structural Concrete, complete	425	cy	450	191,471
Form Work	9,485	sf	6.50	61,653
Steel Reinforcement	18	tons	925	17,009
3.7' high x 31.5' wide Roller Gates	1	each	24,800	24,800
4' high x 31.5' wide Roller Gates	1	each	25,600	25,600
8.5' high x 31.5' wide Roller Gates	1	each	41,600	41,600

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07	$362,133

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 4 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4 - Inland Barrier Harrison County - Elevation 20 Vehicle-RR-Gates*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Harrison_Lod4_Inland Barrier_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections				
Structural Concrete, complete	12,891	cy	450	5,800,931
Form Work	305,078	sf	6.50	1,983,008
Steel Reinforcement	625	tons	925	577,943
16.75' wide x 14' high Swing Gates	50	each	47,200	2,360,000
3' high x 31.5' wide Roller Gates	1	each	22,400	22,400
4' high x 31.5' wide Roller Gates	2	each	25,600	51,200
5' high x 31.5' wide Roller Gates	1	each	29,600	29,600
6' high x 31.5' wide Roller Gates	2	each	32,800	65,600
7' high x 31.5' wide Roller Gates	1	each	36,000	36,000
8' high x 31.5' wide Roller Gates	8	each	39,200	313,600
9' high x 31.5' wide Roller Gates	3	each	43,200	129,600

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07	$11,369,882

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 5 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4 -Inland Barrier Harrison County - Elevation 30 Vehicle-RR-Gates***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Harrison_Lod4_Inland Barrier_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections				
Structural Concrete, complete	49,443	cy	450	22,249,146
Form Work	1,027,645	sf	6.50	6,679,691
Steel Reinforcement	2,207	tons	925	2,041,666
11.5' wide x 36' high Swing Gates (railroad)	2	each	96,000	192,000
16.75' wide x 14' high Swing Gates	138	each	47,200	6,513,600
3' high x 31.5' wide Roller Gates	7	each	22,400	156,800
4' high x 31.5' wide Roller Gates	3	each	25,600	76,800
5' high x 31.5' wide Roller Gates	3	each	29,600	88,800
6' high x 31.5' wide Roller Gates	49	each	32,800	1,607,200
7' high x 31.5' wide Roller Gates	5	each	36,000	180,000
8' high x 31.5' wide Roller Gates	7	each	39,200	274,400
9' high x 31.5' wide Roller Gates	4	each	43,200	172,800

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07	$40,232,904

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 6 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4 - Inland Barrier Harrison County - Elevation 40 Vehicle-RR-Gates*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Harrison_Lod4_Inland Barrier_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections				
Structural Concrete, complete	104,486	cy	450	47,018,762
Form Work	1,923,781	sf	6.50	12,504,579
Steel Reinforcement	4,491	tons	925	4,154,231
11.5' wide x 36' high Swing Gates (railroad)	2	each	96,000	192,000
16.75' wide x 14' high Swing Gates	314	each	47,200	14,820,800
4' high x 31.5' wide Roller Gates	1	each	25,600	25,600

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07	$78,715,972

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 7 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4 - Inland Barrier Hancock County - Elevation 20 Vehicle-RR-Gates*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Hancock_Lod4_Inland Barrier_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections				
Structural Concrete, complete	2,447	cy	450	1,100,927
Form Work	49,422	sf	6.50	321,241
Steel Reinforcement	114	tons	925	105,217
16.75' wide x 14' high Swing Gates	6	each	47,200	283,200
11.5' wide x 16' high Swing Gates (railroad)	4	each	43,200	172,800
4' high x 31.5' wide Roller Gates	3	each	25,600	76,800
8' high x 31.5' wide Roller Gates	1	each	39,200	39,200
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				

Current Contract Cost, Oct 07	$2,099,385

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 8 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4 - Inland Barrier Hancock County - Elevation 30 Vehicle-RR-Gates*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Hancock_Lod4_Inland Barrier_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections				
Structural Concrete, complete	7,829	cy	450	3,522,973
Form Work	153,514	sf	6.50	997,842
Steel Reinforcement	346	tons	925	320,412
16.75' wide x 14' high Swing Gates	18	each	47,200	849,600
11.5' wide x 26' high Swing Gates (railroad)	4	each	72,000	288,000
6' high x 31.5' wide Roller Gates	9	each	32,800	295,200

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07	$6,274,027

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 9 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4 - Inland Barrier Hancock County - Elevation 40 Vehicle-RR-Gates*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Hancock_Lod4_Inland Barrier_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections				
Structural Concrete, complete	14,972	cy	450	6,737,298
Form Work	267,385	sf	6.50	1,738,001
Steel Reinforcement	637	tons	925	589,424
16.75' wide x 14' high Swing Gates	36	each	47,200	1,699,200
11.5' wide x 36' high Swing Gates (railroad)	4	each	96,000	384,000

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07	$11,147,923

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 10 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 3- Ring Levees Hancock County - Elevation 20 Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Hancock_Lod3_RingLevee_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pearlington				
Structural Concrete, complete	3,609	cy	450.00	1,623,949
Form Work	84,427	sf	6.50	548,778
Steel Reinforcement	177	tons	925.00	163,870
16.75' wide x 14' high Swing Gates	18	each	47,200	849,600
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				
Current Contract Cost, Oct 07				$3,186,197

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 11 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 3- Ring Levees Hancock County - Elevation 30 Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Hancock_Lod3_RingLevee_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pearlington				
Structural Concrete, complete	6,980	cy	450.00	3,140,999
Form Work	121,607	sf	6.50	790,445
Steel Reinforcement	289	tons	925.00	267,052
16.75' wide x 14' high Swing Gates	18	each	47,200	849,600
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				
Current Contract Cost, Oct 07				$5,048,096

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 12 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 3- Ring Levees Jackson County - Elevation 20 Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Jackson_Lod3_RingLevee_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Ocean Springs				
Structural Concrete, complete	4,066	cy	450.00	1,829,877
Form Work	93,878	sf	6.50	610,206
Steel Reinforcement	195	tons	925.00	180,673
16.75' wide x 14' high Swing Gates	18	each	47,200	849,600
4' high x 31.5' wide Roller Gates	1	each	25,600	25,600
5' high x 31.5' wide Roller Gates	2	each	29,600	59,200
6' high x 31.5' wide Roller Gates	1	each	32,800	32,800
8' high x 31.5' wide Roller Gates	2	each	39,200	78,400
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				
Current Contract Cost, Oct 07				$3,666,357
Gulf Park Estates				
Structural Concrete, complete	3,867	cy	450.00	1,740,147
Form Work	91,821	sf	6.50	596,834
Steel Reinforcement	190	tons	925.00	175,948
16.75' wide x 14' high Swing Gates	18	each	47,200	849,600
6' high x 31.5' wide Roller Gates	1	each	32,800	32,800
9' high x 31.5' wide Roller Gates	1	each	43,200	43,200
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				
Current Contract Cost, Oct 07				$3,438,529

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 13 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 3- Ring Levees Jackson County - Elevation 20 Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Jackson_Lod3_RingLevee_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Bellefontaine				
Structural Concrete, complete	2,672	cy	450.00	1,202,400
Form Work	62,535	sf	6.50	406,478
Steel Reinforcement	128	tons	925.00	118,400
16.75' wide x 14' high Swing Gates	12	each	47,200	566,400
4' high x 31.5' wide Roller Gates	3	each	25,600	76,800
8' high x 31.5' wide Roller Gates	2	each	39,200	78,400
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				
Current Contract Cost, Oct 07				$2,448,878
Gautier				
Structural Concrete, complete	5,691	cy	450.00	2,560,772
Form Work	132,238	sf	6.50	859,550
Steel Reinforcement	272	tons	925.00	251,849
16.75' wide x 14' high Swing Gates	22	each	47,200	1,038,400
4' high x 31.5' wide Roller Gates	5	each	25,600	128,000
6' high x 31.5' wide Roller Gates	2	each	32,800	65,600
7' high x 31.5' wide Roller Gates	3	each	36,000	108,000
8' high x 31.5' wide Roller Gates	1	each	39,200	39,200
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				
Current Contract Cost, Oct 07				$5,051,370

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 14 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 3- Ring Levees Jackson County - Elevation 20 Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Jackson_Lod3_RingLevee_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pascagoula				
Structural Concrete, complete	20,625	cy	450.00	9,281,315
Form Work	460,958	sf	6.50	2,996,225
Steel Reinforcement	981	tons	925.00	907,571
11.5' wide x 8' high Swing Gates (railroad)	2	each	22,400	44,800
11.5' wide x 14' high Swing Gates (railroad)	4	each	41,600	166,400
11.5' wide x 15' high Swing Gates (railroad)	2	each	42,400	84,800
16.75' wide x 14' high Swing Gates	88	each	47,200	4,153,600
3' high x 31.5' wide Roller Gates	1	each	22,400	22,400
4' high x 31.5' wide Roller Gates	6	each	25,600	153,600
5' high x 31.5' wide Roller Gates	1	each	29,600	29,600
6' high x 31.5' wide Roller Gates	6	each	32,800	196,800
7' high x 31.5' wide Roller Gates	5	each	36,000	180,000
8' high x 31.5' wide Roller Gates	6	each	39,200	235,200
9' high x 31.5' wide Roller Gates	4	each	43,200	172,800

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07	$18,625,110

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 15 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 3- Ring Levees Jackson County - Elevation 30 Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Jackson_Lod3_RingLevee_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Ocean Springs				
Structural Concrete, complete	14,958	cy	450.00	6,731,094
Form Work	317,595	sf	6.50	2,064,370
Steel Reinforcement	688	tons	925.00	636,543
16.75' wide x 14' high Swing Gates	70	each	47,200	3,304,000
6' high x 31.5' wide Roller Gates	4	each	32,800	131,200
7' high x 31.5' wide Roller Gates	1	each	36,000	36,000
8' high x 31.5' wide Roller Gates	1	each	39,200	39,200
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				
Current Contract Cost, Oct 07				$12,942,407
Gulf Park Estates				
Structural Concrete, complete	9,419	cy	450.00	4,238,425
Form Work	168,317	sf	6.50	1,094,063
Steel Reinforcement	395	tons	925	365,471
16.75' wide x 14' high Swing Gates	26	each	47,200	1,227,200
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				
Current Contract Cost, Oct 07				$6,925,159
Bellefontaine				
Structural Concrete, complete	6,153	cy	450.00	2,768,638
Form Work	117,463	sf	6.50	763,507
Steel Reinforcement	268	tons	925	247,619
16.75' wide x 14' high Swing Gates	20	each	47,200	944,000
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				
Current Contract Cost, Oct 07				$4,723,764

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 16 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 3- Ring Levees Jackson County - Elevation 30 Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Jackson_Lod3_RingLevee_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Gautier				
Structural Concrete, complete	13,282	cy	450.00	5,976,809
Form Work	260,864	sf	6.50	1,695,619
Steel Reinforcement	589	tons	925.00	545,180
16.75' wide x 14' high Swing Gates	52	each	47,200	2,454,400
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				
Current Contract Cost, Oct 07				$10,672,007
Pascagoula				
Structural Concrete, complete	49,705	cy	450.00	22,367,224
Form Work	920,758	sf	6.50	5,984,928
Steel Reinforcement	2,134	tons	925.00	1,974,156
11.5' wide x 12' high Swing Gates (railroad)	2	each	32400	64,800
11.5' wide x 18' high Swing Gates (railroad)	2	each	48600	97,200
11.5' wide x 24' high Swing Gates (railroad)	4	each	66480	265,920
11.5' wide x 25' high Swing Gates (railroad)	2	each	69200	138,400
16.75' wide x 14' high Swing Gates	166	each	47,200	7,835,200
8' high x 31.5' wide Roller Gates	1	each	39,200	39,200
Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.				
ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS				
Current Contract Cost, Oct 07				$38,767,028

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 17 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 3- Railway/Vehicle Gates Hancock County - Elevation 11 Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Hancock_Lod3_Railway_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
East of Bay Saint Louis				
Structural Concrete, complete	438	cy	450.00	197,217
Form Work	8,294	sf	6.50	53,912
Steel Reinforcement	18	tons	925.00	17,091
11.5' wide x3' high Swing Gates (railroad)	2	each	18,880	37,760
31.5' wide x 3' high Roller Gates	2	each	22,400	44,800
31.5' wide x 7' high Roller Gates	1	each	36,000	36,000

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07 $ 386,780

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 18 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4- Railway/Vehicle Gates Harrison County - Option 'D' Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Harrison(OptD&E)_Lod4_Inland Barrier(8-07)_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections - Roadway on Levee				
Structural Concrete, complete	27,194	cy	450.00	12,237,417
Form Work	516,538	sf	6.50	3,357,498
Steel Reinforcement	1,061	tons	925.00	981,425
16.75' wide x 14' high Swing Gates	50	each	47,200	2,360,000
3' high x 31.5' wide Roller Gates	1	each	22,400	22,400
4' high x 31.5' wide Roller Gates	2	each	25,600	51,200
5' high x 31.5' wide Roller Gates	1	each	29,600	29,600
6' high x 31.5' wide Roller Gates	2	each	32,800	65,600
7' high x 31.5' wide Roller Gates	1	each	36,000	36,000
8' high x 31.5' wide Roller Gates	8	each	39,200	313,600
9' high x 31.5' wide Roller Gates	3	each	43,200	129,600

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07	**$19,584,340**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 19 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4- Railway/Vehicle Gates Harrison County - Option 'E' Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Harrison(OptD&E)_Lod4_Inland Barrier(8-07)_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections - Roadway on Levee				
Structural Concrete, complete	94,060	cy	450.00	42,326,783
Form Work	1,675,265	sf	6.50	10,889,221
Steel Reinforcement	3,579	tons	925.00	3,310,575
11.5' wide x 6' high Swing Gates (railroad)	2	each	28,800	57,600
16.75' wide x 14' high Swing Gates	138	each	47,200	6,513,600
3' high x 31.5' wide Roller Gates	7	each	22,400	156,800
4' high x 31.5' wide Roller Gates	3	each	25,600	76,800
5' high x 31.5' wide Roller Gates	4	each	29,600	118,400
6' high x 31.5' wide Roller Gates	51	each	32,800	1,672,800
7' high x 31.5' wide Roller Gates	6	each	36,000	216,000
8' high x 31.5' wide Roller Gates	7	each	39,200	274,400
9' high x 31.5' wide Roller Gates	4	each	43,200	172,800

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07 **$65,785,779**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 20 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4- Railway/Vehicle Gates Harrison County - Option 'F' Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Harrison(Opt'F-G-H')_Lod4_Inland Barrier(8-07)_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections - Menge Avenue Alternative				
Structural Concrete, complete	4,704	cy	450.00	2,116,928
Form Work	109,607	sf	6.50	712,446
Steel Reinforcement	219	tons	925.00	202,575
16.75' wide x 14' high Swing Gates	10	each	47,200	472,000
3' high x 31.5' wide Roller Gates	1	each	22,400	22,400
4' high x 31.5' wide Roller Gates	3	each	25,600	76,800
5' high x 31.5' wide Roller Gates	2	each	29,600	59,200
6' high x 31.5' wide Roller Gates	2	each	32,800	65,600
7' high x 31.5' wide Roller Gates	1	each	36,000	36,000
8' high x 31.5' wide Roller Gates	7	each	39,200	274,400
9' high x 31.5' wide Roller Gates	1	each	43,200	43,200

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07	**$4,081,549**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 21 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4- Railway/Vehicle Gates Harrison County - Option 'G' Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Harrison(Opt'F-G-H')_Lod4_Inland Barrier(8-07)_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections - Menge Avenue Alternative				
Structural Concrete, complete	35,366	cy	450.00	15,914,508
Form Work	785,319	sf	6.50	5,104,576
Steel Reinforcement	1,627	tons	925.00	1,504,975
11.5' wide x 6' high Swing Gates (railroad)	2	each	36,000	72,000
16.75' wide x 14' high Swing Gates	100	each	47,200	4,720,000
3' high x 31.5' wide Roller Gates	8	each	22,400	179,200
4' high x 31.5' wide Roller Gates	3	each	25,600	76,800
5' high x 31.5' wide Roller Gates	4	each	29,600	118,400
6' high x 31.5' wide Roller Gates	54	each	32,800	1,771,200
7' high x 31.5' wide Roller Gates	6	each	36,000	216,000
8' high x 31.5' wide Roller Gates	7	each	39,200	274,400
9' high x 31.5' wide Roller Gates	4	each	43,200	172,800

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07	**$30,124,860**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 22 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4- Railway/Vehicle Gates Harrison County - Option 'H' Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Harrison(Opt'F-G-H')_Lod4_Inland Barrier(8-07)_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections - Menge Avenue Alternative				
Structural Concrete, complete	84,216	cy	450	37,897,026
Form Work	1,694,457	sf	6.50	11,013,973
Steel Reinforcement	3,788	tons	925	3,503,900
11.5' wide x 16' high Swing Gates (railroad)	2	each	43,200	86,400
16.75' wide x 14' high Swing Gates	318	each	47,200	15,009,600
4' high x 31.5' wide Roller Gates	2	each	25,600	51,200
6.5' high x 31.5' wide Roller Gates	1	each	41,600	41,600

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07 **$67,603,699**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 23 OF 24
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4- Railway/Vehicle Gates Harrison County - Option 'I' Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Harrison(Opt'I-J')_Lod4_Inland Barrier(8-07)_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections - Menge Avenue Alternative				
Structural Concrete, complete	6,459	cy	450	2,906,378
Form Work	134,893	sf	6.50	876,805
Steel Reinforcement	278	tons	925	257,150
16.75' wide x 14' high Swing Gates	10	each	47,200	472,000
4' high x 31.5' wide Roller Gates	1	each	22,400	22,400
6.5' high x 31.5' wide Roller Gates	3	each	25,600	76,800
5' high x 31.5' wide Roller Gates	2	each	29,600	59,200
6' high x 31.5' wide Roller Gates	1	each	32,800	32,800
7' high x 31.5' wide Roller Gates	1	each	36,000	36,000
8' high x 31.5' wide Roller Gates	7	each	39,200	274,400
9' high x 31.5' wide Roller Gates	1	each	43,200	43,200

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07	**$5,057,133**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 24 OF 24
PREPARED: oseph H. Ellswort CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 4- Railway/Vehicle Gates Harrison County - Option 'J' Vehicle-RR-Gates*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME: Harrison(Opt'I-J')_Lod4_Inland Barrier(8-07)_Vehicle Gates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Levee and Roadway/Railway Intersections - Menge Avenue Alternative				
Structural Concrete, complete	64,538	cy	450	29,042,067
Form Work	1,199,949	sf	6.50	7,799,668
Steel Reinforcement	2,530	tons	925	2,340,250
11.5' wide x 6' high Swing Gates (railroad)	2	each	36,000	72,000
16.75' wide x 14' high Swing Gates	96	each	47,200	4,531,200
4' high x 31.5' wide Roller Gates	8	each	22,400	179,200
6.5' high x 31.5' wide Roller Gates	3	each	25,600	76,800
5' high x 31.5' wide Roller Gates	4	each	29,600	118,400
6' high x 31.5' wide Roller Gates	54	each	32,800	1,771,200
7' high x 31.5' wide Roller Gates	6	each	36,000	216,000
8' high x 31.5' wide Roller Gates	7	each	39,200	274,400
9' high x 31.5' wide Roller Gates	4	each	43,200	172,800

Note: All Gate Unit Costs noted above are installed costs with contingencies included, as provided by New Orleans District; 25% Contingency removed from the figures provided before insertion into this work; Price Level is for 3/23/07.

ABOVE GATE COUNTS ARE FOR INDIVIDUAL GATE LEAVES AT BOTH SWING GATE AND ROLLER GATE INSTALLATIONS

Current Contract Cost, Oct 07 **$46,593,985**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Hancock County Beach Boulevard- Elevation 11*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Beach Boulevard_Lod3_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations W-1 thru W -10					
Structural Concrete, complete all sites		3,931	cy	$450	$1,768,938
Form Work, complete all sites		95,349	sf	$6.50	619,770
Steel Reinforcement, complete all sites		241	tons	$925	222,691
Excavation		6,407	cy	$15	96,104
Backfill		4,483	cy	$5	22,413
Trash Screens and Miscellaneous metal items, All Sites		34	each	$100,000	3,400,000
Pumps by Installation Site					
W-1	Pumps	4	each	$192,500	770,000
	Discharge Piping (42" Dia; 150 L.F.)				123,200
	Energy Dissipation				150,000
W-2	Pumps	4	each	$330,000	1,320,000
	Discharge Piping (54" Dia; 150 L.F.)				197,100
	Energy Dissipation				150,000
W-3	Pumps	4	each	$192,500	770,000
	Discharge Piping (42" Dia; 150 L.F.)				123,200
	Energy Dissipation				150,000
W-4	Pumps	3	each	$440,000	1,320,000
	Discharge Piping (60" Dia; 150 L.F.)				188,500
	Energy Dissipation				120,000
W-5	Pumps	3	each	$330,000	990,000
	Discharge Piping (54" Dia; 150 L.F.)				147,800
	Energy Dissipation				120,000
W-6	Pumps	4	each	$330,000	1,320,000
	Discharge Piping (54" Dia; 150 L.F.)				197,100
	Energy Dissipation				150,000
W-7	Pumps	2	each	$192,500	385,000
	Discharge Piping (42" Dia; 150 L.F.)				61,600
	Energy Dissipation				90,000
W-8	Pumps	4	each	$192,500	770,000
	Discharge Piping (42" Dia; 150 L.F.)				123,200
	Energy Dissipation				150,000
W-9	Pumps	3	each	$330,000	990,000
	Discharge Piping (54" Dia; 150 L.F.)				147,800
	Energy Dissipation				120,000
W-10	Pumps	3	each	$330,000	990,000
	Discharge Piping (54" Dia; 150 L.F.)				147,800
	Energy Dissipation				120,000
Electrical		34	each	$242,100	8,231,400
				Current Contract Cost, Oct 07	**$26,763,616**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3- Pumping Stations Bellfountaine- Elevation 20*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: bellfountaine_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations BF-1 thru BF-7					
Structural Concrete, complete all sites		3,151	cy	$450.00	$1,417,950
Form Work, complete all sites		77,358	sf	6.50	502,827
Steel Reinforcement, complete all sites		193	tons	925.00	178,525
Excavation		4,653	cy	15.00	69,795
Backfill		3,244	cy	5.00	16,220
Trash Screens and Miscellaneous metal items, All Sites		23	each	100,000	2,300,000
Pumps by Installation					
BF-1	Pumps	3	each	203,500	610,500
	Discharge Piping (150 L.F. ; D=60")		Job		225,000
	Energy Dissipation		Job		120,000
BF-2	Pumps	3	each	240,350	721,050
	Discharge Piping (150 L.F. ; D=42")		Job		225,000
	Energy Dissipation		Job		120,000
BF-3	Pumps	2	each	240,350	480,700
	Discharge Piping (150 L.F. ; D=42")		Job		150,000
	Energy Dissipation		Job		90,000
BF-4	Pumps	4	each	120,175	480,700
	Discharge Piping (150 L.F. ; D=60")		Job		300,000
	Energy Dissipation		Job		150,000
BF-5	Pumps	3	each	160,233	721050
	Discharge Piping (150 L.F. ; D=42")		Job		225,000
	Energy Dissipation		Job		120,000
BF-6	Pumps	4	each	398,200	1592800
	Discharge Piping (150 L.F. ; D=54")		Job		300,000
	Energy Dissipation		Job		150,000
BF-7	Pumps	4	each	398,200	1,592,800
	Discharge Piping (150 L.F. ; D=54")		Job		300,000
	Energy Dissipation		Job		150,000
Electrical		23	Job	242,100	5,568,300
				Current Contract Cost, Oct 07	**$18,878,217**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 3 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Bellfontaine- Elevation 30*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Bellfontaine_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations BF-1 thru BF-7					
Structural Concrete, complete all sites		2,558	cy	$450.00	$1,151,100
Form Work, complete all sites		63,943	sf	6.50	415,630
Steel Reinforcement, complete all sites		157	tons	925.00	145,225
Excavation		3,376	cy	15.00	50,640
Backfill		2,425	cy	5.00	12,125
Trash Screens and Miscellaneous metal items, All Sites		21	each	100,000	2,100,000
Pumps by Installation Site					
BF-1	Pumps	3	each	203,500	610,500
	Discharge Piping (250 L.F. ; D=42")		Job		375,000
	Energy Dissipation		Job		120,000
BF-2	Pumps	3	each	240,350	721,050
	Discharge Piping (250 L.F. ; D=42")		Job		375,000
	Energy Dissipation		Job		120,000
BF-3	Pumps	2	each	240,350	480,700
	Discharge Piping (250 L.F. ; D=42")		Job		250,000
	Energy Dissipation		Job		90,000
BF-4	Pumps	2	each	240,350	480,700
	Discharge Piping (250 L.F. ; D=42")		Job		250,000
	Energy Dissipation		Job		90,000
BF-5	Pumps	3	each	240,350	721,050
	Discharge Piping (250 L.F. ; D=42")		Job		375,000
	Energy Dissipation		Job		120,000
BF-6	Pumps	4	each	398,200	1,592,800
	Discharge Piping (250 L.F. ; D=54")		Job		500,000
	Energy Dissipation		Job		150,000
BF-7	Pumps	4	each	398,200	1,592,800
	Discharge Piping (250 L.F. ; D=54")		Job		500,000
	Energy Dissipation		Job		150,000
Electrical		21	Job	242,100	5,084,100
				Current Contract Cost, Oct 07	**$18,623,420**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 4 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Gautier- Elevation 20***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Gautier_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations G-1 thru G-8 (11 Sites Total)					
Structural Concrete, complete all sites		6,860	cy	$450	$3,086,794
Form Work, complete all sites		165,560	sf	$6.50	1,076,141
Steel Reinforcement, complete all sites		418	tons	$925	386,633
Excavation		10,173	cy	$15	152,599
Backfill		6,805	cy	$5	34,025
Discharge Piping and Energy Dissipation (150L.F. + Stilling Str.)		47	each		
Trash Screens and Miscellaneous metal items, All Sites		47	each	100,000	4,700,000
Pumps by Installation					
G-1	Pumps	6	each	440,000	2,640,000
	Discharge Piping (150 L.F. ; D=60")		Job		377,000
	Energy Dissipation		Job		210,000
G-2	Pumps	6	each	440,000	2,640,000
	Discharge Piping (150 L.F. ; D=60")		Job		377,000
	Energy Dissipation		Job		60,000
G-3a	Pumps	3	each	222,200	666,600
	Discharge Piping (150 L.F. ; D=42")		Job		92,400
	Energy Dissipation		Job		30,000
G-3f	Pumps	4	each	440,000	1,760,000
	Discharge Piping (150 L.F. ; D=60")		Job		251,300
	Energy Dissipation		Job		40,000
G-4a	Pumps	6	each	440,000	2640000
	Discharge Piping (150 L.F. ; D=60")		Job		377,000
	Energy Dissipation		Job		60,000
G-5	Pumps	4	each	440,000	140800
	Discharge Piping (150 L.F. ; D=54")		Job		165,100
	Energy Dissipation		Job		40,000
G-6	Pumps	4	each	35,200	1,760,000
	Discharge Piping (150 L.F. ; D=60")		Job		251,300
	Energy Dissipation		Job		40,000
G-7	Pumps	4	each	440,000	1,408,000
	Discharge Piping (150 L.F. ; D=54")		Job		197,100
	Energy Dissipation		Job		40,000
G-8a	Pumps	4	each	352,000	888,800
	Discharge Piping (150 L.F. ; D=42")		Job		123,200
	Energy Dissipation		Job		40,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 5 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Gautier- Elevation 20***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Gautier_Lod3_Ring Levee_Pumping Stations.xls

	DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
G-8c	Pumps	2	each	222,200	407000
	Discharge Piping (150 L.F. ; D=42")		Job		61,600
	Energy Dissipation		Job		20000
G-9	Pumps	4	each	203,500	1,408,000
	Discharge Piping (150 L.F. ; D=54")		Job		197,100
	Energy Dissipation		Job		40,000
Electrical		47	Job	242,100	11,378,700
			Current Contract Cost, Oct 07		**$40,264,191**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 6 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Gautier- Elevation 30*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Gautier_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations G-1 thru G-8 (11 Sites Total)					
Structural Concrete, complete all sites		6,268	cy	$450	$2,820,735
Form Work, complete all sites		154,233	sf	$6.50	1,002,512
Steel Reinforcement, complete all sites		383	tons	$925	354,134
Excavation		9,820	cy	$15	147,295
Backfill		7,055	cy	$5	35,277
Discharge Piping and Energy Dissipation		41	each		
Trash Screens and Miscellaneous metal items, All Sites		41	each	$100,000	4,100,000
Pumps by Installation Site					
G-1	Pumps	6	each	$467,500	2,805,000
	Discharge Piping (250 L.F. ; D=60")		Job		531,200
	Energy Dissipation		Job		210,000
G-2	Pumps	6	each	$467,500	2,805,000
	Discharge Piping (250 L.F. ; D=60")		Job		531,200
	Energy Dissipation		Job		210,000
G-3a	Pumps	3	each	$240,350	721,050
	Discharge Piping (250 L.F. ; D=42")		Job		130,200
	Energy Dissipation		Job		120,000
G-3f	Pumps	4	each	$467,500	1,870,000
	Discharge Piping (250 L.F. ; D=60")		Job		354,100
	Energy Dissipation		Job		150,000
G-4a	Pumps	6	each	$311,667	2,805,000
	Discharge Piping (250 L.F. ; D=60")		Job		531,200
	Energy Dissipation		Job		210,000
G-5	Pumps	4	each	$701,250	1,592,800
	Discharge Piping (250 L.F. ; D=54")		Job		277,800
	Energy Dissipation		Job		150,000
G-6	Pumps	4	each	$467,500	1,870,000
	Discharge Piping (250 L.F. ; D=60")		Job		354,100
	Energy Dissipation		Job		150,000
G-7	Pumps	4	each	$398,200	1,592,800
	Discharge Piping (250 L.F. ; D=54")		Job		277,800
	Energy Dissipation		Job		150,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 7 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Gautier- Elevation 30***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Gautier_Lod3_Ring Levee_Pumping Stations.xls

	DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
G-8a	Pumps	4	each	$467,500	961,400
	Discharge Piping (250 L.F. ; D=42")		Job		173,600
	Energy Dissipation		Job		150,000
G-8c	Pumps	2	each	$796,400	774,400
	Discharge Piping (250 L.F. ; D=42")		Job		86,800
	Energy Dissipation		Job		90,000
G-9	Pumps	4	each	$240,350	1,592,800
	Discharge Piping (250 L.F. ; D=60")		Job		354,100
	Energy Dissipation		Job		150,000
Electrical		41	Job	$242,100	9,926,100
				Current Contract Cost, Oct 07	**$43,118,404**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 8 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3 - Pumping Stations Gulf Park Estates - Elevation 20***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Hancock_Lod3_Inland Barrier_Vehicle Gates.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations GP-1 thru GP-8					
Structural Concrete, complete all sites		3,441	cy	$450	$1,548,413
Form Work, complete all sites		84,868	sf	$6.50	551,640
Steel Reinforcement, complete all sites		210	tons	$925	194,636
Excavation		5,005	cy	$15	75,082
Backfill		3,401	cy	$5	17,007
Trash Screens and Miscellaneous metal items, All Sites		24	each	$100,000	2,400,000
Pumps by Installation Site					
GP-1	Pumps	3	each	$222,200	666,600
	Discharge Piping (42" Dia; 150 L.F.)		job		87,000
	Energy Dissipation		job		120,000
GP-2	Pumps	4	each	$352,000	1,408,000
	Discharge Piping (54" Dia; 150 L.F.)		job		197,100
	Energy Dissipation		job		150,000
GP-3	Pumps	4	each	$440,000	1,760,000
	Discharge Piping (42" Dia; 150 L.F.)		job		240,000
	Energy Dissipation		job		150,000
GP-4	Pumps	3	each	$222,200	666,600
	Discharge Piping (42" Dia; 130 L.F.)		job		77,400
	Energy Dissipation		job		120,000
GP-5	Pumps	4	each	$352,000	1,408,000
	Discharge Piping (54" Dia; 140 L.F.)		job		180,500
	Energy Dissipation		job		150,000
GP-6	Pumps	4	each	$440,000	1,760,000
	Discharge Piping (60" Dia; 150 L.F.)		job		240,000
	Energy Dissipation		job		150,000
GP-7	Pumps	1	each	$385,000	385,000
	Discharge Piping (42" Dia; 125 L.F.)		job		24,000
	Energy Dissipation		job		60,000
GP-8	Pumps	1	each	$385,000	385,000
	Discharge Piping (42" Dia; 150 L.F.)		job		29,000
	Energy Dissipation		job		60,000
Electrical		24	Job	$242,100	5,810,400
				Current Contract Cost, Oct 07	**$21,071,378**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 9 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3 - Pumping Stations Gulf Park Estates - Elevation 30***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: GulfPkEst_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations GP-1 thru GP-8					
Structural Concrete, complete all sites		3,441	cy	$450	$1,548,413
Form Work, complete all sites		84,868	sf	$6.50	551,640
Steel Reinforcement, complete all sites		210	tons	$925	194,636
Excavation		5,005	cy	$15	75,082
Backfill		3,401	cy	$5	17,007
Trash Screens and Miscellaneous metal items, All Sites		65	each	$100,000	6,500,000
Pumps by Installation Site					
GP-1	Pumps	3	each	$240,350	721,050
	Discharge Piping (42" Dia; 150 L.F.)		job		87,000
	Energy Dissipation		job		120,000
GP-2	Pumps	4	each	$398,200	1,592,800
	Discharge Piping (54" Dia; 150 L.F.)		job		197,100
	Energy Dissipation		job		150,000
GP-3	Pumps	4	each	$467,500	1,870,000
	Discharge Piping (42" Dia; 150 L.F.)		job		240,000
	Energy Dissipation		job		150,000
GP-4	Pumps	3	each	$240,350	721,050
	Discharge Piping (42" Dia; 130 L.F.)		job		77,400
	Energy Dissipation		job		120,000
GP-5	Pumps	4	each	$398,200	1,592,800
	Discharge Piping (54" Dia; 140 L.F.)		job		180,500
	Energy Dissipation		job		150,000
GP-6	Pumps	4	each	$467,500	1,870,000
	Discharge Piping (60" Dia; 150 L.F.)		job		240,000
	Energy Dissipation		job		150,000
GP-7	Pumps	1	each	$203,500	203,500
	Discharge Piping (42" Dia; 125 L.F.)		job		24,000
	Energy Dissipation		job		60,000
GP-8	Pumps	1	each	$203,500	203,500
	Discharge Piping (42" Dia; 150 L.F.)		job		29,000
	Energy Dissipation		job		60,000
Electrical		65	Job	$242,100	15,736,500
				Current Contract Cost, Oct 07	**$35,432,978**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 10 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4 - Hancock County Inland Barrier - Elevation 20*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Hancock County_Lod4_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pump Stations HC-1 thru HC-3					
Structural Concrete, complete all sites		618	cy	450	278,142
Form Work, complete all sites		14,777	sf	6.50	96,047
Steel Reinforcement, complete all sites		38	tons	925	34,869
Excavation		1,075	cy	15	16,130
Backfill		721	cy	5	3,603
Trash Screens and Miscellaneous metal items, All Sites		10	each	100,000	1,000,000
Pumps by Installation Site					
HC-1	Pump	4	each	440,000	$1,760,000
	Discharge Piping (130 L.F.; D=60")		job		210,500
	Energy Dissipation		job		150,000
HC-2	Pump	4	each	352,000	$1,408,000
	Discharge Piping (120 L.F.; D=54")		job		148,500
	Energy Dissipation		job		150,000
HC-3	Pump	2	each	203,500	$407,000
	Discharge Piping (65 L.F.; D=42")		job		26,000
	Energy Dissipation		job		90,000
Electrical		10	Job	242,100	2,421,000

Current Contract Cost, Oct 07 **$8,199,791**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 11 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4 - Hancock County Inland Barrier - Elevation 30*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: HancockCounty_Lod4_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations HC-1 thru HC-3					
Structural Concrete, complete all sites		4,042	cy	450	1,818,963
Form Work, complete all sites		90,309	sf	6.50	587,007
Steel Reinforcement, complete all sites		245	tons	925	226,794
Excavation		11,697	cy	15	175,461
Backfill		7,404	cy	5	37,022
Trash Screens and Miscellaneous metal items, All Sites		10	each	100,000	1,000,000
Pumps by Installation Site					
HC-1	Pump	4	each	467,500	1,870,000
	Discharge Piping (190L.F.; D=60")		job		313,300
	Energy Dissipation		job		150,000
HC-2	Pump	4	each	398,200	1,592,800
	Discharge Piping (180 L.F.; D=54")		job		229,100
	Energy Dissipation		job		150,000
HC-3	Pump	2	each	387,200	774,400
	Discharge Piping (130 L.F.; D=42")		job		51,600
	Energy Dissipation		job		774,400
Electrical		10	Job	242,100	2,421,000

Current Contract Cost, Oct 07 **$12,171,846**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 12 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4 - Hancock County Inland Barrier - Elevation 40*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Hancock County_Lod4_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations HC-1 thru HC-3					
Structural Concrete, complete all sites		3,717	cy	450	1,672,671
Form Work, complete all sites		89,251	sf	6.50	580,133
Steel Reinforcement, complete all sites		227	tons	925	209,771
Excavation		6,237	cy	15	93,554
Backfill		4,251	cy	5	21,255
Trash Screens and Miscellaneous metal items, All Sites		12	each	100,000	1,200,000
Pumps by Installation Site					
HC-1	Pump	6	each	451,000	2706000
	Discharge Piping (255 L.F.; D=54")		job		489,600
	Energy Dissipation		job		210,000
HC-2	Pump	4	each	451,000	1804000
	Discharge Piping (240L.F.; D=54")		job		309,800
	Energy Dissipation		job		150,000
HC-3	Pump	2	each	387,200	774400
	Discharge Piping (190 L.F.; D=42")		job		76,800
	Energy Dissipation		job		90,000
Electrical		12	Job	242,100	2,905,200
				Current Contract Cost, Oct 07	**$13,293,184**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 13 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3 - HarrisonCounty Elevated Roadway - Elevation 16*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Harrison County_Lod3_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations H3-1 thru H3-15					
Structural Concrete, complete all sites		5,054	cy	$450	2,274,204
Form Work, complete all sites		119,999	sf	$6.50	779,995
Steel Reinforcement, complete all sites		310	tons	$925	286,503
Excavation		10,041	cy	$15	150,619
Backfill		13,516	cy	$5	67,581
Trash Screens and Miscellaneous metal items, All Sites		47	each	$100,000	4,700,000
Pumps by Installation Site					
H3-1	Pumps	2	each	$192,500	385,000
	Discharge Piping (130 L.F. ; D=42")		Job		51,600
	Energy Dissipation		Job		90,000
H3-2	Pumps	3	each	$376,200	1,128,600
	Discharge Piping (130 L.F. ; D=54")				123,800
	Energy Dissipation				120,000
H3-3	Pumps	3	each	$376,200	1,128,600
	Discharge Piping (130 L.F. ; D=54")				123,800
	Energy Dissipation				120,000
H3-4	Pumps	2	each	$240,350	480,700
	Discharge Piping (140 L.F. ; D=42")				56,400
	Energy Dissipation				90,000
H3-5	Pumps	3	each	$398,200	1,194,600
	Discharge Piping (150 L.F. ; D=54")				147,800
	Energy Dissipation				120,000
H3-6	Pumps	4	each	$467,500	1,870,000
	Discharge Piping (150 L.F. ; D=60")				251,300
	Energy Dissipation				150,000
H3-7	Pumps	4	each	$467,500	1,870,000
	Discharge Piping (150 L.F. ; D=60")				230,100
	Energy Dissipation				150,000
H3-8	Pumps	4	each	$467,500	1,870,000
	Discharge Piping (150 L.F. ; D=60")				251,300
	Energy Dissipation				150,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 14 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3 - HarrisonCounty Elevated Roadway - Elevation 16***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Harrison County_Lod3_Pumping Stations.xls

	DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
H3-9	Pumps	6	each	$467,500	2,805,000
	Discharge Piping (140 L.F. ; D=60")				345,200
	Energy Dissipation				210,000
H3-10	Pumps	3	each	$376,200	1,128,600
	Discharge Piping (130 L.F. ; D=54")				123,800
	Energy Dissipation				120,000
H3-11	Pumps	3	each	$376,200	1,128,600
	Discharge Piping (130 L.F. ; D=54")				123,800
	Energy Dissipation				120,000
H3-12	Pumps	4	each	$203,500	814,000
	Discharge Piping (130 L.F. ; D=42")				103,200
	Energy Dissipation				150,000
H3-13	Pumps	3	each	$203,500	610,500
	Discharge Piping (130 L.F. ; D=42")				77,400
	Energy Dissipation				120,000
H3-14	Pumps	1	each	$203,500	203,500
	Discharge Piping (130 L.F. ; D=42")				25,800
	Energy Dissipation				60,000
H3-15	Pumps	2	each	$240,350	480,700
	Discharge Piping (150 L.F. ; D=42")				61,600
	Energy Dissipation				90,000
Electrical		47	each	$242,100	11,378,700
				Current Contract Cost, Oct 07	**$40,692,903**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 15 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4 - Harrison County Inland Barrier - Elevation 40*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Harrison County_Lod4_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations H4-1 thru H4-7					
Structural Concrete, complete all sites		3,717	cy	$450	1,672,671
Form Work, complete all sites		89,251	sf	6.50	580,133
Steel Reinforcement, complete all sites		227	tons	925	209,771
Excavation		6,237	cy	15	93,554
Backfill		4,251	cy	5	21,255
Trash Screens and Miscellaneous metal items, All Sites		26	each	100,000	2,600,000
Pumps by Installation Site					
H4-1	Pump	4	each	456,500	1,826,000
	Discharge Piping (170L.F.; D=60")		job		270,900
	Energy Dissipation		job		120,000
H4-2	Pump	4	each	376,200	1,504,800
	Discharge Piping (170 L.F.; D=54")		job		212,500
	Energy Dissipation		job		120,000
H4-3	Pump	3	each	352,000	1,056,000
	Discharge Piping (150 L.F.; D=54")		job		147,800
	Energy Dissipation		job		90,000
H4-4	Pump	4	each	660,000	2,640,000
	Discharge Piping (255L.F.; D=60")		job		416,200
	Energy Dissipation		job		120,000
H4-5	Pump	4	each	456,500	1,826,000
	Discharge Piping (180 L.F.; D=60")		job		292,100
	Energy Dissipation		job		120,000
H4-6	Pump	4	each	376,200	1,504,800
	Discharge Piping (170 L.F.; D=54")		job		212,500
	Energy Dissipation		job		120,000
H4-7	Pump	3	each	376,200	1,128,600
	Discharge Piping (170 L.F.; D=54")		job		159,400
	Energy Dissipation		job		90,000
Electrical		26	each	242,100	6,294,600
Current Contract Cost, Oct 07					**$25,449,584**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 16 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4 - Harrison County Inland Barrier - Elevation 20 Option "A"***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Harrison County_Lod4_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations H4-4 (only)					
Structural Concrete, complete all sites		618	cy	$450.00	278,142
Form Work, complete all sites		14,777	sf	6.50	96,047
Steel Reinforcement, complete all sites		38	tons	925	34,869
Excavation		1,075	cy	15	16,130
Backfill		721	cy	5	3,603
Trash Screens and Miscellaneous metal items, All Sites		4	each	100,000	400,000
Pumps by Installation Site					
H4-4	Pump	4	each	400,000	$1,600,000
	Discharge Piping (130 L.F.; D=60")		job		210,500
	Energy Dissipation		job		120,000
Electrical		4	each	242,100	968,400
				Current Contract Cost, Oct 07	**$3,727,691**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 17 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4 - Harrison County Inland Barrier - Elevation 30 Option "B"*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Harrison County_Lod4_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations H4-1 thru H4-7					
Structural Concrete, complete all sites		4,042	cy	$450.00	1,818,963
Form Work, complete all sites		90,309	sf	6.50	587,007
Steel Reinforcement, complete all sites		245	tons	925	226,794
Excavation		11,697	cy	15	175,461
Backfill		7,404	cy	5	37,022
Trash Screens and Miscellaneous metal items, All Sites		26	each	100,000	2,600,000
Pumps by Installation Site					
H4-1	Pump	4	each	440,000	1,760,000
	Discharge Piping (100L.F.; D=60")		job		168,100
	Energy Dissipation		job		120,000
H4-2	Pump	4	each	330,000	1,320,000
	Discharge Piping (100 L.F.; D=54")		job		131,800
	Energy Dissipation		job		120,000
H4-3	Pump	3	each	313,500	940,500
	Discharge Piping (90 L.F.; D=54")		job		86,400
	Energy Dissipation		job		90,000
H4-4	Pump	4	each	456,500	1,826,000
	Discharge Piping (190 L.F.; D=60")		job		313,300
	Energy Dissipation		job		120,000
H4-5	Pump	4	each	440,000	1,760,000
	Discharge Piping (120 L.F.; D=60")		job		189,300
	Energy Dissipation		job		120,000
H4-6	Pump	4	each	330,000	1,320,000
	Discharge Piping (100 L.F.; D=54")		job		131,800
	Energy Dissipation		job		120,000
H4-7	Pump	3	each	330,000	990,000
	Discharge Piping (120 L.F.; D=54")		job		111,400
	Energy Dissipation		job		90,000
Electrical		26	each	242,100	6,294,600
				Current Contract Cost, Oct 07	**$23,568,446**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 18 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4 - Jackson County Inland Barrier - Elevation 20 Option "A"*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Jackson County_Lod4_Inland Barrier_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations J-1 and J-2				
Structural Concrete, complete all sites	1,457	cy	$450	$655,544
Form Work, complete all sites	34,623	sf	$6.50	225,050
Steel Reinforcement, complete all sites	89	tons	$925	81,991
Excavation	2,300	cy	$15	34,507
Backfill	1,512	cy	$5	7,558
Trash Screens and Miscellaneous metal items, All Sites	10	each	$100,000	1,000,000
Pumps by Installation Site				
J-1 Pumps	6	each	$440,000	2,640,000
Discharge Piping (150 L.F.; D=60")		job		377,000
Energy Dissipation		job		210,000
J-2 Pumps	4	each	$330,000	1,320,000
Discharge Piping (65 L.F.; D=54")		job		148,500
Energy Dissipation		job		150,000
Electrical	10	each	$242,100	2,421,000
Current Contract Cost, Oct 07				**$9,271,149**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 19 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4 - Jackson County Inland Barrier - Elevation 30*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Jackson County_Lod4_Inland Barrier_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations J-1 and J-2					
Structural Concrete, complete all sites		1,457	cy	$450	$655,544
Form Work, complete all sites		34,623	sf	$6.50	225,050
Steel Reinforcement, complete all sites		89	tons	$925	81,991
Excavation		2,300	cy	$15	34,507
Backfill		1,512	cy	$5	7,558
Trash Screens and Miscellaneous metal items, All Sites		10	each	100,000	1,000,000
Pumps by Installation Site					
J-1	Pumps	6	each	467,500	2,805,000
	Discharge Piping (217L.F.; D=60")		job		531,200
	Energy Dissipation		job		210,000
J-2	Pumps	4	each	376,200	1,504,800
	Discharge Piping (180 L.F.; D=54")		job		229,100
	Energy Dissipation		job		150,000
Electrical		10	each	242,100	2,421,000
				Current Contract Cost, Oct 07	**$9,855,749**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 20 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4 - Jackson County Inland Barrier - Elevation 40*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Jackson County_Lod4_Inland Barrier_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations J-1 and J-2					
Structural Concrete, complete all sites		1,903	cy	$450	$856,506
Form Work, complete all sites		46,408	sf	$6.50	301,651
Steel Reinforcement, complete all sites		116	tons	$925	107,190
Excavation		2,088	cy	$15	31,314
Backfill		1,357	cy	$5	6,783
Trash Screens and Miscellaneous metal items, All Sites		15	each	100,000	1,500,000
Pumps by Installation Site					
J-1	Pumps	8	each	451,000	3,608,000
	Discharge Piping (280 L.F.; D=54")		job		716,800
	Energy Dissipation		job		270,000
J-2	Pumps	7	each	387,200	2,710,400
	Discharge Piping (240L.F.; D=42")		job		338,800
	Energy Dissipation		job		240,000
Electrical		15	each	242,100	3,631,500
			Current Contract Cost, Oct 07		**$14,318,944**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 21 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Jackson County Elevated Roadway - Elevation 11*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Jackson Co_Seawall _Lod3_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations J3-1 thru J3-9 (7 stations total)					
Structural Concrete, complete all sites		1,756	cy	$450.00	$790,377
Form Work, complete all sites		42,353	sf	6.50	275,295
Steel Reinforcement, complete all sites		108	tons	925.00	100,212
Excavation		3,455	cy	15.00	51,824
Backfill (From Required Excavation)		2,505	cy	5.00	12,526
Trash Screens and Miscellaneous metal items, All Sites		22	each	100,000	2,200,000
Pumps by Installation Site					
J3-1	Pumps	3	each	192,500	577,500
	Discharge Piping (42" Dia; 75 L.F.)				43,200
	Energy Dissipation				120,000
J3-3	Pumps	3	each	330,000	990,000
	Discharge Piping (54" Dia; 100 L.F.)				93,100
	Energy Dissipation				120,000
J3-4	Pumps	2	each	192,500	385,000
	Discharge Piping (42" Dia; 100 L.F.)				38,800
	Energy Dissipation				90,000
J3-5	Pumps	6	each	192,500	1,155,000
	Discharge Piping (42" Dia; 100 L.F.)				116,400
	Energy Dissipation				210,000
J3-6	Pumps	4	each	192,500	770,000
	Discharge Piping (42" Dia; 90 L.F.)				72,400
	Energy Dissipation				150,000
J3-7	Pumps	2	each	330,000	660,000
	Discharge Piping (54" Dia; 100 L.F.)				62,100
	Energy Dissipation				90,000
J3-9	Pumps	2	each	313,500	627,000
	Discharge Piping (54" Dia; 60 L.F.)				37,800
	Energy Dissipation				90,000
Electrical		22	each	242,100	5,326,200

Current Contract Cost, Oct 07 **$15,254,735**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 22 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3 - Jackson County Ocean Springs- Elevation 20*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: OceanSprings_Lod3_RingLevee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations OS-1 thru OS -14					
Structural Concrete, complete all sites		5,615	cy	$450.00	$2,526,969
Form Work, complete all sites		139,413	sf	6.50	906,182
Steel Reinforcement, complete all sites		344	tons	925.00	318,037
Excavation		8,153	cy	15.00	122,290
Backfill		5,810	cy	5.00	29,049
Trash Screens and Miscellaneous metal items, All Sites		40	each	100,000	4,000,000
Pumps by Installation Site					
OS-1	Pumps	2	each	222,200	444,400
	Discharge Piping (130 L.F. ; D=42")				51,600
	Energy Dissipation				90,000
OS-2	Pumps	3	each	352,000	1,056,000
	Discharge Piping (150 L.F. ; D=54")				147,800
	Energy Dissipation				120,000
OS-3	Pumps	4	each	352,000	1,408,000
	Discharge Piping (150 L.F. ; D=54")				197,100
	Energy Dissipation				150,000
OS-4	Pumps	2	each	222,200	444,400
	Discharge Piping (150 L.F. ; D=42")				61,600
	Energy Dissipation				90,000
OS-5	Pumps	4	each	352,000	1,408,000
	Discharge Piping (150 L.F. ; D=54")				197,100
	Energy Dissipation				150,000
OS-6	Pumps	3	each	352,000	1,056,000
	Discharge Piping (150 L.F. ; D=54")				141,000
	Energy Dissipation				120,000
OS-7	Pumps	2	each	352,000	704,000
	Discharge Piping (150 L.F. ; D=54")				98,600
	Energy Dissipation				90,000
OS-8	Pumps	3	each	352,000	1,056,000
	Discharge Piping (150 L.F. ; D=54")				147,800
	Energy Dissipation				120,000
OS-9	Pumps	2	each	352,000	704,000
	Discharge Piping (120 L.F. ; D=54")				74,200
	Energy Dissipation				90,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 23 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3 - Jackson County Ocean Springs- Elevation 20*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: OceanSprings_Lod3_RingLevee_Pumping Stations.xls

	DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations OS-1 thru OS -14					
OS-10	Pumps	2	each	192,500	385,000
	Discharge Piping (65 L.F. ; D=42")				26,000
	Energy Dissipation				90,000
OS-11	Pumps	4	each	192,500	770,000
	Discharge Piping (125 L.F. ; D=42")				52,000
	Energy Dissipation				150,000
OS-12	Pumps	4	each	440,000	1,760,000
	Discharge Piping (150 L.F. ; D=60")				251,300
	Energy Dissipation				150,000
OS-13	Pumps	3	each	352,000	1,056,000
	Discharge Piping (140 L.F. ; D=54")				135,400
	Energy Dissipation				120,000
OS-14	Pumps	2	each	192,500	385,000
	Discharge Piping (90 L.F. ; D=42")				36,400
	Energy Dissipation				90,000
Electrical		40	each	242,100	9,684,000
				Current Contract Cost, Oct 07	**$33,461,226**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 24 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3 - Jackson County Ocean Springs- Elevation 30*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Jackson County_Lod4_Inland Barrier_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations OS-1 thru OS-14					
Structural Concrete, complete all sites		5,555	cy	$450.00	$2,499,806
Form Work, complete all sites		137,982	sf	6.50	896,882
Steel Reinforcement, complete all sites		360	tons	925.00	332,576
Excavation		8,236	cy	15.00	123,536
Backfill		5,884	cy	5.00	29,421
Trash Screens and Miscellaneous metal items, All Sites		40	each	100,000	4,000,000
Pumps by Installation Site					
Pumps by Installation Site					
OS-1	Pumps	2	each	240,350	480,700
	Discharge Piping (190 L.F. ; D=42")				76,800
	Energy Dissipation				90,000
OS-2	Pumps	3	each	398,200	1,194,600
	Discharge Piping (220 L.F. ; D=54")				208,300
	Energy Dissipation				120,000
OS-3	Pumps	4	each	398,200	1,592,800
	Discharge Piping (220 L.F. ; D=54")				277,800
	Energy Dissipation				150,000
OS-4	Pumps	2	each	240,350	480,700
	Discharge Piping (220 L.F. ; D=42")				86,800
	Energy Dissipation				90,000
OS-5	Pumps	4	each	398,200	1,592,800
	Discharge Piping (220 L.F. ; D=54")				277,800
	Energy Dissipation				150,000
OS-6	Pumps	3	each	398,200	1,194,600
	Discharge Piping (210 L.F. ; D=54")				201,900
	Energy Dissipation				120,000
OS-7	Pumps	2	each	398,200	796,400
	Discharge Piping (220 L.F. ; D=54")				138,900
	Energy Dissipation				90,000
OS-8	Pumps	3	each	398,200	1,194,600
	Discharge Piping (220 L.F. ; D=54")				208,300
	Energy Dissipation				120,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 25 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3 - Jackson County Ocean Springs- Elevation 30***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Jackson County_Lod4_Inland Barrier_Pumping Stations.xls

	DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations OS-1 thru OS-14					
OS-9	Pumps	2	each	398,200	796,400
	Discharge Piping (180 L.F. ; D=54")				114,600
	Energy Dissipation				90,000
OS-10	Pumps	2	each	222,200	444,400
	Discharge Piping (130 L.F. ; D=42")				51,600
	Energy Dissipation				90,000
OS-11	Pumps	4	each	188,100	752,400
	Discharge Piping (185 L.F. ; D=54")				237,200
	Energy Dissipation				150,000
OS-12	Pumps	4	each	467,500	1,870,000
	Discharge Piping (220 L.F. ; D=60")				354,100
	Energy Dissipation				150,000
OS-13	Pumps	3	each	398,200	1,194,600
	Discharge Piping (200 L.F. ; D=54")				195,800
	Energy Dissipation				120,000
OS-14	Pumps	2	each	222,200	444,400
	Discharge Piping (150 L.F. ; D=42")				61,600
	Energy Dissipation				90,000
Electrical		40	each	242,100	9,684,000
	Current Contract Cost, Oct 07				**$35,707,123**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 26 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Pascagoula-MossPoint - Elevation 30***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Pascagoula-LossPoint _Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations PM-1 thru PM-28				
Structural Concrete, complete all sites	12,908	cy	$450.00	$5,808,808
Form Work, complete all sites	316,185	sf	6.50	2,055,199
Steel Reinforcement, complete all sites	744	tons	925.00	687,899
Excavation	18,513	cy	15.00	277,701
Backfill	12,815	cy	5.00	64,075
Trash Screens and Miscellaneous metal items, All Sites	21	each	100,000.00	2,100,000
Pumps by Site Name				
PM-1 Pumps	9	each	467,500.00	$4,207,500
Discharge Piping (150 L.F. ; D=54")		each	69,440.00	624,960
Energy Dissipation		Job		300,000
PM-2 Pumps	2	each	302,500.00	$605,000
Discharge Piping (150L.F. ; D=54")		Job	69,440.00	138,880
Energy Dissipation		Job		90,000
PM-3 Pumps	1	each	387,200.00	$387,200
Discharge Piping (140 L.F. ; D=42")		Job	40,800.00	40,800
Energy Dissipation		Job		60,000
PM-4 Pumps	2	each	302,500.00	$605,000
Discharge Piping (150 L.F. ; D=42)		Job	43,400.00	86,800
Energy Dissipation		Job		90,000
PM-5 Pumps	1	each	387,200.00	$387,200
Discharge Piping (150 L.F. ; D=54")		Job	69,440.00	69,440
Energy Dissipation		Job		60,000
PM-6 Pumps	1	each	387,200.00	$387,200
Discharge Piping (150 L.F. ; D=42")		Job	43,400.00	43,400
Energy Dissipation		Job		60,000
PM-7 Pumps	2	each	193,600.00	$387,200
Discharge Piping (130 L.F. ; D=42")		Job	38,400.00	76,800
Energy Dissipation		Job		90,000
PM-8 Pumps	4	each	240,350.00	$961,400
Discharge Piping (150 L.F. ; D=42")		Job	43,400.00	173,600
Energy Dissipation		Job		150,000
PM-9 Pumps	7	each	240,350.00	$1,682,450
Discharge Piping (150L.F. ; D=42")		Job	43,400.00	303,800
Energy Dissipation		Job		240,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 27 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Pascagoula-MossPoint - Elevation 30***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Pascagoula-LossPoint _Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations PM-1 thru PM-28				
PM-10 Pumps	5	each	192,280.00	$961,400
Discharge Piping (150 L.F. ; D=54")		Job	69,440.00	347,200
Energy Dissipation		Job		180,000
PM-11 Pumps	2	each	376,200.00	$752,400
Discharge Piping (150 L.F. ; D=54)		Job	69,440.00	138,880
Energy Dissipation		Job		90,000
PM-12 Pumps	2	each	398,200.00	$796,400
Discharge Piping (150 L.F. ; D=54")		Job	69,440.00	138,880
Energy Dissipation		Job		90,000
PM-13 Pumps	2	each	398,200.00	$796,400
Discharge Piping (150 L.F. ; D=54")		Job	69,440.00	138,880
Energy Dissipation		Job		90,000
PM-14 Pumps	1	each	203,500.00	$203,500
Discharge Piping (125 L.F. ; D=42")		Job	34,500.00	34,500
Energy Dissipation		Job		60,000
PM-15 Pumps	5	each	238,920.00	$1,194,600
Discharge Piping (140 L.F. ; D=54")		Job	65,280.00	326,400
Energy Dissipation		Job		180,000
PM-16 Pumps	2	each	302,500.00	$605,000
Discharge Piping (150L.F. ; D=42")		Job	43,400.00	86,800
Energy Dissipation		Job		90,000
PM-17 Pumps	1	each	961,400.00	$961,400
Discharge Piping (135L.F. ; D=42")		Job	39,600.00	39,600
Energy Dissipation		Job		60,000
PM-18 Pumps	5	each	374,000.00	$1,870,000
Discharge Piping (145 L.F. ; D=42)		Job	42,100.00	210,500
Energy Dissipation		Job		180,000
PM-19 Pumps	5	each	192,280.00	$961,400
Discharge Piping (150 L.F. ; D=42")		Job	43,400.00	217,000
Energy Dissipation		Job		180,000
PM-20 Pumps	4	each	240,350.00	$961,400
Discharge Piping (150 L.F. ; D=42")		Job	43,400.00	173,600
Energy Dissipation		Job		150,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 28 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Pascagoula-MossPoint - Elevation 30***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Pascagoula-LossPoint _Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations PM-1 thru PM-28					
PM-21	Pumps	3	each	398,200.00	$1,194,600
	Discharge Piping (150 L.F. ; D=54")		Job	69440	208,320
	Energy Dissipation		Job		120,000
PM-22	Pumps	10	each	119,460.00	1,194,600
	Discharge Piping (150 L.F. ; D=54")		Job	69,440.00	694,400
	Energy Dissipation		Job		330,000
PM-23	Pumps	4	each	467,500.00	1,870,000
	Discharge Piping (150L.F. ; D=42")		Job	43,400.00	173,600
	Energy Dissipation		Job		150,000
PM-24	Pumps	5	each	238,920.00	1,194,600
	Discharge Piping (105 L.F. ; D=54")		Job	53,120.00	265,600
	Energy Dissipation		Job		180,000
PM-25	Pumps	5	each	238,920.00	1,194,600
	Discharge Piping (150 L.F. ; D=54)		Job	69,440.00	347,200
	Energy Dissipation		Job		180,000
PM-26	Pumps	3	each	623,333.33	1,870,000
	Discharge Piping (150 L.F. ; D=54")		Job	69,440.00	208,320
	Energy Dissipation		Job		120,000
PM-27	Pumps	2	each	480,700.00	961,400
	Discharge Piping (150 L.F. ; D=42")		Job	43,400.00	86,800
	Energy Dissipation		Job		90,000
PM-28	Pumps	2	each	597,300.00	1,194,600
	Discharge Piping (150 L.F. ; D=54")		Job	69440	138,880
	Energy Dissipation		Job		90,000
Electrical		21	each	242,100	5,084,100
			Current Contract Cost, Oct 07		**$55,710,072**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 29 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Pascagoula-MossPoint - Elevation 20***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Pascagoula-MossPoint_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations PM-1 thru PM-28				
Structural Concrete, complete all sites	13,456	cy	$450.00	$6,055,421
Form Work, complete all sites	330,110	sf	6.50	2,145,717
Steel Reinforcement, complete all sites	752	tons	925.00	695,945
Excavation	18,134	cy	15.00	272,014
Backfill	12,560	cy	5.00	62,800
Trash Screens and Miscellaneous metal items, All Sites	23	each	100,000.00	2,300,000
Pumps by Site Name				
PM-1 Pumps	9	each	352,000	3,168,000
Discharge Piping (150 L.F. ; D=54")		each	49,280	443,520
Energy Dissipation		Job		300,000
PM-2 Pumps	2	each	352,000	704,000
Discharge Piping (150L.F. ; D=54")		Job	49,280	98,560
Energy Dissipation		Job		30,000
PM-3 Pumps	1	each	203,500	203,500
Discharge Piping (140 L.F. ; D=42")		Job	28,200	28,200
Energy Dissipation		Job		20,000
PM-4 Pumps	2	each	222,200	444,400
Discharge Piping (150 L.F. ; D=42)		Job	30,800	61,600
Energy Dissipation		Job		40,000
PM-5 Pumps	4	each	352,000	1,408,000
Discharge Piping (150 L.F. ; D=54")		Job	49,280	197,120
Energy Dissipation		Job		30,000
PM-6 Pumps	1	each	203,500	203,500
Discharge Piping (150 L.F. ; D=42")		Job	30,800	30,800
Energy Dissipation		Job		40,000
PM-7 Pumps	2	each	192,500	385,000
Discharge Piping (130 L.F. ; D=42")		Job	25,800	51,600
Energy Dissipation		Job		40,000
PM-8 Pumps	4	each	222,200	888,800
Discharge Piping (150 L.F. ; D=42")		Job	30,800	123,200
Energy Dissipation		Job		30,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 30 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Pascagoula-MossPoint - Elevation 20***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Pascagoula-MossPoint_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations PM-1 thru PM-28				
PM-9 Pumps	7	each	222,200	$1,555,400
Discharge Piping (150L.F. ; D=42")		Job	30,800	215,600
Energy Dissipation		Job		30,000
PM-10 Pumps	3	each	352,000	1,056,000
Discharge Piping (150 L.F. ; D=54")		Job	49,280	147,840
Energy Dissipation		Job		20,000
PM-11 Pumps	2	each	352,000	704,000
Discharge Piping (150 L.F. ; D=54)		Job	49,280	98,560
Energy Dissipation		Job		40,000
PM-12 Pumps	2	each	352,000	704,000
Discharge Piping (150 L.F. ; D=54")		Job	49,280	98,560
Energy Dissipation		Job		30,000
PM-13 Pumps	2	each	352,000	704,000
Discharge Piping (150 L.F. ; D=54")		Job	49,280	98,560
Energy Dissipation		Job		40,000
PM-14 Pumps	1	each	203,500	203,500
Discharge Piping (125 L.F. ; D=42")		Job	24,500	24,500
Energy Dissipation		Job		40,000
PM-15 Pumps	5	each	352,000	1,760,000
Discharge Piping (140 L.F. ; D=54")		Job	45,120	225,600
Energy Dissipation		Job		30,000
PM-16 Pumps	4	each	222,200	888,800
Discharge Piping (150L.F. ; D=42")		Job	30,800	123,200
Energy Dissipation		Job		30,000
PM-17 Pumps	1	each	192,500	192,500
Discharge Piping (135L.F. ; D=42")		Job	27,000	27,000
Energy Dissipation		Job		20,000
PM-18 Pumps	10	each	222,200	2,222,000
Discharge Piping (145 L.F. ; D=42)		Job	29,500	295,000
Energy Dissipation		Job		40,000
PM-19 Pumps	5	each	222,200	1,111,000
Discharge Piping (150 L.F. ; D=42")		Job	30,800	154,000
Energy Dissipation		Job		30,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 31 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Pascagoula-MossPoint - Elevation 20***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Pascagoula-MossPoint_Lod3_Ring Levee_Pumping Stations.xls

	DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations PM-1 thru PM-28					
PM-20	Pumps	8	each	203,500	$1,628,000
	Discharge Piping (150 L.F. ; D=42")		Job	30,800	246,400
	Energy Dissipation		Job		40,000
PM-21	Pumps	3	each	352,000	1,056,000
	Discharge Piping (150 L.F. ; D=54")		Job	49,280	147,840
	Energy Dissipation		Job		40,000
PM-22	Pumps	10	each	352,000	3,520,000
	Discharge Piping (150 L.F. ; D=54")		Job	49,280	492,800
	Energy Dissipation		Job		30,000
PM-23	Pumps	8	each	222,200	1,777,600
	Discharge Piping (150L.F. ; D=42")		Job	30,800	246,400
	Energy Dissipation		Job		30,000
PM-24	Pumps	5	each	330,000	1,650,000
	Discharge Piping (105 L.F. ; D=54")		Job	32,960	164,800
	Energy Dissipation		Job		20,000
PM-25	Pumps	5	each	352,000	1,760,000
	Discharge Piping (150 L.F. ; D=54)		Job	49,280	246,400
	Energy Dissipation		Job		40,000
PM-26	Pumps	4	each	352,000	1,408,000
	Discharge Piping (150 L.F. ; D=54")		Job	49,280	197,120
	Energy Dissipation		Job		30,000
PM-27	Pumps	2	each	222,200	444,400
	Discharge Piping (150 L.F. ; D=42")		Job	30,800	61,600
	Energy Dissipation		Job		40,000
PM-28	Pumps	2	each	352,000	704,000
	Discharge Piping (150 L.F. ; D=54")		Job	49,280	98,560
	Energy Dissipation		Job		40,000
Electrical		23	each	242,100	5,568,300
				Current Contract Cost, Oct 07	**$55,189,536**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 32 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3 - Hancock County Pearlington- Elevation 20*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Pearlington_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations P-1 thru P-6					
Structural Concrete, complete all sites		2,945	cy	$450.00	$1,325,119
Form Work, complete all sites		72,044	sf	6.50	468,284
Steel Reinforcement, complete all sites		180	tons	925.00	166,284
Excavation		4,205	cy	15.00	63,070
Backfill		2,872	cy	5.00	14,361
Trash Screens and Miscellaneous metal items, All Sites		20	each	100,000	2,000,000
Pumps by Installation Site					
P-1	Pumps	4	each	352,000	1,408,000
	Discharge Piping (54" Dia; 150 L.F.)				197,100
	Energy Dissipation				150,000
P-2	Pumps	3	each	352,000	1,056,000
	Discharge Piping (54" Dia; 150 L.F.)				147,800
	Energy Dissipation				120,000
P-3	Pumps	8	each	440,000	3,520,000
	Discharge Piping (60" Dia; 150 L.F.)				502,700
	Energy Dissipation				270,000
P-4	Pumps	2	each	222,200	444,400
	Discharge Piping (42" Dia; 150 L.F.)				61,600
	Energy Dissipation				90,000
P-5	Pumps	2	each	222,200	444,400
	Discharge Piping (42" Dia; 150 L.F.)				61,600
	Energy Dissipation				90,000
P-6	Pumps	1	each	222,200	222,200
	Discharge Piping (42" Dia; 150 L.F.)				30,800
	Energy Dissipation				60,000
Electrical		20	each	242,100	4,842,000
				Current Contract Cost, Oct 07	**$17,755,717**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 33 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3 - Hancock County Pearlington- Elevation 30*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Pearlington_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations P-1 thru P-6					
Structural Concrete, complete all sites		2,945	cy	$450.00	$1,325,119
Form Work, complete all sites		72,044	sf	6.50	468,284
Steel Reinforcement, complete all sites		180	tons	925.00	166,284
Excavation		4,205	cy	15.00	63,070
Backfill		2,872	cy	5.00	14,361
Trash Screens and Miscellaneous metal items, All Sites		20	each	100,000	2,000,000
Pumps by Installation Site					
P-1	Pumps	4	each	398,200	1,592,800
	Discharge Piping (54 Dia; 150 L.F.)				277,800
	Energy Dissipation				150,000
P-2	Pumps	3	each	398,200	1,194,600
	Discharge Piping (54" Dia; 150 L.F.)				208,300
	Energy Dissipation				120,000
P-3	Pumps	8	each	467,500	3,740,000
	Discharge Piping (60" Dia; 150 L.F.)				708,300
	Energy Dissipation				270,000
P-4	Pumps	2	each	240,350	480,700
	Discharge Piping (42" Dia; 130 L.F.)				86,800
	Energy Dissipation				90,000
P-5	Pumps	2	each	240,350	480,700
	Discharge Piping (42" Dia; 140 L.F.)				86,800
	Energy Dissipation				90,000
P-6	Pumps	1	each	240,350	240,350
	Discharge Piping (42" Dia; 150 L.F.)				43,400
	Energy Dissipation				60,000
Electrical		20	each	242,100	4,842,000
				Current Contract Cost, Oct 07	**$18,799,667**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 34 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4 - Harrison County Inland Barrier - Elevation 20 Option "D"*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Harrison County_Lod4_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations H4-4 (only)					
Structural Concrete, complete all sites		618	cy	$450.00	278,142
Form Work, complete all sites		14,777	sf	6.50	96,047
Steel Reinforcement, complete all sites		38	tons	925	34,869
Excavation		1,075	cy	15	16,130
Backfill		721	cy	5	3,603
Trash Screens and Miscellaneous metal items, All Sites		4	each	100,000	400,000
Pumps by Installation Site					
H4-4	Pump	4	each	400,000	$1,600,000
	Discharge Piping (130 L.F.; D=60")		job		210,500
	Energy Dissipation		job		120,000
Electrical		4	each	242,100	968,400
				Current Contract Cost, Oct 07	**$3,727,691**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 35 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4 - Harrison County Inland Barrier - Elevation 30 Option "E"*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Harrison County_Lod4_Pumping Stations.xls

Pumping Stations H4-1 thru H4-7

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Structural Concrete, complete all sites		4,042	cy	$450.00	1,818,963
Form Work, complete all sites		90,309	sf	6.50	587,007
Steel Reinforcement, complete all sites		245	tons	925	226,794
Excavation		11,697	cy	15	175,461
Backfill		7,404	cy	5	37,022
Trash Screens and Miscellaneous metal items, All Sites		26	each	100,000	2,600,000
Pumps by Installation Site					
H4-1	Pump	4	each	440,000	1,760,000
	Discharge Piping (100L.F.; D=60")		job		168,100
	Energy Dissipation		job		120,000
H4-2	Pump	4	each	330,000	1,320,000
	Discharge Piping (100 L.F.; D=54")		job		131,800
	Energy Dissipation		job		120,000
H4-3	Pump	3	each	313,500	940,500
	Discharge Piping (90 L.F.; D=54")		job		86,400
	Energy Dissipation		job		90,000
H4-4	Pump	4	each	456,500	1,826,000
	Discharge Piping (190 L.F.; D=60")		job		313,300
	Energy Dissipation		job		120,000
H4-5	Pump	4	each	440,000	1,760,000
	Discharge Piping (120 L.F.; D=60")		job		189,300
	Energy Dissipation		job		120,000
H4-6	Pump	4	each	330,000	1,320,000
	Discharge Piping (100 L.F.; D=54")		job		131,800
	Energy Dissipation		job		120,000
H4-7	Pump	3	each	330,000	990,000
	Discharge Piping (120 L.F.; D=54")		job		111,400
	Energy Dissipation		job		90,000
Electrical		26	each	242,100	6,294,600
				Current Contract Cost, Oct 07	$23,568,446

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 36 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4- Pumping Stations Menge Ave.- Elevation 20 Optional Arrangement F (8-07)***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: MengeAveOpt(8-07)_Lod4_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Pumping Stations M-1 and M-2				
Structural Concrete, complete all sites	2,497	cy	$450.00	$202,500
Form Work, complete all sites	58,529	ft2	6.50	380,437
Steel Reinforcement, complete all sites	152	lbs	925.00	140,841
Excavation	3,616	cy	15.00	54,235
Backfill	2,338	cy	5.00	11,689
Trash Screens and Miscellaneous metal items, All Sites	28	each	100,000.00	2,800,000
Pumps by Site Name				
M-1 Pumps	11	each	222200	$2,444,200
Discharge Piping (150 L.F. ; D=42")		each	28200	310,200
Energy Dissipation		Job		360,000.00
M-2 Pumps	13	each	280500	$3,646,500
Discharge Piping (150L.F. ; D=48")		Job	35250	458,250
Energy Dissipation		Job		30,000
H4-4 Pump	4	each	400,000	$1,600,000
Discharge Piping (130 L.F.; D=60")		job		210,500
Energy Dissipation		job		120,000
Electrical	28	each	242100	6,778,800
			Current Contract Cost, Oct 07	$19,548,152

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 37 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4- Pumping Stations MengeAve.- Elevation 30 Optional Arrangement G (8-07)*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: MengeAveOpt(8-07)_Lod4_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Pumping Stations M-1 nd M-2					
Structural Concrete, complete all sites		6,307	cy	$450.00	$2,838,183
Form Work, complete all sites		144,481	ft2	6.50	939,127
Steel Reinforcement, complete all sites		383	lbs	925.00	354,411
Excavation		14,238	cy	15.00	213,567
Backfill		9,022	cy	5.00	45,108
Trash Screens and Miscellaneous metal items, All Sites		50	each	100,000.00	5,000,000
Pumps by Site Name					
M-1	Pumps	11	each	240,350.00	$2,643,850
	Discharge Piping (150 L.F. ; D=42")		each	40,800.00	$448,800
	Energy Dissipation		Job		$360,000
M-2	Pumps	13	each	302,500.00	$3,932,500
	Discharge Piping (150L.F. ; D=48")		Job	51,000.00	$663,000
	Energy Dissipation		Job		$420,000
H4-1	Pump	4	each	440,000	1,760,000
	Discharge Piping (100L.F.; D=60")		job		168,100
	Energy Dissipation		job		120,000
H4-2	Pump	4	each	330,000	1,320,000
	Discharge Piping (100 L.F.; D=54")		job		131,800
	Energy Dissipation		job		120,000
H4-3	Pump	3	each	313,500	940,500
	Discharge Piping (90 L.F.; D=54")		job		86,400
	Energy Dissipation		job		90,000
H4-4	Pump	4	each	456,500	1,826,000
	Discharge Piping (190 L.F.; D=60")		job		313,300
	Energy Dissipation		job		120,000
H4-5	Pump	4	each	440,000	1,760,000
	Discharge Piping (120 L.F.; D=60")		job		189,300
	Energy Dissipation		job		120,000
H4-6	Pump	4	each	330,000	1,320,000
	Discharge Piping (100 L.F.; D=54")		job		131,800
	Energy Dissipation		job		120,000
H4-7	Pump	3	each	330,000	990,000
	Discharge Piping (120 L.F.; D=54")		job		111,400
	Energy Dissipation		job		90,000
Electrical		50	each	242,100	$12,105,000
			Current Contract Cost, Oct 07		$41,792,146

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 38 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 4- Pumping Stations MengeAve.- Elevation 40 Optional Arrangement H(8-07)*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: MengeAveOpt(8-07)_Lod4_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Pumping Stations M-1 thru M-7				
Structural Concrete, complete all sites	6,169	cy	$450.00	$2,776,119
Form Work, complete all sites	146,574	ft2	6.50	952,730
Steel Reinforcement, complete all sites	377	lbs	925.00	348,896
Excavation	10,542	cy	15.00	158,136
Backfill	7,177	cy	5.00	35,884
Trash Screens and Miscellaneous metal items, All Sites	59	each	100,000.00	5,900,000
Pumps by Site Name				
M-1 Pumps	10	each	409,200.00	$4,092,000
Discharge Piping (150 L.F. ; D=48")		each	67,000.00	$670,000
Energy Dissipation		Job		$330,000
M-2 Pumps	13	each	409,200.00	$5,319,600
Discharge Piping (150L.F. ; D=48")		Job	67,000.00	$871,000
Energy Dissipation		Job		$420,000
M-3 Pumps	2	each	187,000.00	$374,000
Discharge Piping (140 L.F. ; D=36")		Job	28,800.00	$57,600
Energy Dissipation		Job		$90,000
M-4 Pumps	2	each	97,900.00	$195,800
Discharge Piping (150 L.F. ; D=26")		Job	14,100.00	$28,200
Energy Dissipation		Job		$90,000
M-5 Pumps	2	each	280,500.00	$561,000
Discharge Piping (150 L.F. ; D=48")		Job	35,250.00	$70,500
Energy Dissipation		Job		$90,000
M-6 Pumps	2	each	154,000.00	$308,000
Discharge Piping (150 L.F. ; D=36")		Job	56,000.00	$112,000
Energy Dissipation		Job		$90,000
M-7 Pumps	2	each	376,200.00	$752,400
Discharge Piping (150 L.F. ; D=54")		Job	45,120.00	$90,240
Energy Dissipation		Job		$90,000
H4-1 Pump	4	each	456,500	1,826,000
Discharge Piping (170L.F.; D=60")		job		270,900
Energy Dissipation		job		120,000
H4-2 Pump	4	each	376,200	1,504,800
Discharge Piping (170 L.F.; D=54")		job		212,500
Energy Dissipation		job		120,000
H4-3 Pump	3	each	352,000	1,056,000
Discharge Piping (150 L.F.; D=54")		job		147,800
Energy Dissipation		job		90,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 39 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4- Pumping Stations MengeAve.- Elevation 40 Optional Arrangement H(8-07)*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: MengeAveOpt(8-07)_Lod4_Pumping Stations.xls

	DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Pumping Stations M-1 thru M-7					
H4-4	Pump	4	each	660,000	2,640,000
	Discharge Piping (255L.F.; D=60")		job		416,200
	Energy Dissipation		job		120,000
H4-5	Pump	4	each	456,500	1,826,000
	Discharge Piping (180 L.F.; D=60")		job		292,100
	Energy Dissipation		job		120,000
H4-6	Pump	4	each	376,200	1,504,800
	Discharge Piping (170 L.F.; D=54")		job		212,500
	Energy Dissipation		job		120,000
H4-7	Pump	3	each	376,200	1,128,600
	Discharge Piping (170 L.F.; D=54")		job		159,400
	Energy Dissipation		job		90,000
Electrical		59	each	242,100	$14,283,900
			Current Contract Cost, Oct 07		$53,135,605

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 40 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4- Pumping Stations Menge Ave.- Elevation 20 Optional Arrangement I (8-07)***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: MengeAveOpt(8-07)_Lod4_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Pumping Stations M-1 and M-2				
Structural Concrete, complete all sites	2,497	cy	$450.00	$202,500
Form Work, complete all sites	58,529	ft2	6.50	380,437
Steel Reinforcement, complete all sites	152	lbs	925.00	140,841
Excavation	3,616	cy	15.00	54,235
Backfill	2,338	cy	5.00	11,689
Trash Screens and Miscellaneous metal items, All Sites	28	each	100,000.00	2,800,000
Pumps by Site Name				
M-1 Pumps	11	each	222200	$2,444,200
Discharge Piping (150 L.F. ; D=42")		each	28200	310,200
Energy Dissipation		Job		360,000.00
M-2 Pumps	13	each	280500	$3,646,500
Discharge Piping (150L.F. ; D=48")		Job	35250	458,250
Energy Dissipation		Job		30,000
H4-4 Pump	4	each	400,000	$1,600,000
Discharge Piping (130 L.F.; D=60")		job		210,500
Energy Dissipation		job		120,000
Electrical	28	each	242100	6,778,800
			Current Contract Cost, Oct 07	$19,548,152

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 41 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 4- Pumping Stations MengeAve.- Elevation 30 Optional Arrangement J (8-07)*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: MengeAveOpt(8-07)_Lod4_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Harrison County Pumping Stations M-1 nd M-2					
Structural Concrete, complete all sites		6,307	cy	$450.00	$2,838,183
Form Work, complete all sites		144,481	ft2	6.50	939,127
Steel Reinforcement, complete all sites		383	lbs	925.00	354,411
Excavation		14,238	cy	15.00	213,567
Backfill		9,022	cy	5.00	45,108
Trash Screens and Miscellaneous metal items, All Sites		50	each	100,000.00	5,000,000
Pumps by Site Name					
M-1	Pumps	11	each	240,350.00	$2,643,850
	Discharge Piping (150 L.F. ; D=42")		each	40,800.00	$448,800
	Energy Dissipation		Job		$360,000
M-2	Pumps	13	each	302,500.00	$3,932,500
	Discharge Piping (150L.F. ; D=48")		Job	51,000.00	$663,000
	Energy Dissipation		Job		$420,000
H4-1	Pump	4	each	440,000	1,760,000
	Discharge Piping (100L.F.; D=60")		job		168,100
	Energy Dissipation		job		120,000
H4-2	Pump	4	each	330,000	1,320,000
	Discharge Piping (100 L.F.; D=54")		job		131,800
	Energy Dissipation		job		120,000
H4-3	Pump	3	each	313,500	940,500
	Discharge Piping (90 L.F.; D=54")		job		86,400
	Energy Dissipation		job		90,000
H4-4	Pump	4	each	456,500	1,826,000
	Discharge Piping (190 L.F.; D=60")		job		313,300
	Energy Dissipation		job		120,000
H4-5	Pump	4	each	440,000	1,760,000
	Discharge Piping (120 L.F.; D=60")		job		189,300
	Energy Dissipation		job		120,000
H4-6	Pump	4	each	330,000	1,320,000
	Discharge Piping (100 L.F.; D=54")		job		131,800
	Energy Dissipation		job		120,000
H4-7	Pump	3	each	330,000	990,000
	Discharge Piping (120 L.F.; D=54")		job		111,400
	Energy Dissipation		job		90,000
Electrical		50	each	242,100	$12,105,000
			Current Contract Cost, Oct 07		$41,792,146

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 42 OF 57
PREPARED Joseph H. Ellswortl CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Washington Ave.- Elevation 20 Optional Arrangement 'C'(8-07)*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: WashingtonAveOpt(8-07)_Lod4_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Jackson County Pumping Stations W-1 thru W-6 (with Washington Ave.)				
Structural Concrete, complete all sites	2,951	cy	$450.00	$1,328,133
Form Work, complete all sites	69,582	sf	6.50	452,283
Steel Reinforcement, complete all sites	180	tons	925.00	166,683
Excavation	5,224	cy	15.00	78,356
Backfill	3,524	cy	5.00	17,619
Trash Screens and Miscellaneous metal items, All Sites	26	each	100,000.00	2,600,000
Pumps by Site Name				
W-1 Pumps	3	each	302500	$907,500
Discharge Piping (150 L.F. ; D=48")		each	38500	115,500
Energy Dissipation		Job		120,000.00
W-2 Pumps	5	each	456500	$2,282,500
Discharge Piping (150L.F. ; D=60")		Job	60180	300,900
Energy Dissipation		Job		30,000
W-3 Pumps	3	each	280500	$841,500
Discharge Piping (140 L.F. ; D=48")		Job	38500	115,500
Energy Dissipation		Job		20,000
W-4 Pumps	4	each	376200	$1,504,800
Discharge Piping (150 L.F. ; D=54")		Job	49280	197,120
Energy Dissipation		Job		40,000
W-5 Pumps	4	each	376200	$1,504,800
Discharge Piping (150 L.F. ; D=54")		Job	49280	197,120
Energy Dissipation		Job		30,000
W-6 Pumps	7	each	330000	$2,310,000
Discharge Piping (150 L.F. ; D=54")		Job	32960	230,720
Energy Dissipation		Job		40,000
Electrical	26	each	242100	6,294,600
Current Contract Cost, Oct 07				$21,725,635

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 43 OF 57
PREPARED Joseph H. Ellswortl CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Washington Ave.- Elevation 30 Optional Arrangement 'D'(8-07)*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: WashingtonAveOpt(8-07)_Lod4_Pumping Stations.xls

Jackson County Pumping Stations W-1 thru W-6 (with Washington Ave.)

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Structural Concrete, complete all sites	3,452	cy	$450.00	$1,553,571
Form Work, complete all sites	83,467	sf	6.50	542,537
Steel Reinforcement, complete all sites	211	tons	925.00	194,746
Excavation	5,227	cy	15.00	78,399
Backfill	3,537	cy	5.00	17,683
Trash Screens and Miscellaneous metal items, All Sites	24	each	100,000.00	2,400,000
Pumps by Site Name				
W-1 Pumps	3	each	302,500.00	$907,500
Discharge Piping (150 L.F. ; D=48")		each	38,500.00	$115,500
Energy Dissipation		Job		$120,000
W-2 Pumps	5	each	561,000.00	$2,805,000
Discharge Piping (150L.F. ; D=60")		Job	60,180.00	$300,900
Energy Dissipation		Job		$180,000
W-3 Pumps	3	each	302,500.00	$907,500
Discharge Piping (140 L.F. ; D=48")		Job	38,500.00	$115,500
Energy Dissipation		Job		$120,000
W-4 Pumps	4	each	398,200.00	$1,592,800
Discharge Piping (150 L.F. ; D=54")		Job	49,280.00	$197,120
Energy Dissipation		Job		$150,000
W-5 Pumps	4	each	451,000.00	$1,804,000
Discharge Piping (150 L.F. ; D=54")		Job	49,280.00	$197,120
Energy Dissipation		Job		$150,000
W-6 Pumps	5	each	456,500.00	$2,282,500
Discharge Piping (150 L.F. ; D=60")		Job	42,024.00	$210,120
Energy Dissipation		Job		$180,000
Electrical	24	each	242,100	$5,810,400

Current Contract Cost, Oct 07 $22,932,896

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 44 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations MossPoint - Elevation 20 Optional Arrangement 'E'(8-07)***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: MossPoint(8-07)_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations MP-1 thru MP-10				
Structural Concrete, complete all sites	2,907	cy	$450.00	$1,308,148
Form Work, complete all sites	70,100	sf	6.50	455,652
Steel Reinforcement, complete all sites	179	tons	925.00	165,312
Excavation	5,267	cy	15.00	79,012
Backfill	3,742	cy	5.00	18,708
Trash Screens and Miscellaneous metal items, All Sites	32	each	100,000.00	3,200,000
Pumps by Site Name				
MP-1 Pumps	3	each	192,500	$577,500
Discharge Piping (150 L.F. ; D=42")		each	18,200	$54,600
Energy Dissipation		Job		$120,000
MP-2 Pumps	2	each	376,200	$752,400
Discharge Piping (150L.F. ; D=54")		Job	49,280	$98,560
Energy Dissipation		Job		$30,000
MP-3 Pumps	4	each	376,200	$1,504,800
Discharge Piping (140 L.F. ; D=54")		Job	49,280	$197,120
Energy Dissipation		Job		$20,000
MP-4 Pumps	7	each	330,000	$2,310,000
Discharge Piping (150 L.F. ; D=54)		Job	32,960	$230,720
Energy Dissipation		Job		$40,000
MP-5 Pumps	2	each	222,200	$444,400
Discharge Piping (150 L.F. ; D=42")		Job	20,600	$41,200
Energy Dissipation		Job		$30,000
MP-6 Pumps	4	each	192,500	$770,000
Discharge Piping (150 L.F. ; D=42")		Job	20,600	$82,400
Energy Dissipation		Job		$40,000
MP-7 Pumps	3	each	280,500	$841,500
Discharge Piping (130 L.F. ; D=48")		Job	29,000	$87,000
Energy Dissipation		Job		$40,000
MP-8 Pumps	2	each	154,000	$308,000
Discharge Piping (150 L.F. ; D=36")		Job	15,450	$30,900
Energy Dissipation		Job		$30,000
PM-9 Pumps	2	each	330,000	$660,000
Discharge Piping (150L.F. ; D=54")		Job	29,120	$58,240
Energy Dissipation		Job		$30,000
MP-10 Pumps	3	each	154,000	$462,000
Discharge Piping (150 L.F. ; D=36")		Job	15,450	$46,350
Energy Dissipation		Job		$20,000
Electrical	32	each	242,100	7,747,200
	Current Contract Cost, Oct 07			$22,931,722

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 45 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations MossPoint - Elevation 30 Optional Arrangement 'F' (8-07)***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: MossPoint(8-07)_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations PM-1 thru PM-10				
Structural Concrete, complete all sites	3,400	cy	$450.00	$1,530,208
Form Work, complete all sites	84,293	sf	6.50	547,901
Steel Reinforcement, complete all sites	209	tons	925.00	192,952
Excavation	5,059	cy	15.00	75,879
Backfill	3,617	cy	5.00	18,087
Trash Screens and Miscellaneous metal items, All Sites	29	each	100,000.00	2,900,000
Pumps by Site Name				
MP-1 Pumps	3	each	203,500.00	$610,500
Discharge Piping (150 L.F. ; D=42")		each	30,800.00	$92,400
Energy Dissipation		Job		$120,000
MP-2 Pumps	2	each	451,000.00	$902,000
Discharge Piping (150L.F. ; D=54")		Job	69,440.00	$138,880
Energy Dissipation		Job		$90,000
MP-3 Pumps	4	each	451,000.00	$1,804,000
Discharge Piping (140 L.F. ; D=54")		Job	69,440.00	$277,760
Energy Dissipation		Job		$150,000
MP-4 Pumps	5	each	456,500.00	$2,282,500
Discharge Piping (150 L.F. ; D=60")		Job	67,700.00	$338,500
Energy Dissipation		Job		$180,000
MP-5 Pumps	2	each	240,350.00	$480,700
Discharge Piping (150 L.F. ; D=42")		Job	33,200.00	$66,400
Energy Dissipation		Job		$90,000
MP-6 Pumps	4	each	203,500.00	$814,000
Discharge Piping (150 L.F. ; D=42")		Job	33,200.00	$132,800
Energy Dissipation		Job		$150,000
MP-7 Pumps	2	each	240,350.00	$480,700
Discharge Piping (130 L.F. ; D=42")		Job	35,800.00	$71,600
Energy Dissipation		Job		$90,000
MP-8 Pumps	2	each	176,000.00	$352,000
Discharge Piping (150 L.F. ; D=36")		Job	24,900.00	$49,800
Energy Dissipation		Job		$90,000
PM-9 Pumps	2	each	376,200.00	$752,400
Discharge Piping (150L.F. ; D=54")		Job	49,300.00	$98,600
Energy Dissipation		Job		$90,000
MP-10 Pumps	3	each	176,000.00	$528,000
Discharge Piping (150 L.F. ; D=36")		Job	20,250.00	$60,750
Energy Dissipation		Job		$120,000
Electrical	29	each	242,100	7,020,900
Current Contract Cost, Oct 07				$23,790,218

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 46 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Washington Ave.-MossPoint - Elevation 20 Optional Configuration 'G' (8/07)*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Washington-MossPtComb_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations WM-1 thru WM-14				
Structural Concrete, complete all sites	4,694	cy	$450.00	$2,112,267
Form Work, complete all sites	112,710	sf	6.50	732,615
Steel Reinforcement, complete all sites	288	tons	925.00	266,328
Excavation	8,393	cy	15.00	125,891
Backfill	5,880	cy	5.00	29,398
Trash Screens and Miscellaneous metal items, All Sites	47	each	100,000.00	4,700,000
Pumps by Site Name				
WM-1 Pumps	3	each	192,500	$577,500
Discharge Piping (150 L.F. ; D=42")		each	18,200	54,600
Energy Dissipation		Job		120,000
WM-2 Pumps	2	each	376,200	$752,400
Discharge Piping (150L.F. ; D=54")		Job	49,280	98,560
Energy Dissipation		Job		90,000
WM-3 Pumps	3	each	302,500	$907,500
Discharge Piping (140 L.F. ; D=48)		Job	38,500	115,500
Energy Dissipation		Job		120,000
WM-4 Pumps	5	each	456,500	$2,282,500
Discharge Piping (150 L.F. ; D=60)		Job	62,832	314,160
Energy Dissipation		Job		180,000
WM-5 Pumps	3	each	280,500	$841,500
Discharge Piping (150 L.F. ; D=48")		Job	35,250	105,750
Energy Dissipation		Job		120,000
WM-6 Pumps	4	each	376,200	$1,504,800
Discharge Piping (150 L.F. ; D=54")		Job	45,120	180,480
Energy Dissipation		Job		150,000
WM-7 Pumps	4	each	376,200	$1,504,800
Discharge Piping (130 L.F. ; D=54")		Job	49,280	197,120
Energy Dissipation		Job		150,000
WM-8 Pumps	7	each	330,000	$2,310,000
Discharge Piping (150 L.F. ; D=54")		Job	32,960	230,720
Energy Dissipation		Job		240,000
WM-9 Pumps	2	each	222,200	$444,400
Discharge Piping (150L.F. ; D=42")		Job	20,600	41,200
Energy Dissipation		Job		90,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 47 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Washington Ave.-MossPoint - Elevation 20 Optional Configuration 'G' (8/07)*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Washington-MossPtComb_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations WM-1 thru WM-14				
WM-10 Pumps	4	each	192,500	$770,000
Discharge Piping (150 L.F. ; D=42")		Job	20,600	82,400
Energy Dissipation		Job		150,000
WM-11 Pumps	3	each	280,500	$841,500
Discharge Piping (150 L.F. ; D=48)		Job	29,000	87,000
Energy Dissipation		Job		120,000
WM-12 Pumps	2	each	154,000	$308,000
Discharge Piping (150 L.F. ; D=36)		Job	15,450	30,900
Energy Dissipation		Job		90,000
WM-13 Pumps	2	each	330,000	$660,000
Discharge Piping (150 L.F. ; D=54")		Job	29,120	58,240
Energy Dissipation		Job		90,000
WM-14 Pumps	3	each	154,000	$462,000
Discharge Piping (125 L.F. ; D=36")		Job	10,725	32,175
Energy Dissipation		Job		120,000
Electrical	47	each	242,100	11,378,700
			Current Contract Cost, Oct 07	$36,970,904

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 48 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Washington Ave.-MossPoint - Elevation 30 Optional Configuration 'H'(8/07)***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Washington-MossPtComb_Lod3_Ring Levee_Pumping Stations.xls

Pumping Stations WM-1 thru WM-14

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Structural Concrete, complete all sites	5,550	cy	$450.00	$2,497,494
Form Work, complete all sites	136,692	sf	6.50	888,499
Steel Reinforcement, complete all sites	340	tons	925.00	314,305
Excavation	8,184	cy	15.00	122,758
Backfill	5,756	cy	5.00	28,778
Trash Screens and Miscellaneous metal items, All Sites	44	each	100,000.00	4,400,000
Pumps by Site Name				
WM-1 Pumps	3	each	203,500.00	610,500
Discharge Piping (150 L.F. ; D=42")		each	30,800.00	92,400
Energy Dissipation		Job		120,000
WM-2 Pumps	2	each	451,000.00	902,000
Discharge Piping (150L.F. ; D=54")		Job	69,440.00	138,880
Energy Dissipation		Job		90,000
WM-3 Pumps	3	each	302,500.00	907,500
Discharge Piping (140 L.F. ; D=48")		Job	54,250.00	162,750
Energy Dissipation		Job		120,000
WM-4 Pumps	5	each	561,000.00	2,805,000
Discharge Piping (150 L.F. ; D=60)		Job	88,536.00	442,680
Energy Dissipation		Job		180,000
WM-5 Pumps	3	each	302,500.00	907,500
Discharge Piping (150 L.F. ; D=48")		Job	51,000.00	153,000
Energy Dissipation		Job		120,000
WM-6 Pumps	4	each	398,200.00	1,592,800
Discharge Piping (150 L.F. ; D=54)		Job	65,280.00	261,120
Energy Dissipation		Job		150,000
WM-7 Pumps	4	each	451,000.00	1,804,000
Discharge Piping (130 L.F. ; D=54")		Job	69,440.00	277,760
Energy Dissipation		Job		150,000
WM-8 Pumps	5	each	456,500.00	2,282,500
Discharge Piping (150 L.F. ; D=60")		Job	67,728.00	338,640
Energy Dissipation		Job		180,000
WM-9 Pumps	2	each	240,350.00	480,700
Discharge Piping (150L.F. ; D=42")		Job	33,200.00	66,400
Energy Dissipation		Job		90,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 49 OF 57
PREPARED Joseph H. Ellsworth CHECKED:
WORK ITEM: ***Line of Defense 3- Pumping Stations Washington Ave.-MossPoint - Elevation 30 Optional Configuration 'H'(8/07)*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Washington-MossPtComb_Lod3_Ring Levee_Pumping Stations.xls

Pumping Stations WM-10 thru WM-14

	DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
WM-10	Pumps	4	each	203,500.00	814,000
	Discharge Piping (150 L.F. ; D=42)		Job	33,200.00	132,800
	Energy Dissipation		Job		150,000
WM-11	Pumps	2	each	240,350.00	480,700
	Discharge Piping (150 L.F. ; D=42)		Job	35,800.00	71,600
	Energy Dissipation		Job		90,000
WM-12	Pumps	2	each	176,000.00	352,000
	Discharge Piping (150 L.F. ; D=36")		Job	24,900.00	49,800
	Energy Dissipation		Job		90,000
WM-13	Pumps	2	each	376,200.00	752,400
	Discharge Piping (150 L.F. ; D=54")		Job	49,280.00	98,560
	Energy Dissipation		Job		90,000
WM-14	Pumps	3	each	176,000.00	528,000
	Discharge Piping (125 L.F. ; D=36)		Job	20,250.00	60,750
	Energy Dissipation		Job		120,000
	Electrical	44	each	242,100	10,652,400

Current Contract Cost, Oct 07 $38,210,974

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 50 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Bellfountaine- Elevation 20 Optional Arrangement 'C'(8/07)***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: bellfountaine(8/07)_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations BF-1 thru BF-7					
Structural Concrete, complete all sites		2,130	cy	$450.00	$958,371
Form Work, complete all sites		51,955	sf	6.50	337,709
Steel Reinforcement, complete all sites		131	tons	925.00	121,109
Excavation		3,571	cy	15.00	53,560
Backfill		2,556	cy	5.00	12,782
Trash Screens and Miscellaneous metal items, All Sites		23	each	100,000	2,300,000
Pumps by Installation					
BF-1	Pumps	5	each	222,200	1,111,000
	Discharge Piping (150 L.F. ; D=42")		Job	23,000	115,000
	Energy Dissipation		Job		180,000
BF-2	Pumps	3	each	203,500	610,500
	Discharge Piping (150 L.F. ; D=42")		Job	28,200	84,600
	Energy Dissipation		Job		120,000
BF-3	Pumps	2	each	222,200	444,400
	Discharge Piping (150 L.F. ; D=42")		Job	28,200	56,400
	Energy Dissipation		Job		90,000
BF-4	Pumps	3	each	456,500	1,369,500
	Discharge Piping (150 L.F. ; D=60")		Job	62,832	188,496
	Energy Dissipation		Job		120,000
BF-5	Pumps	3	each	192,500	577,500
	Discharge Piping (150 L.F. ; D=42")		Job	18,200	54,600
	Energy Dissipation		Job		120,000
BF-6	Pumps	4	each	192,500	770,000
	Discharge Piping (150 L.F. ; D=42")		Job	15,600	62,400
	Energy Dissipation		Job		150,000
BF-7	Pumps	3	each	376,200	1,128,600
	Discharge Piping (150 L.F. ; D=54")		Job	49,280	147,840
	Energy Dissipation		Job		120,000
Electrical		23	Job	242,100	5,568,300
				Current Contract Cost, Oct 07	$16,972,667

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 51 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Bellfontaine- Elevation 30 Optional Arrangement 'D'(8/07)*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: bellfountaine(8/07)_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations BF-1 thru BF-7					
Structural Concrete, complete all sites		2,637	cy	$450.00	$1,186,704
Form Work, complete all sites		65,655	sf	6.50	426,759
Steel Reinforcement, complete all sites		162	tons	925.00	149,570
Excavation		3,571	cy	15.00	53,560
Backfill		2,556	cy	5.00	12,782
Trash Screens and Miscellaneous metal items, All Sites		23	each	100,000	2,300,000
Pumps by Installation Site					
BF-1	Pumps	5	each	240,350	1,201,750
	Discharge Piping (250 L.F. ; D=42")		Job	35,000	175,000
	Energy Dissipation		Job		180,000
BF-2	Pumps	3	each	387,200	1,161,600
	Discharge Piping (250 L.F. ; D=42")		Job	40,800	122,400
	Energy Dissipation		Job		120,000
BF-3	Pumps	2	each	240,350	480,700
	Discharge Piping (250 L.F. ; D=42")		Job	40,800	81,600
	Energy Dissipation		Job		90,000
BF-4	Pumps	3	each	561,000	1,683,000
	Discharge Piping (250 L.F. ; D=60")		Job	88,536	265,608
	Energy Dissipation		Job		120,000
BF-5	Pumps	3	each	203,500	610,500
	Discharge Piping (250 L.F. ; D=42")		Job	30,800	92,400
	Energy Dissipation		Job		120,000
BF-6	Pumps	4	each	203,500	814,000
	Discharge Piping (250 L.F. ; D=42")		Job	28,200	112,800
	Energy Dissipation		Job		150,000
BF-7	Pumps	3	each	451,000	1,353,000
	Discharge Piping (250 L.F. ; D=54")		Job	69,440	208,320
	Energy Dissipation		Job		120,000
Electrical		23	Job	242,100	5,568,300

Current Contract Cost, Oct 07 $18,960,353

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 52 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3 - Pumping Stations Gulf Park Estates - Elevation 20 Optional Arrangement 'C'(8/07)***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: GulfPkEst(8-07)_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations GP-1 thru GP-9					
Structural Concrete, complete all sites		2,425	cy	$450	$1,091,145
Form Work, complete all sites		59,717	sf	$6.50	388,157
Steel Reinforcement, complete all sites		149	tons	$925	138,232
Excavation		3,376	cy	$15	50,642
Backfill		2,424	cy	$5	12,119
Trash Screens and Miscellaneous metal items, All Sites		34	each	$100,000	3,400,000
Pumps by Installation Site					
GP-1	Pumps	3	each	$203,500	610,500
	Discharge Piping (42" Dia; 150 L.F.)		job	$29,500	88,500
	Energy Dissipation		job		120,000
GP-2	Pumps	6	each	$203,500	1,221,000
	Discharge Piping (42" Dia; 150 L.F.)		job	$30,800	184,800
	Energy Dissipation		job		210,000
GP-3	Pumps	8	each	$203,500	1,628,000
	Discharge Piping (42" Dia; 150 L.F.)		job	$29,500	236,000
	Energy Dissipation		job		270,000
GP-4	Pumps	3	each	$222,200	666,600
	Discharge Piping (42" Dia; 130 L.F.)		job	$25,800	77,400
	Energy Dissipation		job		120,000
GP-5	Pumps	5	each	$192,500	962,500
	Discharge Piping (42" Dia; 140 L.F.)		job	$21,900	109,500
	Energy Dissipation		job		180,000
GP-6	Pumps	3	each	$154,000	462,000
	Discharge Piping (36" Dia; 150 L.F.)		job	$9,750	29,250
	Energy Dissipation		job		120,000
GP-7	Pumps	2	each	$97,900	195,800
	Discharge Piping (26" Dia; 125 L.F.)		job	$12,250	24,500
	Energy Dissipation		job		90,000
GP-8	Pumps	2	each	$97,900	195,800
	Discharge Piping (26" Dia; 150 L.F.)		job	$14,750	29,500
	Energy Dissipation		job		90,000
GP-9	Pumps	2	each	$192,500	385,000
	Discharge Piping (42" Dia; 150 L.F.)		job	$16,900	33,800
	Energy Dissipation		job		90,000
Electrical		34	Job	$242,100	8,231,400
				Current Contract Cost, Oct 07	$21,742,146

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 53 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3 - Pumping Stations Gulf Park Estates - Elevation 30 Optional Arrangement 'D'(8/07)***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: GulfPkEst(8-07)_Lod3_Ring Levee_Pumping Stations.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations GP-1 thru GP-8					
Structural Concrete, complete all sites		3,441	cy	$450	$1,548,413
Form Work, complete all sites		84,868	sf	$6.50	551,640
Steel Reinforcement, complete all sites		210	tons	$925	194,636
Excavation		5,005	cy	$15	75,082
Backfill		3,401	cy	$5	17,007
Trash Screens and Miscellaneous metal items, All Sites		33	each	$100,000	3,300,000
Pumps by Installation Site					
GP-1	Pumps	3	each	$387,200	1,161,600
	Discharge Piping (42" Dia; 150 L.F.)		job	$38,400	115,200
	Energy Dissipation		job		120,000
GP-2	Pumps	6	each	$387,200	2,323,200
	Discharge Piping (42" Dia; 150 L.F.)		job	$39,600	237,600
	Energy Dissipation		job		210,000
GP-3	Pumps	8	each	$387,200	3,097,600
	Discharge Piping (42" Dia; 150 L.F.)		job	$38,400	307,200
	Energy Dissipation		job		270,000
GP-4	Pumps	3	each	$240,350	721,050
	Discharge Piping (42" Dia; 130 L.F.)		job	$34,500	103,500
	Energy Dissipation		job		120,000
GP-5	Pumps	5	each	$203,500	1,017,500
	Discharge Piping (42" Dia; 140 L.F.)		job	$28,200	141,000
	Energy Dissipation		job		180,000
GP-6	Pumps	2	each	$222,200	444,400
	Discharge Piping (42" Dia; 150 L.F.)		job	$27,000	54,000
	Energy Dissipation		job		90,000
GP-7	Pumps	2	each	$103,400	206,800
	Discharge Piping (26" Dia; 125 L.F.)		job	$16,600	33,200
	Energy Dissipation		job		90,000
GP-8	Pumps	2	each	$387,200	774,400
	Discharge Piping (42" Dia; 150 L.F.)		job	$38,400	76,800
	Energy Dissipation		job		90,000
GP-9	Pumps	2	each	$203,500	407,000
	Discharge Piping (42" Dia; 150 L.F.)		job	$28,200	56,400
	Energy Dissipation		job		90,000
Electrical		33	Job	$242,100	7,989,300
			Current Contract Cost, Oct 07		$26,214,528

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 54 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations*** BASIS of ESTIMATE: by L.O. project delv'd. team
Bay Saint Louis- Elevation 20 FILE NAME: BaySt Lou_Lod3_Ring Levee_Pumping Stations.xls
Optional Arrangement 'A' ***Hancock County***

Pumping Stations BSL1 thru BSL12

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Structural Concrete, complete all sites		5,061	cy	$450.00	$2,277,233
Form Work, complete all sites		124,378	sf	6.50	808,457
Steel Reinforcement, complete all sites		310	tons	925.00	286,829
Excavation		6,535	cy	15.00	98,019
Backfill		4,569	cy	5.00	22,846
Trash Screens and Miscellaneous metal items, All Sites		52	each	100,000	5,200,000
Pumps by Installation					
BSL-1	Pumps	8	each	222,200	1,777,600
	Discharge Piping (150 L.F. ; D=42")		each	25,800	206,400
	Energy Dissipation		Job		270,000
BSL-2	Pumps	4	each	280,500	1,122,000
	Discharge Piping (150 L.F. ; D=48")		each	29,000	116,000
	Energy Dissipation		Job		150,000
BSL-3	Pumps	2	each	154,000	308,000
	Discharge Piping (150 L.F. ; D=36")		each	13,000	26,000
	Energy Dissipation		Job		90,000
BSL-4	Pumps	3	each	192,500	577,500
	Discharge Piping (150 L.F. ; D=42")		each	18,200	54,600
	Energy Dissipation		Job		120,000
BSL-5	Pumps	4	each	330,000	1,320,000
	Discharge Piping (150 L.F. ; D=54")		each	20,600	82,400
	Energy Dissipation		Job		150,000
BSL-6	Pumps	4	each	280,500	1,122,000
	Discharge Piping (150 L.F. ; D=48")		each	29,000	116,000
	Energy Dissipation		Job		150,000
BSL-7	Pumps	3	each	222,200	666,600
	Discharge Piping (150 L.F. ; D=42")		each	23,200	69,600
	Energy Dissipation		Job		120,000
BSL-8	Pumps	7	each	192,500	1,347,500
	Discharge Piping (150 L.F. ; D=42")		each	20,600	144,200
	Energy Dissipation		Job		240,000
BSL-9	Pumps	3	each	192,500	577,500
	Discharge Piping (150 L.F. ; D=42")		each	15,600	46,800
	Energy Dissipation		Job		120,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 55 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations Bay Saint Louis- Elevation 20 Optional Arrangement 'A'*** ***Hancock County***
BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: BayStLou_Lod3_Ring Levee_Pumping Stations.xls

	DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations BSL1 thru BSL12					
BSL-10	Pumps	6	each	280,500	1,683,000
	Discharge Piping (150 L.F. ; D=48")		each	32,250	193,500
	Energy Dissipation		Job		210,000
BSL-11	Pumps	5	each	222,200	1,111,000
	Discharge Piping (150 L.F. ; D=42")		each	28,200	141,000
	Energy Dissipation		Job		180,000
BSL-12	Pumps	3	each	192,500	577,500
	Discharge Piping (150 L.F. ; D=42")		each	20,600	61,800
	Energy Dissipation		Job		120,000
Electrical		52	Job	242,100	12,589,200
	Current Contract Cost, Oct 07				$36,651,084

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 56 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM: ***Line of Defense 3- Pumping Stations*** BASIS of ESTIMATE: by L.O. project delv'd. team
Bay Saint Louis- Elevation 30 FILE NAME: Beach Boulevard_Lod3_Pumping Stations.xls
Optional Arrangement 'B' ***Hancock County***

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations BSL1 thru BSL12					
Structural Concrete, complete all sites		4828	cy	$450.00	$2,172,600
Form Work, complete all sites		118906	sf	6.50	772,889
Steel Reinforcement, complete all sites		296	tons	925.00	273,800
Excavation		6335	cy	15.00	95,025
Backfill		4452	cy	5.00	22,260
Trash Screens and Miscellaneous metal items, All Sites		49	each	100,000	4,900,000
Pumps by Installation					
BSL-1	Pumps	8	each	240,350	1,922,800
	Discharge Piping (150 L.F. ; D=42")		each	38,400	307,200
	Energy Dissipation		Job		270,000
BSL-2	Pumps	4	each	302,500	1,210,000
	Discharge Piping (150 L.F. ; D=48")		each	44,750	179,000
	Energy Dissipation		Job		150,000
BSL-3	Pumps	2	each	176,000	352,000
	Discharge Piping (150 L.F. ; D=36")		each	25,800	51,600
	Energy Dissipation		Job		90,000
BSL-4	Pumps	3	each	203,500	610,500
	Discharge Piping (150 L.F. ; D=42")		each	30,800	92,400
	Energy Dissipation		Job		120,000
BSL-5	Pumps	4	each	376,200	1,504,800
	Discharge Piping (150 L.F. ; D=54")		each	53,120	212,480
	Energy Dissipation		Job		150,000
BSL-6	Pumps	3	each	398,200	1,194,600
	Discharge Piping (150 L.F. ; D=54")		each	57,280	171,840
	Energy Dissipation		Job		120,000
BSL-7	Pumps	3	each	240,350	721,050
	Discharge Piping (150 L.F. ; D=42")		each	35,800	107,400
	Energy Dissipation		Job		120,000
BSL-8	Pumps	7	each	192,500	1,347,500
	Discharge Piping (150 L.F. ; D=54")		each	53,120	371,840
	Energy Dissipation		Job		240,000
BSL-9	Pumps	3	each	203,500	610,500
	Discharge Piping (150 L.F. ; D=42")		each	28,200	84,600
	Energy Dissipation		Job		120,000

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 57 OF 57
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 3- Pumping Stations Bay Saint Louis- Elevation 30 Optional Arrangement 'B'*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: bellfountaine_Lod3_Ring Levee_Pumping Stations.xls
Hancock County

	DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Pumping Stations BSL1 thru BSL12					
BSL-10	Pumps	6	each	302,500	1,815,000
	Discharge Piping (150 L.F. ; D=48")		each	48,000	288,000
	Energy Dissipation		Job		210,000
BSL-11	Pumps	3	each	176,000	528,000
	Discharge Piping (150 L.F. ; D=42")		each	40,800	122,400
	Energy Dissipation		Job		120,000
BSL-12	Pumps	3	each	561,000	1,683,000
	Discharge Piping (150 L.F. ; D=36")		each	33,200	99,600
	Energy Dissipation		Job		120,000
	Electrical	49	Job	242,100	11,862,900
	Current Contract Cost, Oct 07				$37,517,584

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 1 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 3 - Elevated Roadway*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Hanc Co-Lod 3-Elevated Roadway-Elev 11-BoatGate.xls

Boat Access Gate Structures

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Boat Access Gate Structures				
Hanc Co-Lod 3-Elevated Roadway-Elev 11-BoatGate.xls				**$13,587,948**
Jack Co-Lod 3-Ring Levee-Pas-Elev 20-BoatGates.xls				
Pascagoula - El20 Estimate(PG-1)				**$12,920,900**
Estimate(G-1)				10,756,700
Estimate(G-2)				12,836,100
Estimate(G-3)				9,321,720
Estimate(G-4)				21,534,300
Estimate(G-5)				18,458,200
Gautier.-El.20				**$72,907,018**
Jack Co-Lod 3-Ring Levee-Pas-Elev 30-BoatGates.xls				
Pascagoula - El30 Estimate(PG-1)				**$14,917,980**
Estimate(G-1)				11,460,580
Estimate(G-2)				14,148,380
Estimate(G-3)				9,372,720
Estimate(G-4)				25,448,480
Estimate(G-5)				19,818,780
Gautier-El.30				**$80,248,938**

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 2 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Line of Defense 3 - Elevated Roadway*** BASIS of ESTIMATE: by L.O. project delv'd. team
Hancock County - Elevation 11 FILE NAME: Hanc Co-Lod 3-Elevated Roadway-Elev 11-BoatGate.xls
Boat Access Gate HK-1

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	73,800	C.Y.	20	1,476,000
Foundation Piling (500 Piles)18x18 precast c	100000	L.F.	35	3,500,000
Structural Fill	45,800	C.Y.	10	458,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	13,344	C.Y.	450	6,004,728
Forming	13,123	S.Y.	6.50	85,300
Reinforcement	28	Tons	925	25,900
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	82	Tons	9,800	802,620
Stainless Steel	82	Tons	11,700	959,400
Miscellaneous Metal	2	Tons	8,000	16,000
Mechanical:	6	Tons	10,000	60,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$13,577,948

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 3 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3*** BASIS of ESTIMATE: by L.O. project delv'd. team
Ring Levee - Pascagoula - Elevation 20 FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 20-BoatGates.xls
Boat Access Gate PG-1

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	65,300	C.Y.	20	1,306,000
Foundation Piling (380 Piles)18x18 precast c	76000	L.F.	35	2,660,000
Structural Fill	42,300	C.Y.	10	423,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	13,300	C.Y.	450	5,985,000
Forming	13,123	S.Y.	6.50	85,300
Reinforcement	60	Tons	925	55,500
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	68	Tons	9,800.00	666,400
Stainless Steel	121	Tons	11,700.00	1,415,700
Miscellaneous Metal	3	Tons	8,000.00	24,000
Mechanical:	10	Tons	10,000.00	100,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$12,910,900

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 4 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3 Ring Levee - Gautier - Elevation 20 Boat Access Gate G-1*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 20-BoatGates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	58,900	C.Y.	20	1,178,000
Foundation Piling (300 Piles)	60000	L.F.	35	2,100,000
Structural Fill	39,700	C.Y.	10	397,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	12,600	C.Y.	450	5,670,000
Forming	13,123	S.Y.	6.50	85,300
Reinforcement	60	Tons	925	55,500
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	36	Tons	9,800.00	352,800
Stainless Steel	53	Tons	11,700.00	620,100
Miscellaneous Metal	1	Tons	8,000.00	8,000
Mechanical:	10	Tons	10,000.00	100,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$10,756,700

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 5 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3*** BASIS of ESTIMATE: by L.O. project delv'd. team
Ring Levee - Gautier - Elevation 20 FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 20-BoatGates.xls
Boat Access Gate G-2

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	64,000	C.Y.	20	1,280,000
Foundation Piling (360 Piles)18x18 precast c	72000	L.F.	35	2,520,000
Structural Fill	41,800	C.Y.	10	418,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	14100	C.Y.	450	6,345,000
Forming	13,123	S.Y.	6.50	85,300
Reinforcement	60	Tons	925	55,500
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	61	Tons	9,800.00	597,800
Stainless Steel	105	Tons	11,700.00	1,228,500
Miscellaneous Metal	2	Tons	8,000.00	16,000
Mechanical:	10	Tons	10,000.00	100,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$12,836,100

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 6 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3*** BASIS of ESTIMATE: by L.O. project delv'd. team
Ring Levee - Gautier - Elevation 20 FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 20-BoatGates.xls
Boat Access Gate G-3

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	54,300	C.Y.	20	1,086,000
Foundation Piling (240 Piles)18x18 precast c	48000	L.F.	35	1,680,000
Structural Fill	37,900	C.Y.	10	379,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	11800	C.Y.	450	5,310,000
Forming	13,123	S.Y.	6.50	85,300
Reinforcement	60	Tons	925	55,500
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	17.4	Tons	9,800.00	170,520
Stainless Steel	22	Tons	11,700.00	257,400
Miscellaneous Metal	1	Tons	8,000.00	8,000
Mechanical:	10	Tons	10,000.00	100,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$9,321,720

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 7 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3*** BASIS of ESTIMATE: by L.O. project delv'd. team
Ring Levee - Gautier - Elevation 20 FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 20-BoatGates.xls
Boat Access Gate G-4

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	79,900	C.Y.	20	1,598,000
Foundation Piling (580 Piles) 18x18 precast c	116000	L.F.	35	4,060,000
Structural Fill	48,200	C.Y.	10	482,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	19500	C.Y.	450	8,775,000
Forming	13,123	S.Y.	6.50	85,300
Reinforcement	60	Tons	925	55,500
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	178	Tons	9,800.00	1,744,400
Stainless Steel	373	Tons	11,700.00	4,364,100
Miscellaneous Metal	10	Tons	8,000.00	80,000
Mechanical:	10	Tons	10,000.00	100,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$21,534,300

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 8 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3*** BASIS of ESTIMATE: by L.O. project delv'd. team
Ring Levee - Gautier - Elevation 20 FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 20-BoatGates.xls
Boat Access Gate G-5

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	72,700	C.Y.	20	1,454,000
Foundation Piling (480 Piles)18x18 precast c	96000	L.F.	35	3,360,000
Structural Fill	45,300	C.Y.	10	453,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	17100	C.Y.	450	7,695,000
Forming	13,123	S.Y.	6.50	85,300
Reinforcement	60	Tons	925	55,500
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	118	Tons	9,800.00	1,156,400
Stainless Steel	330	Tons	11,700.00	3,861,000
Miscellaneous Metal	6	Tons	8,000.00	48,000
Mechanical:	10	Tons	10,000.00	100,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$18,458,200

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 9 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3*** BASIS of ESTIMATE: by L.O. project delv'd. team
Ring Levee - Pascagoula - Elevation 30 FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 30-BoatGates.xls
Boat Access Gate PG-1

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	65,300	C.Y.	20	1,306,000
Foundation Piling (380 Piles)18x18 precast c	76000	L.F.	35	2,660,000
Structural Fill	42,300	C.Y.	10	423,000
Stone Protection	500	C.Y.	90	55,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	15,030	C.Y.	450	6,763,500
Forming	16,493	S.Y.	6.50	107,205
Reinforcement	71	Tons	925	65,675
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	149	Tons	9,800.00	1,460,200
Stainless Steel	152	Tons	11,700.00	1,778,400
Miscellaneous Metal	3	Tons	8,000.00	24,000
Mechanical:	13	Tons	10,000.00	130,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$14,917,980

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 10 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3*** BASIS of ESTIMATE: by L.O. project delv'd. team
Ring Levee - Gautier - Elevation 30 FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 30-BoatGates.xls
Boat Access Gate G-1

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	58,900	C.Y.	20	1,178,000
Foundation Piling (300 Piles18x18 precast cc	60000	L.F.	35	2,100,000
Structural Fill	39,700	C.Y.	10	397,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	12,830	C.Y.	450	5,773,500
Forming	16,493	S.Y.	6.50	107,205
Reinforcement	71	Tons	925	65,675
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	72	Tons	9,800.00	705,600
Stainless Steel	68	Tons	11,700.00	795,600
Miscellaneous Metal	1	Tons	8,000.00	8,000
Mechanical:	13	Tons	10,000.00	130,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$11,450,580

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 11 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3*** BASIS of ESTIMATE: by L.O. project delv'd. team
Ring Levee - Gautier - Elevation 30 FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 30-BoatGates.xls
Boat Access Gate G-2

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	64,000	C.Y.	20	1,280,000
Foundation Piling (360 Piles)18x18 precast c	72000	L.F.	35	2,520,000
Structural Fill	41,800	C.Y.	10	418,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	14590	C.Y.	450	6,565,500
Forming	16,493	S.Y.	6.50	107,205
Reinforcement	71	Tons	925	65,675
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	132	Tons	9,800.00	1,293,600
Stainless Steel	132	Tons	11,700.00	1,544,400
Miscellaneous Metal	3	Tons	8,000.00	24,000
Mechanical:	13	Tons	10,000.00	130,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$14,138,380

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 12 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3*** BASIS of ESTIMATE: by L.O. project delv'd. team
Ring Levee - Gautier - Elevation 30 FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 30-BoatGates.xls
Boat Access Gate G-3

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	54,300	C.Y.	20	1,086,000
Foundation Piling (240 Piles)	48000	L.F.	35	1,680,000
Structural Fill	37,900	C.Y.	10	379,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	11240	C.Y.	450	5,058,000
Forming	16,493	S.Y.	6.50	107,205
Reinforcement	71	Tons	925	65,675
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	33.8	Tons	9,800.00	331,240
Stainless Steel	28	Tons	11,700.00	327,600
Miscellaneous Metal	1	Tons	8,000.00	8,000
Mechanical:	13	Tons	10,000.00	130,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$9,362,720

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 13 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3 Ring Levee - Gautier - Elevation 30 Boat Access Gate G-4*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 30-BoatGates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	79,900	C.Y.	20	1,598,000
Foundation Piling (580 Piles)	116000	L.F.	35	4,060,000
Structural Fill	48,200	C.Y.	10	482,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	20050	C.Y.	450	9,022,500
Forming	16,493	S.Y.	6.50	107,205
Reinforcement	71	Tons	925	65,675
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	431	Tons	9,800.00	4,223,800
Stainless Steel	469	Tons	11,700.00	5,487,300
Miscellaneous Metal	9	Tons	8,000.00	72,000
Mechanical:	13	Tons	10,000.00	130,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$25,438,480

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 14 OF 14
PREPARED: Joseph H. Ellsworth CHECKED: Lloyd Oliver
WORK ITEM ***Jackson County - Line of Defense 3 Ring Levee - Gautier - Elevation 30 Boat Access Gate G-5*** BASIS of ESTIMATE: by L.O. project delv'd. team
FILE NAME: Jack Co-Lod 3-Ring Levee-Pas-Elev 30-BoatGates.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Civil:				
Cofferdam and Dewatering	$100,000	Job		$100,000
Earthwork:				
Structural Excavation	72,700	C.Y.	20	1,454,000
Foundation Piling (480 Piles)	96000	L.F.	35	3,360,000
Structural Fill	45,300	C.Y.	10	453,000
Stone Protection	500	C.Y.	90	45,000
Structural:				
Concrete:				
Gate Structure				
Structural Concrete	17580	C.Y.	450	7,911,000
Forming	16,493	S.Y.	6.50	107,205
Reinforcement	71	Tons	925	65,675
Structural Steel:				
Rising Sector Gates (Incl. end disks and Trunnion Hubs & Bearings)				
Mild Steel	274	Tons	9,800.00	2,685,200
Stainless Steel	291	Tons	11,700.00	3,404,700
Miscellaneous Metal	6	Tons	8,000.00	48,000
Mechanical:	13	Tons	10,000.00	130,000
Electrical:	1	Job		45,000
Current Contract Cost, Oct 07				$19,808,780

COMPREHENSIVE PLAN " STRUCTURAL " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Line of Defense 1*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Beach / Dune Construction FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Ship Island Fort Mass & French Warehouse Emergency Beach Nourishment				
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$290,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipmen	1	job	allow	3,000
Construct Sand (dune), Dredged from near Shore Borrow Site	125,000	cy	5.50	687,500
Misc Site Items	1	ls	allow	1,700
Current Contract Cost, Oct 07				$982,200
CONTINGENCY		@	**25.0%**	245,550
				$1,227,750
01 Account, Lands & Damage		PCA	**LS**	25,000
				$1,252,750
30 Account, Plan, Engr.& Design		@	**8.0%**	100,220
				$1,352,970
31 Account, Constr. Management		@	**6.0%**	81,178
				$1,434,148
ESCALATION		@	**0.0%**	
				$1,434,148
				rounded
TOTAL PROJECT COST, Oct 07				$ 1,430,000

Notes:

Unit Dredge Cost based on Current Dredge Project, Dauphin Island Berm, Al

COMPREHENSIVE STUDY " Programmatic Environmental Restoration Summary"

PROJECT: **Mississippi Coastal Improvement Project** ITEM NO. DATE 25-Jul-08
LOCATION **Mississippi** SHEET NO. 1 OF 1
PREPARED: loseph H. Ellswort CHECKED: Michael McKown
WORK ITEM ***Summary*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

ENVIRONMENTAL RESTORATION 32 SITES

Area No.	Area Name	Acreage	ESTIMATED AMOUNT	ANNUAL O&M THOUS
1	Pearlington	76	$ 30,200,000	40
2	*Pearlington South*	11	$ 23,400,000	11
3	*Port/West*	49	$ 19,800,000	20
4	*Ansley*	2,023	$ 482,100,000	500
5	*Heron Bay*	594	$ 192,100,000	100
6	*Lower Bay Road*	226	$ 53,000,000	60
7	*Lakeshore*	275	$ 69,200,000	75
8	*Bayou Caddy/Lakeshore*	362	$ 113,400,000	78
9	*Clermont Harbor*	209	$ 208,300,000	60
10	*Bayou La Croix*	259	$ 207,100,000	72
11	*Shoreline Park*	889	$ 1,259,200,000	110
12	*Chapman Road*	146	$ 174,100,000	35
13	*Jourdan River-Interstate 10 Development*	638	$ 155,900,000	100
14	*Diamondhead*	433	$ 267,700,000	90
15	*Delisle*	120	$ 41,900,000	59
16	*Ellis Property*	443	$ 60,300,000	70
17	*Pine Point East*	103	$ 47,500,000	35
18	*Pine Point West*	83	$ 36,700,000	20
19	*Pass Christian Beach Front low forested drainage way*	21	$ 10,700,000	15
20	*Pass Christian Site-Bayou Portage*	43	$ 27,800,000	17
21	*Brickyard Bayou*	14	$ 7,000,000	10
22	*Biloxi River-Shorecrest Drive*	15	$ 12,500,000	10
23	*Biloxi River-Eagle Point*	17	$ 17,400,000	10
24	*Biloxi Front Beach-South of Highway 90*	40	$ 60,500,000	13
25	*Keegan Bayou*	54	$ 31,500,000	14
26	*St. Martin*	467	$ 147,500,000	95
27	*Fort Point*	83	$ 29,400,000	38
28	*Pine Island*	2,531	$ 518,600,000	550
29	*Belle Fontaine*	1,516	$ 373,700,000	450
30	*Griffin Point*	182	$ 70,900,000	66
31	*Bayou Chico*	258	$ 82,900,000	69
32	*Grand Bay Marsh*	2,666	$ 621,400,000	500
	Grand Total		$ 5,453,700,000	3,392
			* see backup for Cost Derivation	

Notes:

Price Level, FY-07

Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment

Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"

Quantities listed within the Estimate represent Major Elements of the Project

Structural Removal Cost includes minor Site Restoration (filling septic tanks, removal outside structures, pavements & utilities)

Utility Removal Cost includes, sewer, storm drain, water, gas, power, cable, phone, traffic signaling

Estimate Excl Operational & Maintenance Cost

Project Escalation

Relocations, Environment, HTRW & Real Estate Cost (except PCA)

Historical Preservation

Asbestos Removal during Structure Removal

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Pearlington**
Hancock County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$260,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	490,973	cy	12.00	5,891,676
b. Removal of structures (1,500 sf avg size @ 7 ea =)	10,500	sf	3.50	36,750
b. Disposal Fee	389	cy	2.50	972
c. Removal of roads (24' wide assumed)	2,415	lf	14.00	33,810
d. Removal of utilities	2,415	lf	41.00	99,015
2. Herbicide, hand application (untouched areas from excavation)	10	acre	3,100	31,000
3. Filling of existing ditches and channels (from req'd. excavation)	2,500	cy	5.00	12,500
4. Plantings	76	acre	57,600	4,377,600
Misc Site Items	1	ls	allow	50,000
	Current Contract Cost, FY 07			$ 10,793,323
CONTINGENCY		@	**25.0%**	2,698,331
				$ 13,491,654
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, acqs.			**LS**	16,098,678
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$29,615,332
30 Account, Plan, Engr.& Design		@	**8.0%**	2,369,227
				$ 31,984,559
31 Account, Constr. Management		@	**6.0%**	1,919,074
				$ 33,903,632
ESCALATION		@	**0.0%**	
				$ 33,903,632 rounded
TOTAL PROJECT COST, FY- 07				**$ 33,900,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Pearlington South**
Hancock County

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME:

DATE 25-Jul-08
OF 1
CHECKED: Michael McKown

mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$40,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	70,140	cy	12.00	841,680
b. Removal of structures (1,500 sf avg size @ 1ea =)	1,440	sf	3.50	5,040
b. Disposal Fee	56	cy	2.50	139
c. Removal of roads (24' wide assumed)	345	lf	14.00	4,830
d. Removal of utilities	345	lf	41.00	14,145
2. Herbicide, hand application (untouched areas from excavation)	11	acre	3,100	34,100
3. Filling of existing ditches and channels (from req'd. excavation)	205	cy	5.00	1,025
4. Plantings	11	acre	57,600	633,600
Misc Site Items	1	ls	allow	10,000
	Current Contract Cost, FY 07			$ 1,584,559
CONTINGENCY		@	**25.0%**	396,140
				$ 1,980,699
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, acqs.			**LS**	23,012,156
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$25,017,855
30 Account, Plan, Engr.& Design		@	**8.0%**	2,001,428
				$ 27,019,283
31 Account, Constr. Management		@	**6.0%**	1,621,157
				$ 28,640,440
ESCALATION		@	**0.0%**	
				$ 28,640,440
				rounded
TOTAL PROJECT COST, FY- 07				**$ 28,600,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Port West**
Hancock County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$170,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	327,316	cy	12.00	3,927,792
b. Removal of structures (1,500 sf avg size @ 5 ea =)	7,500	sf	3.50	26,250
b. Disposal Fee	278	cy	2.50	694
c. Removal of roads (24' wide assumed)	1,610	lf	14.00	22,540
d. Removal of utilities	1,610	lf	41.00	66,010
2. Herbicide, hand application (untouched areas from excavation)	8	acre	3,100	24,800
3. Filling of existing ditches and channels (from req'd. excavation)	954	cy	5.00	4,770
4. Plantings	49	acre	57,600	2,822,400
Misc Site Items	1	ls	allow	30,000
Current Contract Cost, FY 07				$ 7,095,256
CONTINGENCY		@	**25.0%**	1,773,814
				$ 8,869,071
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aqas.			**LS**	10,486,413
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$19,380,484
30 Account, Plan, Engr.& Design		@	**8.0%**	1,550,439
				$ 20,930,922
31 Account, Constr. Management		@	**6.0%**	1,255,855
				$ 22,186,778
ESCALATION		@	**0.0%**	
				$ 22,186,778
				rounded
TOTAL PROJECT COST, FY- 07				**$ 22,200,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Ansley**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$6,860,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	12,695,161	cy	12.00	152,341,932
b. Removal of structures (1,500 sf avg size @ 174 ea =)	261,000	sf	3.50	913,500
b. Disposal Fee	9,667	cy	2.50	24,167
c. Removal of roads (24' wide assumed)	62,429	lf	14.00	874,006
d. Removal of utilities	62,429	lf	41.00	2,559,589
2. Herbicide, hand application (untouched areas from excavation)	310	acre	3,100	961,000
3. Filling of existing ditches and channels (from req'd. excavation)	5,000	cy	5.00	25,000
3. Plantings	2,023	acre	57,600	116,524,800
Misc Site Items	1	ls	allow	1,370,000
	Current Contract Cost, FY 07			$ 282,453,994
CONTINGENCY		@	**25.0%**	70,613,498
				$ 353,067,492
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	85,003,422
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$438,095,914
30 Account, Plan, Engr.& Design		@	**8.0%**	35,047,673
				$ 473,143,587
31 Account, Constr. Management		@	**6.0%**	28,388,615
				$ 501,532,202
ESCALATION		@	**0.0%**	
				$ 501,532,202 rounded
TOTAL PROJECT COST, FY- 07				**$ 501,500,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Heron Bay**
Hancock County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,020,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	3,740,748	cy	12.00	44,888,976
b. Removal of structures (1,500 sf avg size @ 52 ea =)	78,000	sf	3.50	273,000
b. Disposal Fee	2,889	cy	2.50	7,222
c. Removal of roads (24' wide assumed)	18,396	lf	14.00	257,544
d. Removal of utilities	18,396	lf	41.00	754,236
2. Herbicide, hand application (untouched areas from excavation)	92	acre	3,100	285,200
3. Filling of existing ditches and channels (from req'd. excavation)	2,500	cy	5.00	12,500
3. Plantings	594	acre	57,600	34,214,400
Misc Site Items	1	ls	allow	400,000
	Current Contract Cost, FY 07			$ 83,113,078
CONTINGENCY		@	**25.0%**	20,778,270
				$ 103,891,348
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	79,883,456
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$183,799,804
30 Account, Plan, Engr.& Design		@	**8.0%**	14,703,984
				$ 198,503,788
31 Account, Constr. Management		@	**6.0%**	11,910,227
				$ 210,414,015
ESCALATION		@	**0.0%**	
				$ 210,414,015 rounded
TOTAL PROJECT COST, FY- 07				**$ 210,400,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Lower Bay Road**
Hancock County

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08
OF 1
CHECKED: Michael McKown

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$770,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	1,421,485	cy	12.00	17,057,820
b. Removal of structures (1,500 sf avg size @ 20 ea =)	30,000	sf	3.50	105,000
b. Disposal Fee	1,111	cy	2.50	2,778
c. Removal of roads (24' wide assumed)	6,991	lf	14.00	97,874
d. Removal of utilities	6,991	lf	41.00	286,631
2. Herbicide, hand application (untouched areas from excavation)	35	acre	3,100	108,500
3. Filling of existing ditches and channels (from req'd. excavation)	1,431	cy	5.00	7,155
3. Plantings	226	acre	57,600	13,017,600
Misc Site Items	1	ls	allow	200,000
Current Contract Cost, FY 07				$ 31,653,358
CONTINGENCY		@	**25.0%**	7,913,339
				$ 39,566,697
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	8,400,156
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$47,991,853
30 Account, Plan, Engr.& Design		@	**8.0%**	3,839,348
				$ 51,831,201
31 Account, Constr. Management		@	**6.0%**	3,109,872
				$ 54,941,074
ESCALATION		@	**0.0%**	
				$ 54,941,074 rounded
TOTAL PROJECT COST, FY- 07				**$ 54,900,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Lakeshore**
Hancock County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$930,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	1,734,212	cy	12.00	20,810,544
b. Removal of structures (1,500 sf avg size @ 25 ea =)	37,500	sf	3.50	131,250
b. Disposal Fee	1,389	cy	2.50	3,472
c. Removal of roads (24' wide assumed)	8,530	lf	14.00	119,420
d. Removal of utilities	8,530	lf	41.00	349,730
2. Herbicide, hand application (untouched areas from excavation)	43	acre	3,100	133,300
3. Filling of existing ditches and channels (from req'd. excavation)	1,431	cy	5.00	7,155
3. Plantings	275	acre	57,600	15,840,000
Misc Site Items	1	ls	allow	200,000
Current Contract Cost, FY 07				$ 38,524,871
CONTINGENCY		@	**25.0%**	9,631,218
				$ 48,156,089
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	15,323,959
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$63,505,048
30 Account, Plan, Engr.& Design		@	**8.0%**	5,080,404
				$ 68,585,452
31 Account, Constr. Management		@	**6.0%**	4,115,127
				$ 72,700,579
ESCALATION		@	**0.0%**	
				$ 72,700,579 rounded
TOTAL PROJECT COST, FY- 07				**$ 72,700,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Bayou Caddy Lakeshore**
Hancock County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$1,230,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	2,291,208	cy	12.00	27,494,496
b. Removal of structures (1,500 sf avg size @ 33 ea =)	49,500	sf	3.50	173,250
b. Disposal Fee	1,833	cy	2.50	4,583
c. Removal of roads (24' wide assumed)	11,260	lf	14.00	157,640
d. Removal of utilities	11,260	lf	41.00	461,660
2. Herbicide, hand application (untouched areas from excavation)	57	acre	3,100	176,700
3. Filling of existing ditches and channels (from req'd. excavation)	1,431	cy	5.00	7,155
3. Plantings	362	acre	57,600	20,851,200
Misc Site Items	1	ls	allow	200,000
Current Contract Cost, FY 07				$ 50,756,684
CONTINGENCY		@	**25.0%**	12,689,171
				$ 63,445,855
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	44,506,544
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$107,977,399
30 Account, Plan, Engr.& Design		@	**8.0%**	8,638,192
				$ 116,615,591
31 Account, Constr. Management		@	**6.0%**	6,996,935
				$ 123,612,527
ESCALATION		@	**0.0%**	
				$ 123,612,527
				rounded
TOTAL PROJECT COST, FY- 07				**$ 123,600,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Clermont Harbor**
Hancock County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$720,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	1,332,642	cy	12.00	15,991,704
b. Removal of structures (1,500 sf avg size @ 20 ea =)	30,000	sf	3.50	105,000
b. Disposal Fee	1,111	cy	2.50	2,778
c. Removal of roads (24' wide assumed)	6,531	lf	14.00	91,434
d. Removal of utilities	6,531	lf	41.00	267,771
2. Herbicide, hand application (untouched areas from excavation)	34	acre	3,100	105,400
3. Filling of existing ditches and channels (from req'd. excavation)	1,431	cy	5.00	7,155
3. Plantings	209	acre	57,600	12,038,400
Misc Site Items	1	ls	allow	100,000
		Current Contract Cost, FY 07		$ 29,429,642
CONTINGENCY		@	**25.0%**	7,357,410
				$ 36,787,052
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	181,417,747
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$218,229,799
30 Account, Plan, Engr.& Design		@	**8.0%**	17,458,384
				$ 235,688,183
31 Account, Constr. Management		@	**6.0%**	14,141,291
				$ 249,829,474
ESCALATION		@	**0.0%**	
				$ 249,829,474 rounded
TOTAL PROJECT COST, FY- 07				**$ 249,800,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Bayou La Croix**
Hancock County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$880,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	1,636,577	cy	12.00	19,638,924
b. Removal of structures (1,500 sf avg size @ 25 ea =)	37,500	sf	3.50	131,250
b. Disposal Fee	1,389	cy	2.50	3,472
c. Removal of roads (24' wide assumed)	8,099	lf	14.00	113,386
d. Removal of utilities	8,099	lf	41.00	332,059
2. Herbicide, hand application (untouched areas from excavation)	43	acre	3,100	133,300
3. Filling of existing ditches and channels (from req'd. excavation)	1,431	cy	5.00	7,155
3. Plantings	259	acre	57,600	14,918,400
Misc Site Items	1	ls	allow	200,000
		Current Contract Cost, FY 07		$ 36,357,946
CONTINGENCY		@	**25.0%**	9,089,487
				$ 45,447,433
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	169,307,134
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$214,779,567
30 Account, Plan, Engr.& Design		@	**8.0%**	17,182,365
				$ 231,961,932
31 Account, Constr. Management		@	**6.0%**	13,917,716
				$ 245,879,648
ESCALATION		@	**0.0%**	
				$ 245,879,648 rounded
TOTAL PROJECT COST, FY- 07				**$ 245,900,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Shoreline Park**
Hancock County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$3,020,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	5,587,742	cy	12.00	67,052,904
b. Removal of structures (1,500 sf avg size @ 88 ea =)	132,000	sf	3.50	462,000
b. Disposal Fee	4,889	cy	2.50	12,222
c. Removal of roads (24' wide assumed)	27,933	lf	14.00	391,062
d. Removal of utilities	27,933	lf	41.00	1,145,253
2. Herbicide, hand application (untouched areas from excavation)	149	acre	3,100	461,900
3. Filling of existing ditches and channels (from req'd. excavation)	1,431	cy	5.00	7,155
3. Plantings	889	acre	57,600	51,206,400
Misc Site Items	1	ls	allow	600,000
		Current Contract Cost, FY 07		$ 124,358,896
CONTINGENCY		@	**25.0%**	31,089,724
				$ 155,448,620
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	19,250,916
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$174,724,536
30 Account, Plan, Engr.& Design		@	**8.0%**	13,977,963
				$ 188,702,499
31 Account, Constr. Management		@	**6.0%**	11,322,150
				$ 200,024,649
ESCALATION		@	**0.0%**	
				$ 200,024,649 rounded
TOTAL PROJECT COST, FY- 07				**$ 200,000,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Chapman Road**
Hancock County

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08
OF 1
CHECKED: Michael McKown

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$500,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	935,187	cy	12.00	11,222,244
b. Removal of structures (1,500 sf avg size @ 13ea =)	19,500	sf	3.50	68,250
b. Disposal Fee	722	cy	2.50	1,806
c. Removal of roads (24' wide assumed)	4,599	lf	14.00	64,386
d. Removal of utilities	4,599	lf	41.00	188,559
2. Herbicide, hand application (untouched areas from excavation)	23	acre	3,100	71,300
3. Filling of existing ditches and channels (from req'd. excavation)	1,431	cy	5.00	7,155
3. Plantings	146	acre	57,600	8,409,600
Misc Site Items	1	ls	allow	100,000
	Current Contract Cost, FY 07			$ 20,633,300
CONTINGENCY		@	**25.0%**	5,158,325
				$ 25,791,624
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	1,180,610,509
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$1,206,427,133
30 Account, Plan, Engr.& Design		@	**8.0%**	96,514,171
				$ 1,302,941,304
31 Account, Constr. Management		@	**6.0%**	78,176,478
				$ 1,381,117,782
ESCALATION		@	**0.0%**	
				$ 1,381,117,782 rounded
TOTAL PROJECT COST, FY- 07				$ 1,381,100,000

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Jourdan River I-10 Dev**
Hancock County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,170,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	4,021,304	cy	12.00	48,255,648
b. Removal of structures (1,500 sf avg size @ 56ea =)	84,000	sf	3.50	294,000
b. Disposal Fee	3,111	cy	2.50	7,778
c. Removal of roads (24' wide assumed)	19,775	lf	14.00	276,850
d. Removal of utilities	19,775	lf	41.00	810,775
2. Herbicide, hand application (untouched areas from excavation)	99	acre	3,100	306,900
3. Filling of existing ditches and channels (from req'd. excavation)	4,000	cy	5.00	20,000
3. Plantings	638	acre	57,600	36,748,800
Misc Site Items	1	ls	allow	400,000
Current Contract Cost, FY 07				$ 89,290,751
CONTINGENCY		@	**25.0%**	22,322,688
				$ 111,613,438
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	157,856,094
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$269,494,532
30 Account, Plan, Engr.& Design		@	**8.0%**	21,559,563
				$ 291,054,095
31 Account, Constr. Management		@	**6.0%**	17,463,246
				$ 308,517,341
ESCALATION		@	**0.0%**	
				$ 308,517,341 rounded
TOTAL PROJECT COST, FY- 07				**$ 308,500,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Diamondhead**
Hancock County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$1,470,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	2,735,422	cy	12.00	32,825,064
b. Removal of structures (1,500 sf avg size @ 38ea =)	57,000	sf	3.50	199,500
b. Disposal Fee	2,111	cy	2.50	5,278
c. Removal of roads (24' wide assumed)	13,452	lf	14.00	188,328
d. Removal of utilities	13,452	lf	41.00	551,532
2. Herbicide, hand application (untouched areas from excavation)	67	acre	3,100	207,700
3. Filling of existing ditches and channels (from req'd. excavation)	3,000	cy	5.00	15,000
3. Plantings	433	acre	57,600	24,940,800
Misc Site Items	1	ls	allow	300,000
Current Contract Cost, FY 07				$ 60,703,202
CONTINGENCY		@	**25.0%**	15,175,800
				$ 75,879,002
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	30,631,509
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$106,535,511
30 Account, Plan, Engr.& Design		@	**8.0%**	8,522,841
				$ 115,058,352
31 Account, Constr. Management		@	**6.0%**	6,903,501
				$ 121,961,853
ESCALATION		@	**0.0%**	
				$ 121,961,853 rounded
TOTAL PROJECT COST, FY- 07				**$ 122,000,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Delisle**
Harrison County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$410,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	771,529	cy	12.00	9,258,348
b. Removal of structures (1,500 sf avg size @ 11ea =)	16,500	sf	3.50	57,750
b. Disposal Fee	611	cy	2.50	1,528
c. Removal of roads (24' wide assumed)	3,795	lf	14.00	53,130
d. Removal of utilities	3,795	lf	41.00	155,595
2. Herbicide, hand application (untouched areas from excavation)	19	acre	3,100	58,900
3. Filling of existing ditches and channels (from req'd. excavation)	2,000	cy	5.00	10,000
3. Plantings	120	acre	57,600	6,912,000
Misc Site Items	1	ls	allow	100,000
Current Contract Cost, FY 07				$ 17,017,251
CONTINGENCY		@	**25.0%**	4,254,313
				$ 21,271,563
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	197,388,356
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$218,684,919
30 Account, Plan, Engr.& Design		@	**8.0%**	17,494,794
				$ 236,179,713
31 Account, Constr. Management		@	**6.0%**	14,170,783
				$ 250,350,496
ESCALATION		@	**0.0%**	
				$ 250,350,496 rounded
TOTAL PROJECT COST, FY- 07				**$ 250,400,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Ellis Property**
Harrison County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$800,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	500,000	cy	12.00	6,000,000
b. Removal of structures (1,500 sf avg size @ 11ea =)	16,500	sf	3.50	57,750
b. Disposal Fee	611	cy	2.50	1,528
c. Removal of roads (24' wide assumed)	3,795	lf	14.00	53,130
d. Removal of utilities	3,795	lf	41.00	155,595
2. Herbicide, hand application (untouched areas from excavation)	68	acre	3,100	210,800
3. Filling of existing ditches and channels (from req'd. excavation)	2,000	cy	5.00	10,000
3. Plantings	443	acre	57,600	25,516,800
Misc Site Items	1	ls	allow	200,000
Current Contract Cost, FY 07				$ 33,005,603
CONTINGENCY		@	**25.0%**	8,251,401
				$ 41,257,003
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	19,166,243
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$60,448,246
30 Account, Plan, Engr.& Design		@	**8.0%**	4,835,860
				$ 65,284,106
31 Account, Constr. Management		@	**6.0%**	3,917,046
				$ 69,201,153
ESCALATION		@	**0.0%**	
				$ 69,201,153 rounded
TOTAL PROJECT COST, FY- 07				**$ 69,200,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Pine Point East**
Harrison County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$350,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	654,631	cy	12.00	7,855,572
b. Removal of structures (1,500 sf avg size @ 9ea =)	13,500	sf	3.50	47,250
b. Disposal Fee	500	cy	2.50	1,250
c. Removal of roads (24' wide assumed)	3,219	lf	14.00	45,066
d. Removal of utilities	3,219	lf	41.00	131,979
2. Herbicide, hand application (untouched areas from excavation)	16	acre	3,100	49,600
3. Filling of existing ditches and channels (from req'd. excavation)	2,000	cy	5.00	10,000
3. Plantings	103	acre	57,600	5,932,800
Misc Site Items	1	ls	allow	100,000
Current Contract Cost, FY 07				$ 14,523,517
CONTINGENCY		@	**25.0%**	3,630,879
				$ 18,154,396
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aqu			**LS**	14,199,388
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$32,378,784
30 Account, Plan, Engr.& Design		@	**8.0%**	2,590,303
				$ 34,969,087
31 Account, Constr. Management		@	**6.0%**	2,098,145
				$ 37,067,232
ESCALATION		@	**0.0%**	
				$ 37,067,232 rounded
TOTAL PROJECT COST, FY- 07				**$ 37,100,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Pine Point West**
Harrison County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$290,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	537,733	cy	12.00	6,452,796
b. Removal of structures (1,500 sf avg size @ 8ea =)	12,000	sf	3.50	42,000
b. Disposal Fee	444	cy	2.50	1,111
c. Removal of roads (24' wide assumed)	2,645	lf	14.00	37,030
d. Removal of utilities	2,645	lf	41.00	108,445
2. Herbicide, hand application (untouched areas from excavation)	14	acre	3,100	43,400
3. Filling of existing ditches and channels (from req'd. excavation)	2,000	cy	5.00	10,000
3. Plantings	83	acre	57,600	4,780,800
Misc Site Items	1	ls	allow	100,000
Current Contract Cost, FY 07				$ 11,865,582
CONTINGENCY		@	**25.0%**	2,966,396
				$ 14,831,978
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aqua			**LS**	29,155,568
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$44,012,546
30 Account, Plan, Engr.& Design		@	**8.0%**	3,521,004
				$ 47,533,549
31 Account, Constr. Management		@	**6.0%**	2,852,013
				$ 50,385,562
ESCALATION		@	**0.0%**	
				$ 50,385,562 rounded
TOTAL PROJECT COST, FY- 07				**$ 50,400,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Pass Christian Beach Front**
Harrison County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$70,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	140,278	cy	12.00	1,683,336
b. Removal of structures (1,500 sf avg size @ 2ea =)	3,000	sf	3.50	10,500
b. Disposal Fee	111	cy	2.50	278
c. Removal of roads (24' wide assumed)	690	lf	14.00	9,660
d. Removal of utilities	690	lf	41.00	28,290
2. Herbicide, hand application (untouched areas from excavation)	4	acre	3,100	12,400
3. Filling of existing ditches and channels (from req'd. excavation)	1,500	cy	5.00	7,500
3. Plantings	21	acre	57,600	1,209,600
Misc Site Items	1	ls	allow	10,000
Current Contract Cost, FY 07				$ 3,041,564
CONTINGENCY		@	**25.0%**	760,391
				$ 3,801,955
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	21,510,900
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$25,337,855
30 Account, Plan, Engr.& Design		@	**8.0%**	2,027,028
				$ 27,364,883
31 Account, Constr. Management		@	**6.0%**	1,641,893
				$ 29,006,776
ESCALATION		@	**0.0%**	
				$ 29,006,776 rounded
TOTAL PROJECT COST, FY- 07				**$ 29,000,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Pass Christian Bayou Portage**
Harrison County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$150,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	280,556	cy	12.00	3,366,672
b. Removal of structures (1,500 sf avg size @ 4ea =)	6,000	sf	3.50	21,000
b. Disposal Fee	222	cy	2.50	556
c. Removal of roads (24' wide assumed)	1,380	lf	14.00	19,320
d. Removal of utilities	1,380	lf	41.00	56,580
2. Herbicide, hand application (untouched areas from excavation)	7	acre	3,100	21,700
3. Filling of existing ditches and channels (from req'd. excavation)	1,500	cy	5.00	7,500
3. Plantings	43	acre	57,600	2,476,800
Misc Site Items	1	ls	allow	30,000
		Current Contract Cost, FY 07		$ 6,150,128
CONTINGENCY		@	**25.0%**	1,537,532
				$ 7,687,659
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	6,904,320
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$14,616,979
30 Account, Plan, Engr.& Design		@	**8.0%**	1,169,358
				$ 15,786,338
31 Account, Constr. Management		@	**6.0%**	947,180
				$ 16,733,518
ESCALATION		@	**0.0%**	
				$ 16,733,518 rounded
TOTAL PROJECT COST, FY- 07				**$ 16,700,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Bayou Brickyard**
Harrison County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$50,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	93,519	cy	12.00	1,122,228
b. Removal of structures (1,500 sf avg size @ 2ea =)	3,000	sf	3.50	10,500
b. Disposal Fee	111	cy	2.50	278
c. Removal of roads (24' wide assumed)	460	lf	14.00	6,440
d. Removal of utilities	460	lf	41.00	18,860
2. Herbicide, hand application (untouched areas from excavation)	3	acre	3,100	9,300
3. Filling of existing ditches and channels (from req'd. excavation)	1,000	cy	5.00	5,000
3. Plantings	14	acre	57,600	806,400
Misc Site Items	1	ls	allow	10,000
Current Contract Cost, FY 07				$ 2,039,006
CONTINGENCY		@	**25.0%**	509,751
				$ 2,548,757
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	20,763,975
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$23,337,732
30 Account, Plan, Engr.& Design		@	**8.0%**	1,867,019
				$ 25,204,751
31 Account, Constr. Management		@	**6.0%**	1,512,285
				$ 26,717,036
ESCALATION		@	**0.0%**	
				$ 26,717,036 rounded
TOTAL PROJECT COST, FY- 07				**$ 26,700,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Biloxi River Shorecrest**
Harrison County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$50,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	93,519	cy	12.00	1,122,228
b. Removal of structures (1,500 sf avg size @ 2ea =)	3,000	sf	3.50	10,500
b. Disposal Fee	111	cy	2.50	278
c. Removal of roads (24' wide assumed)	460	lf	14.00	6,440
d. Removal of utilities	460	lf	41.00	18,860
2. Herbicide, hand application (untouched areas from excavation)	3	acre	3,100	9,300
3. Filling of existing ditches and channels (from req'd. excavation)	1,000	cy	5.00	5,000
3. Plantings	15	acre	57,600	864,000
Misc Site Items	1	ls	allow	10,000
Current Contract Cost, FY 07				$ 2,096,606
CONTINGENCY		@	**25.0%**	524,151
				$ 2,620,757
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	736,178
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$3,381,935
30 Account, Plan, Engr.& Design		@	**8.0%**	270,555
				$ 3,652,490
31 Account, Constr. Management		@	**6.0%**	219,149
				$ 3,871,639
ESCALATION		@	**0.0%**	
				$ 3,871,639 rounded
TOTAL PROJECT COST, FY- 07				**$ 3,900,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Biloxi River Eagle Poin**
Harrison County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$50,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	93,519	cy	12.00	1,122,228
b. Removal of structures (1,500 sf avg size @ 2ea =)	3,000	sf	3.50	10,500
b. Disposal Fee	111	cy	2.50	278
c. Removal of roads (24' wide assumed)	460	lf	14.00	6,440
d. Removal of utilities	460	lf	41.00	18,860
2. Herbicide, hand application (untouched areas from excavation)	3	acre	3,100	9,300
3. Filling of existing ditches and channels (from req'd. excavation)	1,000	cy	5.00	5,000
3. Plantings	17	acre	57,600	979,200
Misc Site Items	1	ls	allow	10,000
Current Contract Cost, FY 07				$ 2,211,806
CONTINGENCY		@	**25.0%**	552,951
				$ 2,764,757
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	4,432,825
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$7,222,582
30 Account, Plan, Engr.& Design		@	**8.0%**	577,807
				$ 7,800,389
31 Account, Constr. Management		@	**6.0%**	468,023
				$ 8,268,412
ESCALATION		@	**0.0%**	
				$ 8,268,412 rounded
TOTAL PROJECT COST, FY- 07				**$ 8,300,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Biloxi Front Beach S of 90t**
Harrison County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$120,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	200,000	cy	12.00	2,400,000
b. Removal of structures (1,500 sf avg size @ 5ea =)	7,500	sf	3.50	26,250
b. Disposal Fee	278	cy	2.50	694
c. Removal of roads (24' wide assumed)	950	lf	14.00	13,300
d. Removal of utilities	950	lf	41.00	38,950
2. Herbicide, hand application (untouched areas from excavation)	7	acre	3,100	21,700
3. Filling of existing ditches and channels (from req'd. excavation)	1,500	cy	5.00	7,500
3. Plantings	40	acre	57,600	2,304,000
Misc Site Items	1	ls	allow	20,000
	Current Contract Cost, FY 07			$ 4,952,394
CONTINGENCY		@	**25.0%**	1,238,099
				$ 6,190,493
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aqua			**LS**	10,326,300
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$16,541,793
30 Account, Plan, Engr.& Design		@	**8.0%**	1,323,343
				$ 17,865,137
31 Account, Constr. Management		@	**6.0%**	1,071,908
				$ 18,937,045
ESCALATION		@	**0.0%**	
				$ 18,937,045
				rounded
TOTAL PROJECT COST, FY- 07				**$ 18,900,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Keegan Bayou**
Harrison County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$190,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	350,696	cy	12.00	4,208,352
b. Removal of structures (1,500 sf avg size @ 5ea =)	7,500	sf	3.50	26,250
b. Disposal Fee	278	cy	2.50	694
c. Removal of roads (24' wide assumed)	1,725	lf	14.00	24,150
d. Removal of utilities	1,725	lf	41.00	70,725
2. Herbicide, hand application (untouched areas from excavation)	9	acre	3,100	27,900
3. Filling of existing ditches and channels (from req'd. excavation)	1,700	cy	5.00	8,500
3. Plantings	54	acre	57,600	3,110,400
Misc Site Items	1	ls	allow	40,000
Current Contract Cost, FY 07				$ 7,706,971
CONTINGENCY		@	**25.0%**	1,926,743
				$ 9,633,714
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	15,537,250
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$25,195,964
30 Account, Plan, Engr.& Design		@	**8.0%**	2,015,677
				$ 27,211,641
31 Account, Constr. Management		@	**6.0%**	1,632,698
				$ 28,844,340
ESCALATION		@	**0.0%**	
				$ 28,844,340 rounded
TOTAL PROJECT COST, FY- 07				**$ 28,800,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **St Martin**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$1,590,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	2,945,839	cy	12.00	35,350,068
b. Removal of structures (1,500 sf avg size @ 41ea =)	61,500	sf	3.50	215,250
b. Disposal Fee	2,278	cy	2.50	5,694
c. Removal of roads (24' wide assumed)	14,487	lf	14.00	202,818
d. Removal of utilities	14,487	lf	41.00	593,967
2. Herbicide, hand application (untouched areas from excavation)	72	acre	3,100	223,200
3. Filling of existing ditches and channels (from req'd. excavation)	4,000	cy	5.00	20,000
3. Plantings	467	acre	57,600	26,899,200
Misc Site Items	1	ls	allow	320,000
Current Contract Cost, FY 07				$ 65,420,197
CONTINGENCY		@	**25.0%**	16,355,049
				$ 81,775,247
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	58,274,698
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$140,074,945
30 Account, Plan, Engr.& Design		@	**8.0%**	11,205,996
				$ 151,280,940
31 Account, Constr. Management		@	**6.0%**	9,076,856
				$ 160,357,797
ESCALATION		@	**0.0%**	
				$ 160,357,797 rounded
TOTAL PROJECT COST, FY- 07				**$ 160,400,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Fort Point**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$290,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	537,733	cy	12.00	6,452,796
b. Removal of structures (1,500 sf avg size @ 8ea =)	12,000	sf	3.50	42,000
b. Disposal Fee	444	cy	2.50	1,111
c. Removal of roads (24' wide assumed)	2,645	lf	14.00	37,030
d. Removal of utilities	2,645	lf	41.00	108,445
2. Herbicide, hand application (untouched areas from excavation)	14	acre	3,100	43,400
3. Filling of existing ditches and channels (from req'd. excavation)	1,800	cy	5.00	9,000
3. Plantings	83	acre	57,600	4,780,800
Misc Site Items	1	ls	allow	60,000
Current Contract Cost, FY 07				$ 11,824,582
CONTINGENCY		@	**25.0%**	2,956,146
				$ 14,780,728
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	22,349,145
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$37,154,873
30 Account, Plan, Engr.& Design		@	**8.0%**	2,972,390
				$ 40,127,262
31 Account, Constr. Management		@	**6.0%**	2,407,636
				$ 42,534,898
ESCALATION		@	**0.0%**	
				$ 42,534,898
				rounded
TOTAL PROJECT COST, FY- 07				**$ 42,500,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Pine Island**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$8,550,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	15,804,657	cy	12.00	189,655,884
b. Removal of structures (1,500 sf avg size @ 218ea =)	327,000	sf	3.50	1,144,500
b. Disposal Fee	12,111	cy	2.50	30,278
c. Removal of roads (24' wide assumed)	78,065	lf	14.00	1,092,910
d. Removal of utilities	78,065	lf	41.00	3,200,665
2. Herbicide, hand application (untouched areas from excavation)	388	acre	3,100	1,202,800
3. Filling of existing ditches and channels (from req'd. excavation)	5,000	cy	5.00	25,000
3. Plantings	2,531	acre	57,600	145,785,600
Misc Site Items	1	ls	allow	1,710,000
Current Contract Cost, FY 07				$ 352,397,637
CONTINGENCY		@	**25.0%**	88,099,409
				$ 440,497,046
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	58,771,659
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$499,293,705
30 Account, Plan, Engr.& Design		@	**8.0%**	39,943,496
				$ 539,237,201
31 Account, Constr. Management		@	**6.0%**	32,354,232
				$ 571,591,433
ESCALATION		@	**0.0%**	
				$ 571,591,433 rounded
TOTAL PROJECT COST, FY- 07				**$ 571,600,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Belle Fountaine**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$5,120,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	9,445,387	cy	12.00	113,344,644
b. Removal of structures (1,500 sf avg size @ 130ea =)	195,000	sf	3.50	682,500
b. Disposal Fee	7,222	cy	2.50	18,056
c. Removal of roads (24' wide assumed)	46,793	lf	14.00	655,102
d. Removal of utilities	46,793	lf	41.00	1,918,513
2. Herbicide, hand application (untouched areas from excavation)	232	acre	3,100	719,200
3. Filling of existing ditches and channels (from req'd. excavation)	4,000	cy	5.00	20,000
3. Plantings	1,516	acre	57,600	87,321,600
Misc Site Items	1	ls	allow	1,020,000
		Current Contract Cost, FY 07		$ 210,819,615
CONTINGENCY		@	**25.0%**	52,704,904
				$ 263,524,518
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	13,639,822
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$277,189,340
30 Account, Plan, Engr.& Design		@	**8.0%**	22,175,147
				$ 299,364,487
31 Account, Constr. Management		@	**6.0%**	17,961,869
				$ 317,326,357
ESCALATION		@	**0.0%**	
				$ 317,326,357 rounded
TOTAL PROJECT COST, FY- 07				**$ 317,300,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Griffin Point**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$620,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	1,145,604	cy	12.00	13,747,248
b. Removal of structures (1,500 sf avg size @ 16ea =)	24,000	sf	3.50	84,000
b. Disposal Fee	889	cy	2.50	2,222
c. Removal of roads (24' wide assumed)	5,634	lf	14.00	78,876
d. Removal of utilities	5,634	lf	41.00	230,994
2. Herbicide, hand application (untouched areas from excavation)	28	acre	3,100	86,800
3. Filling of existing ditches and channels (from req'd. excavation)	1,800	cy	5.00	9,000
3. Plantings	182	acre	57,600	10,483,200
Misc Site Items	1	ls	allow	120,000
Current Contract Cost, FY 07				$ 25,462,340
CONTINGENCY		@	**25.0%**	6,365,585
				$ 31,827,925
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	15,564,422
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$47,417,347
30 Account, Plan, Engr.& Design		@	**8.0%**	3,793,388
				$ 51,210,735
31 Account, Constr. Management		@	**6.0%**	3,072,644
				$ 54,283,379
ESCALATION		@	**0.0%**	
				$ 54,283,379 rounded
TOTAL PROJECT COST, FY- 07				**$ 54,300,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Bayou Chico**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$880,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	1,636,577	cy	12.00	19,638,924
b. Removal of structures (1,500 sf avg size @ 23ea =)	34,500	sf	3.50	120,750
b. Disposal Fee	1,278	cy	2.50	3,194
c. Removal of roads (24' wide assumed)	8,048	lf	14.00	112,672
d. Removal of utilities	8,048	lf	41.00	329,968
2. Herbicide, hand application (untouched areas from excavation)	40	acre	3,100	124,000
3. Filling of existing ditches and channels (from req'd. excavation)	2,200	cy	5.00	11,000
3. Plantings	258	acre	57,600	14,860,800
Misc Site Items	1	ls	allow	180,000
Current Contract Cost, FY 07				$ 36,261,308
CONTINGENCY		@	**25.0%**	9,065,327
				$ 45,326,636
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	78,568,456
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$123,920,092
30 Account, Plan, Engr.& Design		@	**8.0%**	9,913,607
				$ 133,833,699
31 Account, Constr. Management		@	**6.0%**	8,030,022
				$ 141,863,721
ESCALATION		@	**0.0%**	
				$ 141,863,721 rounded
TOTAL PROJECT COST, FY- 07				**$ 141,900,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvements Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Grand Bay Marsh Bayou Cumbest**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Michael McKown
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$9,030,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	16,716,465	cy	12.00	200,597,580
b. Removal of structures (1,500 sf avg size @ 229ea =)	343,500	sf	3.50	1,202,250
b. Disposal Fee	12,722	cy	2.50	31,806
c. Removal of roads (24' wide assumed)	82,204	lf	14.00	1,150,856
d. Removal of utilities	82,204	lf	41.00	3,370,364
2. Herbicide, hand application (untouched areas from excavation)	408	acre	3,100	1,264,800
3. Filling of existing ditches and channels (from req'd. excavation)	4,500	cy	5.00	22,500
3. Plantings	2,666	acre	57,600	153,561,600
Misc Site Items	1	ls	allow	1,810,000
		Current Contract Cost, FY 07		$ 372,041,756
CONTINGENCY		@	**25.0%**	93,010,439
				$ 465,052,194
01 Account, Lands & Damage		PCA	**LS**	25,000
02 Account, Relocations, aquas			**LS**	37,575,406
_ Account, Environmental			**LS**	
09 Account, Aids to Navigation			**LS**	
				$502,652,600
30 Account, Plan, Engr.& Design		@	**8.0%**	40,212,208
				$ 542,864,808
31 Account, Constr. Management		@	**6.0%**	32,571,889
				$ 575,436,697
ESCALATION		@	**0.0%**	
				$ 575,436,697 rounded
TOTAL PROJECT COST, FY- 07				**$ 575,400,000**

COMPREHENSIVE STUDY " Admiral Island Environmental Restoration " Summary

PROJECT:	**Mississippi Coastal Improvements Program "MsCIP"**	ITEM NO.	DATE	(revised) 25-Jul-08
LOCATION:	**Mississippi**	SHEET NO. 1	OF	1
		PREPARED: Joseph H. Ellsworth	CHECKED:	Gary A. Payton
WORK ITEM:	***Summary***	BASIS of ESTIMATE: Info furnished per Project Delivery Team		
		FILE NAME:		mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	ESTIMATED AMOUNT

ENVIRONMENTAL RESTORATION

Hancock County **Admiral Island**

0.5 METER PLANTINGS WITH FILL	**$ 26,300,000**
1.0 METER PLANTINGS WITH FILL	**$ 23,800,000**
2.0 METER PLANTINGS WITH FILL	**$ 22,500,000**
0.5 METER PLANTINGS WITHOUT FILL	**$ 26,300,000**
1.0 METER PLANTINGS WITHOUT FILL	**$ 23,700,000**
2.0 METER PLANTINGS WITHOUT FILL	**$ 22,400,000**

Notes:

Price Level, Oct 07

Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment

Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"

Quantities listed within the Estimate represent Major Elements of the Project

Structural Removal Cost included in nonstructural estimates

Utility Removal Cost includes, sewer, storm drain, water, gas, power, cable, phone, traffic signaling

Estimate Exclud Operational & Maintenance Cost

Project Escalation

Relocations, Environment, HTRW & Real Estate Cost (except PCA)

Historical Preservation

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: **Admiral Island** ***0.5 Meter Planting W/ Fill*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,400,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	916,483	cy	12.00	10,997,796
b. Removal of structures (1,500 sf avg size @ ea =)	cost included in the nonstructural estimate			
b. Disposal Fee	cost included in the nonstructural estimate			
c. Removal of roads (24' wide assumed)	3,500	lf	14.00	49,000
d. Removal of utilities	3,500	lf	41.00	143,500
2. Herbaside, application from truck (untouched areas from excavation)	62	acre	3,100	192,200
3. Filling of existing ditches and channels (from req'd. excavation)	7,000	cy	5.00	35,000
4. Plantings a. 0.5 meter spacing	62	acre	57,600	3,571,200
Misc Site Items	1	ls	allow	1,000,000
	Current Contract Cost, Oct 07			$18,388,696
CONTINGENCY		@	**25.0%**	4,597,174
				$22,985,870
01 Account, Lands & Damage		PCA	**LS**	25,000
				$23,010,870
30 Account, Plan, Engr.& Design		@	**8.0%**	1,840,870
				$24,851,740
31 Account, Constr. Management		@	**6.0%**	1,491,104
				$26,342,844
ESCALATION		@	**0.0%**	
				$26,342,844
				rounded
TOTAL PROJECT COST, Oct 07				$ 26,300,000

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: **Admiral Island** ***1 Meter Planting W/ Fill***
Hancock County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,400,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	916,483	cy	12.00	10,997,796
b. Removal of structures (1,500 sf avg size @ 225 ea =)	cost included in the nonstructural estimate			
b. Disposal Fee	cost included in the nonstructural estimate			
c. Removal of roads (24' wide assumed)	3,500	lf	14.00	49,000
d. Removal of utilities	3,500	lf	41.00	143,500
2. Herbaside, application from truck (untouched areas from excavation)	62	acre	3,100	192,200
3. Filling of existing ditches and channels (from req'd. excavation)	7,000	cy	5.00	35,000
4. Plantings b. 1.0 meter spacing	62	acre	28,800	1,785,600
Misc Site Items	1	ls	allow	1,000,000
	Current Contract Cost, Oct 07			$16,603,096
CONTINGENCY		@	**25.0%**	4,150,774
				$20,753,870
01 Account, Lands & Damage		PCA	**LS**	25,000
				$20,778,870
30 Account, Plan, Engr.& Design		@	**8.0%**	1,662,310
				$22,441,180
31 Account, Constr. Management		@	**6.0%**	1,346,471
				$23,787,650
ESCALATION		@	**0.0%**	
				$23,787,650 rounded
TOTAL PROJECT COST, Oct 07				**$23,800,000**

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: **Admiral Island** ***2 Meter Planting W/ Fill*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,400,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	915,483	cy	12.00	10,985,796
b. Removal of structures (1,500 sf avg size @ 225 ea =)	cost included in the nonstructural estimate			
b. Disposal Fee	cost included in the nonstructural estimate			
c. Removal of roads (24' wide assumed)	3,500	lf	14.00	49,000
d. Removal of utilities	3,500	lf	41.00	143,500
2. Herbaside, application from truck (untouched areas from excavation)	62	acre	3,100	192,200
3. Filling of existing ditches and channels (from req'd. excavation)	7,000	cy	5.00	35,000
4. Plantings c. 2.0 meter spacing	62	acre	14,400	892,800
Misc Site Items	1	ls	allow	1,000,000
	Current Contract Cost, OCT 07			$15,698,296
CONTINGENCY		@	**25.0%**	3,924,574
				$19,622,870
01 Account, Lands & Damage		PCA	**LS**	25,000
				$19,647,870
30 Account, Plan, Engr.& Design		@	**8.0%**	1,571,830
				$21,219,700
31 Account, Constr. Management		@	**6.0%**	1,273,182
				$22,492,882
ESCALATION		@	**0.0%**	
				$22,492,882
				rounded
TOTAL PROJECT COST, Oct 07				**$22,500,000**

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: **Admiral Island** ***0.5 Meter Planting WOUT/ Fill*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization		1	job	allow	$2,400,000
1. Removals:	a. Excavation existing Area from -0.5 to +2.0	915,483	cy	12.00	10,985,796
	b. Removal of structures (1,500 sf avg size @ 225 ea =)	cost included in the nonstructural estimate			
	b. Disposal Fee	cost included in the nonstructural estimate			
	c. Removal of roads (24' wide assumed)	3,500	lf	14.00	49,000
	d. Removal of utilities	3,500	lf	41.00	143,500
2. Herbaside, application from truck (untouched areas from excavation)		62	acre	3,100	192,200
3. Plantings	a. 0.5 meter spacing	62	acre	57,600	3,571,200
Misc Site Items		1	ls	allow	1,000,000
		Current Contract Cost, Oct 07			$18,341,696
	CONTINGENCY		@	**25.0%**	4,585,424
					$22,927,120
	01 Account, Lands & Damage		PCA	**LS**	25,000
					$22,952,120
	30 Account, Plan, Engr.& Design		@	**8.0%**	1,836,170
					$24,788,290
	31 Account, Constr. Management		@	**6.0%**	1,487,297
					$26,275,587
	ESCALATION		@	**0.0%**	
					$26,275,587
					rounded
	TOTAL PROJECT COST, Oct 07				**$ 26,300,000**

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: **Admiral Island** ***1 Meter Planting WOUT/ Fill*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,400,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	915,483	cy	12.00	10,985,796
b. Removal of structures (1,500 sf avg size @ 0 ea =)	cost included in the nonstructural estimate			
b. Disposal Fee	cost included in the nonstructural estimate			
c. Removal of roads (24' wide assumed)	3,500	lf	14.00	49,000
d. Removal of utilities	3,500	lf	41.00	143,500
2. Herbaside, application from truck (untouched areas from excavation)	62	acre	3,100	192,200
3. Plantings b. 1.0 meter spacing	62	acre	28,800	1,785,600
Misc Site Items	1	ls	allow	1,000,000
	Current Contract Cost, Oct 07			$16,556,096
CONTINGENCY		@	**25.0%**	4,139,024
				$20,695,120
01 Account, Lands & Damage		PCA	**LS**	25,000
				$20,720,120
30 Account, Plan, Engr.& Design		@	**8.0%**	1,657,610
				$22,377,730
31 Account, Constr. Management		@	**6.0%**	1,342,664
				$23,720,393
ESCALATION		@	**0.0%**	
				$23,720,393 rounded
TOTAL PROJECT COST, Oct 07				**$23,700,000**

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: **Admiral Island** ***2 Meter Planting WOUT/ Fill*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$2,400,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	915,483	cy	12.00	10,985,796
b. Removal of structures (1,500 sf avg size @ 0 ea =)	cost included in the nonstructural estimate			
b. Disposal Fee	cost included in the nonstructural estimate			
c. Removal of roads (24' wide assumed)	3,500	lf	14.00	49,000
d. Removal of utilities	3,500	lf	41.00	143,500
2. Herbaside, application from truck (untouched areas from excavation)	62	acre	3,100	192,200
3. Plantings c. 2.0 meter spacing	62	acre	14,400	892,800
Misc Site Items	1	ls	allow	1,000,000
		Current Contract Cost, Oct 07		$15,663,296
CONTINGENCY		@	**25.0%**	3,915,824
				$19,579,120
01 Account, Lands & Damage		PCA	**LS**	25,000
				$19,604,120
30 Account, Plan, Engr.& Design		@	**8.0%**	1,568,330
				$21,172,450
31 Account, Constr. Management		@	**6.0%**	1,270,347
				$22,442,797
ESCALATION		@	**0.0%**	
				$22,442,797
				rounded
TOTAL PROJECT COST, Oct 07				**$22,400,000**

COMPREHENSIVE STUDY " Environmental Restoration - O & M " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Admiral Island**

ITEM NO.
SHEET NO. 1 OF 1
DATE 25-Jul-08
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-admiral-enviro-restor-compreh-study-O&M-cost-13sep07.xls

DESCRIPTION		ESTIMATED AMOUNT
ENVIRONMENTAL RESTORATION O&M		
Hancock County Replanting Effort	**Admiral Island**	
0.5 METER PLANTINGS WITH FILL	(monitoring only 5 yrs @ $7,000)	$ 35,000
1.0 METER PLANTINGS WITH FILL		$ 1,233,000
2.0 METER PLANTINGS WITH FILL		$ 1,233,000
0.5 METER PLANTINGS WITHOUT FILL	(monitoring only 5 yrs @ $7,000)	$ 35,000
1.0 METER PLANTINGS WITHOUT FILL		$ 1,233,000
2.0 METER PLANTINGS WITHOUT FILL		$ 1,233,000

****THESE REPLANTING COSTS WILL OCCUR IN YEARS 3 AND 5 OF THE PERIOD OF ANALYSIS.***

Notes:

Price Level, Oct 07
Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment
Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"
Quantities listed within the Estimate represent Major Elements of the Project
Estimate Excludes Project Escalation

COMPREHENSIVE STUDY " Environmental Restoration - O & M " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Admiral Island** ***Replanting 25% of area***
Hancock County ***Years 3 and 5***

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-admiral-enviro-restor-compreh-study-O&M-cost-13sep07.xls
DATE 25-Jul-08

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (2 ea)		1	job	allow	$20,000
Re-Plantings b. 1.0 meter spacing	at year 3	14	acre	28,800	403,200
Re-Plantings b. 1.0 meter spacing	at year 5	14	acre	28,800	403,200
Monitoring b. 1.0 meter spacing		5	yrs	7,000	35,000
Misc Site Items		1	ls	allow	0
		Current Contract Cost, OCT 07			$861,400
	CONTINGENCY		@	**25.0%**	215,350
					$ 1,076,750
	30 Account, Plan, Engr.& Design		@	**8.0%**	86,140
					$ 1,162,890
	31 Account, Constr. Management		@	**6.0%**	69,773
					$ 1,232,663
	ESCALATION		@	**0.0%**	
					$ 1,232,663 rounded
	TOTAL PROJECT COST, OCT 07				**$ 1,233,000**

COMPREHENSIVE STUDY " Environmental Restoration - O & M " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Admiral Island** ***Replanting 50% of area***
Hancock County ***in Years 3 and 5***

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
DATE 25-Jul-08

DESCRIPTION			Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (2 ea)			1	job	allow	$20,000
Re-Plantings	b. 2.0 meter spacing	at year 3	28	acre	14,400	403,200
Re-Plantings	b. 2.0 meter spacing	at year 5	28	acre	14,400	403,200
Monitoring	b. 2.0 meter spacing		5	yrs	7,000	35,000
Misc Site Items			1	ls	allow	0
			Current Contract Cost, OCT 07			$861,400
		CONTINGENCY		@	**25.0%**	215,350
						$ 1,076,750
		30 Account, Plan, Engr.& Design		@	**8.0%**	86,140
						$ 1,162,890
		31 Account, Constr. Management		@	**6.0%**	69,773
						$ 1,232,663
		ESCALATION		@	**0.0%**	
						$ 1,232,663
						rounded
			TOTAL PROJECT COST, OCT 07			**$ 1,233,000**

COMPREHENSIVE STUDY " Environmental Restoration - O & M " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Admiral Island** ***Replanting 25% of area***
Hancock County ***in Years 3 and 5***

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08
OF 1
CHECKED: Gary A. Payton

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (2 ea)		1	job	allow	$20,000
Re-Plantings b. 1.0 meter spacing	at year 3	14	acre	28,800	403,200
Re-Plantings b. 1.0 meter spacing	at year 5	14	acre	28,800	403,200
Monitoring b. 1.0 meter spacing		5	yrs	7,000	35,000
Misc Site Items		1	ls	allow	0
		Current Contract Cost, OCT 07			$ 861,400
	CONTINGENCY		@	**25.0%**	215,350
					$ 1,076,750
	30 Account, Plan, Engr.& Design		@	**8.0%**	86,140
					$ 1,162,890
	31 Account, Constr. Management		@	**6.0%**	69,773
					$ 1,232,663
	ESCALATION		@	**0.0%**	
					$ 1,232,663 rounded
		TOTAL PROJECT COST, OCT 07			**$1,233,000**

COMPREHENSIVE STUDY " Environmental Restoration - O & M " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: **Admiral Island** ***Replanting 50% of area*** BASIS of ESTIMATE: Info furnished per Project Delivery Team
Hancock County ***in Years 3 and 5*** FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (2 ea)			1	job	allow	$20,000
Re-Plantings	b. 2.0 meter spacing	at year 3	28	acre	14,400	403,200
Re-Plantings	b. 2.0 meter spacing	at year 5	28	acre	14,400	403,200
Monitoring	b. 2.0 meter spacing		5	yrs	7,000	35,000
Misc Site Items			1	ls	allow	0
		Current Contract Cost, OCT 07				$861,400
		CONTINGENCY		@	**25.0%**	215,350
						$ 1,076,750
		30 Account, Plan, Engr.& Design		@	**8.0%**	86,140
						$ 1,162,890
		31 Account, Constr. Management		@	**6.0%**	69,773
						$ 1,232,663
		ESCALATION		@	**0.0%**	
						$ 1,232,663
						rounded
		TOTAL PROJECT COST, OCT 0				**$ 1,233,000**

COMPREHENSIVE STUDY " Turkey Creek Environmental Restoration " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Summary*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			ESTIMATED AMOUNT
ENVIRONMENTAL RESTORATION			
Harrison County	**Turkey Creek**	**North and South of Railroad**	**$ 7,600,000**
Harrison County	**Turkey Creek**	**North of Railroad**	**$1,900,000**
Harrison County	**Turkey Creek**	**South of Railroad**	**$5,900,000**

Notes:

Price Level, Oct 07
Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment
Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"
Quantities listed within the Estimate represent Major Elements of the Project
Structural Removal Cost includes minor Site Restoration (filling septic tanks, removal outside structures, pavements & utilities)
Utility Removal Cost includes, sewer, storm drain, water, gas, power, cable, phone, traffic signaling
Estimate Excluc Operational & Maintenance Cost
Project Escalation
Relocations, Environment, HTRW & Real Estate Cost (except PCA)
Historical Preservation
Asbestos Removal during Structure Removal
01 Account, Lands & Damage (land + admin + 25% contingency) in all options at $736,178.

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Turkey Creek*** **North and South of Railroad** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$20,000
1. Fill in Ditches (from off-site borrow)	130,202	cy	12.00	1,562,424
2a. Burn Vegetation (surface only burn)	879	acre	150	131,850
b. Mow vegitation (annually)	879	acre	85	74,715
3. Removals b. Removal of structures (1,500 sf avg size @ 15 ea =)	22,500	sf	3.50	78,750
b. Disposal Fee	833	cy	2.50	2,083
c. Removal of roads (24' wide assumed)	45,822	lf	14.00	641,508
d. Removal of utilities	45,822	lf	41.00	1,878,702
Misc Site Items	1	ls	allow	45,000
		Current Contract Cost, Oct 07		$4,435,032
CONTINGENCY		@	**25.0%**	1,108,758
				$5,543,790
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	1,101,000
				$6,669,790
30 Account, Plan, Engr.& Design		@	**8.0%**	533,583
				$7,203,374
31 Account, Constr. Management		@	**6.0%**	432,202
				$7,635,576
ESCALATION		@	**0.0%**	
				$7,635,576
				rounded
TOTAL PROJECT COST, Oct 07				**$ 7,600,000**

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Turkey Creek*** **North of Railroad** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$20,000
1. Fill in Ditches (from off-site borrow)	28,124	cy	12.00	337,484
2a. Burn Vegetation (surface only burn)	190	acre	150	28,480
b. Mow vegitation (annually)	190	acre	85	16,138
3. Removals b. Removal of structures (1,500 sf avg size @ 3 ea =)	4,500	sf	3.50	15,750
b. Disposal Fee	167	cy	2.50	417
c. Removal of roads (24' wide assumed)	9,898	lf	14.00	138,566
d. Removal of utilities	9,898	lf	41.00	405,800
Misc Site Items	1	ls	allow	45,000
			Current Contract Cost, Oct 07	$1,007,634
CONTINGENCY		@	**25.0%**	251,908
				$1,259,542
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	350,000
				$1,634,542
30 Account, Plan, Engr.& Design		@	**8.0%**	130,763
				$1,765,305
31 Account, Constr. Management		@	**6.0%**	105,918
				$1,871,224
ESCALATION		@	**0.0%**	
				$1,871,224
				rounded

TOTAL PROJECT COST, Oct 07 $1,900,000

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP'** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Turkey Creek*** **South of Railroad** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$20,000
1. Fill in Ditches (from off-site borrow)	102,078	cy	12.00	1,224,940
2a. Burn Vegetation (surface only burn)	689	acre	150	103,370
b. Mow vegitation (annually)	689	acre	85	58,577
3. Removals b. Removal of structures (1,500 sf avg size @ 12 ea =	18,000	sf	3.50	63,000
b. Disposal Fee	667	cy	2.50	1,667
c. Removal of roads (24' wide assumed)	35,924	lf	14.00	502,942
d. Removal of utilities	35,924	lf	41.00	1,472,902
Misc Site Items	1	ls	allow	45,000
		Current Contract Cost, Oct 07		$3,492,399
CONTINGENCY		@	**25.0%**	873,100
				$4,365,498
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)			**LS**	752,000
				$5,142,498
30 Account, Plan, Engr.& Design		@	**8.0%**	411,400
				$5,553,898
31 Account, Constr. Management		@	**6.0%**	333,234
				$5,887,132
ESCALATION		@	**0.0%**	
				$5,887,132 rounded
TOTAL PROJECT COST, Oct 07				**$5,900,000**

COMPREHENSIVE STUDY " Turkey Creek O & M Environmental Restoration " SUMMARY

PROJECT:	**Mississippi Coastal Improvement Project "MsCIP"**		ITEM NO.	DATE	25-Jul-08
LOCATION:	**Mississippi**		SHEET NO. 1	OF	1
			PREPARED Joseph H. Ellsworth	CHECKED:	Gary A. Payton
WORK ITEM:	***Summary***	North & South O&M	BASIS of ESTIMATE:	info furnished per Project Delivery Team	
			FILE NAME:	mscip-comprehensive-study-compbined-cost-est-25jul08.xls	

DESCRIPTION			ESTIMATED AMOUNT
Harrison County	**Turkey Creek**	**Burn North and South of Railroad**	$190,000
Harrison County	**Turkey Creek**	**Mow North and South of Railroad**	$110,000
Harrison County	**Turkey Creek**	**Burn North of Railroad**	$41,000
Harrison County	**Turkey Creek**	**Mow North of Railroad**	$20,000
Harrison County	**Turkey Creek**	**Burn South of Railroad**	$149,000
Harrison County	**Turkey Creek**	**Mow South of Railroad**	$80,000

ENVIRONMENTAL RESTORATION

Notes: *** see backup for Cost Derivation**

Price Level, FY-07

Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment

Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"

Quantities listed within the Estimate represent Major Elements of the Operations and Maintenance

Estimate Excludes: Project Escalation

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Turkey Creek*** **Burn North and South of Railroad** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$1,000
Burn Vegetation (surface only burn)	879	acre	150	131,850
	Current Contract Cost, FY 07			$132,850
CONTINGENCY		@	**25.0%**	33,213
				$166,063
30 Account, Plan, Engr.& Design		@	**8.0%**	13,285
				$179,348
31 Account, Constr. Management		@	**6.0%**	10,761
				$190,108
ESCALATION		@	**0.0%**	
				$190,108 rounded
	TOTAL PROJECT COST, FY- 07			$190,000

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***Turkey Creek*** **Mow North and South of Railroad**
Hancock County

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08
OF 1
CHECKED: Gary A. Payton

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$400
b. Mow vegitation (annually)	879	acre	85	74,715
		Current Contract Cost, FY 07		$75,115
CONTINGENCY		@	**25.0%**	18,779
				$93,894
30 Account, Plan, Engr.& Design		@	**8.0%**	7,512
				$101,405
31 Account, Constr. Management		@	**6.0%**	6,084
				$107,490
ESCALATION		@	**0.0%**	
				$107,490
				rounded
		TOTAL PROJECT COST, FY- 07		$110,000

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Turkey Creek*** **Burn North of Railroad** BASIS of ESTIMATE: info furnished per Project Delivery Team
Hancock County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$100
Burn Vegetation (surface only burn)	190	acre	150	28,500
	Current Contract Cost, FY 07			$28,600
CONTINGENCY		@	**25.0%**	7,150
				$35,750
30 Account, Plan, Engr.& Design		@	**8.0%**	2,860
				$38,610
31 Account, Constr. Management		@	**6.0%**	2,317
				$40,927
ESCALATION		@	**0.0%**	
				$40,927 rounded
	TOTAL PROJECT COST, FY- 07			$41,000

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***Turkey Creek*** **Mow North of Railroad**
Hancock County

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: Info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08
OF 1
CHECKED: Gary A. Payton

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$100
b. Mow vegitation (annually)	190	acre	85	16,150
		Current Contract Cost, FY 07		$16,250
CONTINGENCY		@	**25.0%**	4,063
				$20,313
30 Account, Plan, Engr.& Design		@	**8.0%**	1,625
				$21,938
31 Account, Constr. Management		@	**6.0%**	1,316
				$23,254
ESCALATION		@	**0.0%**	
				$23,254 rounded
TOTAL PROJECT COST, FY- 07				$20,000

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***Turkey Creek*** **Burn South of Railroad**
Hancock County

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08
OF 1
CHECKED: Gary A. Payton

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$500
Burn Vegetation (surface only burn)	689	acre	150	103,350
	Current Contract Cost, FY 07			$103,850
CONTINGENCY		@	**25.0%**	25,963
				$129,813
30 Account, Plan, Engr.& Design		@	**8.0%**	10,385
				$140,198
31 Account, Constr. Management		@	**6.0%**	8,412
				$148,609
ESCALATION		@	**0.0%**	
				$148,609 rounded
TOTAL PROJECT COST, FY- 07				$149,000

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Project "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***Turkey Creek*** **Mow South of Railroad**
Hancock County

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: Info furnished per Project Delivery Team
FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08
OF 1
CHECKED: Gary A. Payton

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$300
b. Mow vegitation (annually)	689	acre	85	58,565
		Current Contract Cost, FY 07		$58,865
CONTINGENCY		@	**25.0%**	14,716
				$73,581
30 Account, Plan, Engr.& Design		@	**8.0%**	5,887
				$79,468
31 Account, Constr. Management		@	**6.0%**	4,768
				$84,236
ESCALATION		@	**0.0%**	
				$84,236
				rounded
TOTAL PROJECT COST, FY- 07				$80,000

COMPREHENSIVE STUDY " Dantzler Environmental Restoration " SUMMARY

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***Summary***

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION			ESTIMATED AMOUNT
ENVIRONMENTAL RESTORATION			
Jackson County	**Dantzler**	**Area A and B**	**$ 1,900,000**
Jackson County	**Dantzler**	**Area A**	**$ 870,000**
Jackson County	**Dantzler**	**Area B**	**$ 1,040,000**

Notes:

Price Level, Oct 07
Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment
Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"
Quantities listed within the Estimate represent Major Elements of the Project
Structural Removal Cost included in nonstructural estimates
Utility Removal Cost includes, sewer, storm drain, water, gas, power, cable, phone, traffic signaling
Estimate Exclude Operational & Maintenance Cost
Project Escalation
Relocations, Environment, HTRW & Real Estate Cost (except PCA)
Historical Preservation

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: ***Dantzler*** **Area A and B**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$40,000
1. Fill in Ditches (from off-site borrow)	66,560	cy	12.00	798,720
2a. Burn Vegetation (surface only burn)	385	acre	150	57,750
b. Mow vegitation (annually)	385	acre	85	32,725
3. Removals b. Removal of structures (1,500 sf avg size @ 5 ea =)		cost included in the nonstructural estmate		
b. Disposal Fee		cost included in the nonstructural estmate		
c. Removal of roads (24' wide assumed)	5,000	lf	14.00	70,000
d. Removal of utilities	5,000	lf	41.00	205,000
Misc Site Items	1	ls	allow	90,000
		Current Contract Cost, Oct 07		$1,294,195
CONTINGENCY		@	**25.0%**	323,549
				$1,617,744
01 Account, Lands & Damage		PCA	**LS**	25,000
				$1,642,744
30 Account, Plan, Engr.& Design		@	**8.0%**	131,420
				$1,774,163
31 Account, Constr. Management		@	**6.0%**	106,450
				$1,880,613
ESCALATION		@	**0.0%**	
				$1,880,613 rounded
		TOTAL PROJECT COST, Oct 07		**$1,900,000**

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***Dantzler*** **Area North**
Jackson County

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME:

DATE 25-Jul-08
OF 1
CHECKED: Gary A. Payton

mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$20,000
1. Fill in Ditches (from off-site borrow)	30,560	cy	12.00	366,720
2a. Burn Vegetation (surface only burn)	151	acre	150	22,650
b. Mow vegitation (annually)	151	acre	85	12,835
3. Removals b. Removal of structures (1,500 sf avg size @ 3 ea =)		cost included in the nonstructural estmate		
b. Disposal Fee		cost included in the nonstructural estmate		
c. Removal of roads (24' wide assumed)	2,200	lf	14.00	30,800
d. Removal of utilities	2,200	lf	41.00	90,200
Misc Site Items	1	ls	allow	45,000
			Current Contract Cost, Oct 07	$588,205
CONTINGENCY		@	**25.0%**	147,051
				$735,256
01 Account, Lands & Damage		PCA	**LS**	25,000
				$760,256
30 Account, Plan, Engr.& Design		@	**8.0%**	60,821
				$821,077
31 Account, Constr. Management		@	**6.0%**	49,265
				$870,341
ESCALATION		@	**0.0%**	
				$870,341
				rounded
TOTAL PROJECT COST, Oct 07				**$ 870,000**

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***Dantzler*** **Area South**
Jackson County

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME:

DATE 25-Jul-08
OF 1
CHECKED: Gary A. Payton

mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$20,000
1. Fill in Ditches (from off-site borrow)	36,000	cy	12.00	432,000
2a. Burn Vegetation (surface only burn)	234	acre	150	35,100
b. Mow vegitation (annually)	234	acre	85	19,890
3. Removals b. Removal of structures (1,500 sf avg size @ 2 ea =)	cost included in the nonstructural estmate			
b. Disposal Fee	cost included in the nonstructural estmate			
c. Removal of roads (24' wide assumed)	2,800	lf	14.00	39,200
d. Removal of utilities	2,800	lf	41.00	114,800
Misc Site Items	1	ls	allow	45,000
			Current Contract Cost, Oct 07	$705,990
CONTINGENCY		@	**25.0%**	176,498
				$882,488
01 Account, Lands & Damage		PCA	**LS**	25,000
				$907,488
30 Account, Plan, Engr.& Design		@	**8.0%**	72,599
				$980,087
31 Account, Constr. Management		@	**6.0%**	58,805
				$1,038,892
ESCALATION		@	**0.0%**	
				$1,038,892
				rounded
TOTAL PROJECT COST, Oct 07				**$1,040,000**

COMPREHENSIVE STUDY " Dantzler Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: **Dantzler** Area North and South O&M

ITEM NO.
SHEET NO. 1
PREPARED Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08
OF 1
CHECKED: Gary A. Payton

DESCRIPTION			ESTIMATED AMOUNT
ENVIRONMENTAL RESTORATION O&M			
Jackson County	**Dantzler**	**Burn Area North and South**	$ 83,000
Jackson County	**Dantzler**	**Mow Area North and South**	$ 47,000
Jackson County	**Dantzler**	**Burn Area North**	$ 33,000
Jackson County	**Dantzler**	**Mow Area North**	$ 19,000
Jackson County	**Dantzler**	**Burn Area South**	$ 51,000
Jackson County	**Dantzler**	**Mow Area South**	$ 29,000

Notes:

Price Level, Oct 07
Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment
Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"
Quantities listed within the Estimate represent Major Elements of the Operations and Maintenance
Estimate Exclud Project Escalation

COMPREHENSIVE STUDY " Dantzler Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Project "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: ***Dantzler*** **Jackson County** **Burn Area North and South**

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08
OF 1
CHECKED: Gary A. Payton

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$0
Burn Vegetation (surface only burn)	385	acre	150	57,750
		Current Contract Cost, OCT 07		$57,750
CONTINGENCY		@	**25.0%**	14,438
				$72,188
30 Account, Plan, Engr.& Design		@	**8.0%**	5,775
				$77,963
31 Account, Constr. Management		@	**6.0%**	4,678
				$82,640
ESCALATION		@	**0.0%**	
				$82,640 rounded
		TOTAL PROJECT COST, OCT 07		$83,000

COMPREHENSIVE STUDY " Dantzler Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Dantzler*** **Mow Area North and south** **Jackson County** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$200
b. Mow vegitation (annually)	385	acre	85	32,725
	Current Contract Cost, OCT 07			$32,925
CONTINGENCY		@	**25.0%**	8,231
				$41,156
30 Account, Plan, Engr.& Design		@	**8.0%**	3,293
				$44,449
31 Account, Constr. Management		@	**6.0%**	2,667
				$47,116
ESCALATION		@	**0.0%**	
				$47,116
				rounded
TOTAL PROJECT COST, OCT 07				$47,000

COMPREHENSIVE STUDY " Dantzler Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Dantzler*** **Burn North**
Jackson County
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$100
Burn Vegetation (surface only burn)	151	acre	150	22,650
	Current Contract Cost,OCT 07			$22,750
CONTINGENCY		@	**25.0%**	5,688
				$28,438
30 Account, Plan, Engr.& Design		@	**8.0%**	2,275
				$30,713
31 Account, Constr. Management		@	**6.0%**	1,843
				$32,555
ESCALATION		@	**0.0%**	
				$32,555 rounded
TOTAL PROJECT COST, OCT 07				$33,000

COMPREHENSIVE STUDY " Dantzler Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Dantzler*** **Mow Area North** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$100
b. Mow vegitation (annually)	151	acre	85	12,835
	Current Contract Cost, OCT07			$12,935
CONTINGENCY		@	**25.0%**	3,234
				$16,169
30 Account, Plan, Engr.& Design		@	**8.0%**	1,294
				$17,462
31 Account, Constr. Management		@	**6.0%**	1,048
				$18,510
ESCALATION		@	**0.0%**	
				$18,510
				rounded
	TOTAL PROJECT COST, OCT 07			$19,000

Environmental Restoration, 5 Sites O/M Costs - O&M Area North Mow

COMPREHENSIVE STUDY " Dantzler Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Dantzler*** **Burn Area South** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$200
Burn Vegetation (surface only burn)	234	acre	150	35,100
	Current Contract Cost, OCT 07			$35,300
CONTINGENCY		@	**25.0%**	8,825
				$44,125
30 Account, Plan, Engr.& Design		@	**8.0%**	3,530
				$47,655
31 Account, Constr. Management		@	**6.0%**	2,859
				$50,514
ESCALATION		@	**0.0%**	
				$50,514 rounded
	TOTAL PROJECT COST, OCT 07			$51,000

COMPREHENSIVE STUDY " Dantzler Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Dantzler*** **Mow Area South** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$100
b. Mow vegitation (annually)	234	acre	85	19,890
	Current Contract Cost, OCT 07			$19,990
CONTINGENCY		@	**25.0%**	4,998
				$24,988
30 Account, Plan, Engr.& Design		@	**8.0%**	1,999
				$26,987
31 Account, Constr. Management		@	**6.0%**	1,619
				$28,606
ESCALATION		@	**0.0%**	
				$28,606
				rounded
TOTAL PROJECT COST, OCT 07				$29,000

COMPREHENSIVE STUDY "Franklin Creek Environmental Restoration " SUMMARY

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***Summary***

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION			ESTIMATED AMOUNT
Jackson County	**Franklin Creek**	**Area A and B**	**$ 1,630,000**
Jackson County	**Franklin Creek**	**Area A**	**$ 1,110,000**
Jackson County	**Franklin Creek**	**Area B**	**$ 550,000**

ENVIRONMENTAL RESTORATION

Notes:

Price Level, Oct 07
Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment
Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"
Quantities listed within the Estimate represent Major Elements of the Project
Structural Removal Cost included in nonstructural estimates
Utility Removal Cost includes, sewer, storm drain, water, gas, power, cable, phone, traffic signaling

Estimate Excludes:

Operational & Maintenance Cost
Project Escalation
Relocations, Environment, HTRW & Real Estate Cost (except PCA)
Historical Preservation

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Franklin Creek*** **Area A and B**
Jackson County
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$40,000
24 inch RCP culverts, (15 @100 ft long ea.)	1500	lf	100.00	150,000
1. Fill in Ditches (from off-site borrow)	26,000	cy	12.00	312,000
2a. Burn Vegetation (surface only burn)	149	acre	150	22,350
b. Mow vegitation (annually)	149	acre	85	12,665
3. Removals b. Removal of structures (1,500 sf avg size @ 15 ea =)		cost included in the nonstructural estmate		
b. Disposal Fee		cost included in the nonstructural estmate		
c. Removal of roads (24' wide assumed)	9,000	lf	14.00	126,000
d. Removal of utilities	9,000	lf	41.00	369,000
Misc Site Items	1	ls	allow	90,000
		Current Contract Cost, Oct 07		$1,122,015
CONTINGENCY		@	**25.0%**	280,504
				$1,402,519
01 Account, Lands & Damage		PCA	**LS**	25,000
				$1,427,519
30 Account, Plan, Engr.& Design		@	**8.0%**	114,202
				$1,541,720
31 Account, Constr. Management		@	**6.0%**	92,503
				$1,634,223
ESCALATION		@	**0.0%**	
				$1,634,223 rounded
TOTAL PROJECT COST, Oct 07				**$ 1,630,000**

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Franklin Creek*** **Area A**
Jackson County
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$20,000
24 inch RCP culverts, (15 @100 ft long ea.)	1500	lf	100.00	150,000
1. Fill in Ditches (from off-site borrow)	16,000	cy	12.00	192,000
2a. Burn Vegetation (surface only burn)	93	acre	150	13,950
b. Mow vegitation (annually)	93	acre	85	7,905
3. Removals b. Removal of structures (1,500 sf avg size @ 15 ea =)		cost included in the nonstructural estmate		
b. Disposal Fee		cost included in the nonstructural estmate		
c. Removal of roads (24' wide assumed)	6,000	lf	14.00	84,000
d. Removal of utilities	6,000	lf	41.00	246,000
Misc Site Items	1	ls	allow	45,000
			Current Contract Cost, Oct 07	$758,855
CONTINGENCY		@	**25.0%**	189,714
				$948,569
01 Account, Lands & Damage		PCA	**LS**	25,000
				$973,569
30 Account, Plan, Engr.& Design		@	**8.0%**	77,886
				$1,051,454
31 Account, Constr. Management		@	**6.0%**	63,087
				$1,114,542
ESCALATION		@	**0.0%**	
				$1,114,542
				rounded
TOTAL PROJECT COST, Oct 07				**$ 1,110,000**

Environmental Restoration, 5 Sites Costs - Area A (2)

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: ***Franklin Creek*** **Area B**
Jackson County

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08
OF 1
CHECKED: Gary A. Payton

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant)	1	job	allow	$20,000
1. Fill in Ditches (from off-site borrow)	10,000	cy	12.00	120,000
2a. Burn Vegetation (surface only burn)	56	acre	150	8,400
b. Mow vegitation (annually)	56	acre	85	4,760
3. Removals b. Removal of structures (1,500 sf avg size @ 15 ea =)		cost included in the nonstructural estmate		
b. Disposal Fee		cost included in the nonstructural estmate		
c. Removal of roads (24' wide assumed)	3,000	lf	14.00	42,000
d. Removal of utilities	3,000	lf	41.00	123,000
Misc Site Items	1	ls	allow	45,000
			Current Contract Cost, Oct 07	$363,160
CONTINGENCY		@	**25.0%**	90,790
				$453,950
01 Account, Lands & Damage		PCA	**LS**	25,000
				$478,950
30 Account, Plan, Engr.& Design		@	**8.0%**	38,316
				$517,266
31 Account, Constr. Management		@	**6.0%**	31,036
				$548,302
ESCALATION		@	**0.0%**	
				$548,302
				rounded
			TOTAL PROJECT COST, Oct 07	**$ 550,000**

COMPREHENSIVE STUDY " Franklin Creek Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**

WORK ITEM: **Franklin Creek** **Area A and B O&M**

ITEM NO.
SHEET NO. 1
PREPARED: Joseph H. Ellsworth
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08
OF 1
CHECKED: Gary A. Payton

DESCRIPTION			ESTIMATED AMOUNT
ENVIRONMENTAL RESTORATION			
Jackson County	**Franklin Creek**	**Burn Area A and B**	$ 34,000
Jackson County	**Franklin Creek**	**Mow Area A and B**	$ 19,000
Jackson County	**Franklin Creek**	**Burn Area A**	$ 21,000
Jackson County	**Franklin Creek**	**Mow Area A**	$ 12,000
Jackson County	**Franklin Creek**	**Burn Area B**	$ 13,000
Jackson County	**Franklin Creek**	**Mow Area B**	$ 7,000

Notes:

Price Level, Oct 07
Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment
Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"
Quantities listed within the Estimate represent Major Elements of the Operations and Maintenance
Estimate Excludes Project Escalation

COMPREHENSIVE STUDY " Franklin Creek Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: ***Franklin Creek*** **Burn Area A and B**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$1,100
Burn Vegetation (surface only burn)	149	acre	150	22,350
		Current Contract Cost, OCT 07		$23,450
CONTINGENCY		@	**25.0%**	5,863
				$29,313
30 Account, Plan, Engr.& Design		@	**8.0%**	2,345
				$31,658
31 Account, Constr. Management		@	**6.0%**	1,899
				$33,557
ESCALATION		@	**0.0%**	
				$33,557
				rounded
		TOTAL PROJECT COST, OCT07		**$34,000**

COMPREHENSIVE STUDY " Franklin Creek Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: ***Franklin Creek*** **Mow Area A and B**
Jackson County

ITEM NO. DATE 25-Jul-08
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$600
b. Mow vegitation (annually)	149	acre	85	12,665
		Current Contract Cost, OCT 07		$13,265
CONTINGENCY		@	**25.0%**	3,316
				$16,581
30 Account, Plan, Engr.& Design		@	**8.0%**	1,327
				$17,908
31 Account, Constr. Management		@	**6.0%**	1,074
				$18,982
ESCALATION		@	**0.0%**	
				$18,982
				rounded
			TOTAL PROJECT COST, OCT 07	**$19,000**

COMPREHENSIVE STUDY " Franklin Creek Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: ***Franklin Creek*** **Burn Area A**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$700
Burn Vegetation (surface only burn)	93	acre	150	13,950
		Current Contract Cost, OCT07		$14,650
CONTINGENCY		@	**25.0%**	3,663
				$18,313
30 Account, Plan, Engr.& Design		@	**8.0%**	1,465
				$19,778
31 Account, Constr. Management		@	**6.0%**	1,187
				$20,964
ESCALATION		@	**0.0%**	
				$20,964
				rounded
		TOTAL PROJECT COST, OCT 07		**$21,000**

COMPREHENSIVE STUDY " Franklin Creek Environmental Restoration - O & M " SUMMARY

PROJECT:	**Mississippi Coastal Improvement Program "MsCIP"**	ITEM NO.		DATE	25-Jul-08
LOCATION:	**Mississippi**	SHEET NO.	1	OF	1
		PREPARED:	Joseph H. Ellsworth	CHECKED:	Gary A. Payton
WORK ITEM:	***Franklin Creek*** **Mow Area A**	BASIS of ESTIMATE:	info furnished per Project Delivery Team		
	Jackson County	FILE NAME:			
			mscip-comprehensive-study-compbined-cost-est-25jul08.xls		

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$400
b. Mow vegitation (annually)	93	acre	85	7,905
		Current Contract Cost, OCT 07		$8,305
CONTINGENCY		@	**25.0%**	2,076
				$10,381
30 Account, Plan, Engr.& Design		@	**8.0%**	831
				$11,212
31 Account, Constr. Management		@	**6.0%**	673
				$11,884
ESCALATION		@	**0.0%**	
				$11,884
				rounded
TOTAL PROJECT COST, OCT07				**$12,000**

COMPREHENSIVE STUDY " Franklin Creek Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: ***Franklin Creek*** **Burn Area B**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$420
Burn Vegetation (surface only burn)	56	acre	150	8,400
		Current Contract Cost, OCT 07		$8,820
CONTINGENCY		@	**25.0%**	2,205
				$11,025
30 Account, Plan, Engr.& Design		@	**8.0%**	882
				$11,907
31 Account, Constr. Management		@	**6.0%**	714
				$12,621
ESCALATION		@	**0.0%**	
				$12,621
				rounded
TOTAL PROJECT COST, OCT 07				**$13,000**

COMPREHENSIVE STUDY " Franklin Creek Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: ***Franklin Creek*** **Mow Area B**
Jackson County

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
DATE 25-Jul-08

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$240
b. Mow vegitation (annually)	56	acre	85	4,760
		Current Contract Cost, OCT 07		$5,000
CONTINGENCY		@	**25.0%**	1,250
				$6,250
30 Account, Plan, Engr.& Design		@	**8.0%**	500
				$6,750
31 Account, Constr. Management		@	**6.0%**	405
				$7,155
ESCALATION		@	**0.0%**	
				$7,155
				rounded
TOTAL PROJECT COST, OCT 07				**$7,000**

COMPREHENSIVE STUDY " Bayou Cumbest Environmental Restoration " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Summary*** BASIS of ESTIMATE Info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	ESTIMATED AMOUNT

ENVIRONMENTAL RESTORATION

Jackson County **Bayou Cumbest** **Area 34**

0.5 METER PLANTINGS WITH FILL	**$ 28,000,000**
1.0 METER PLANTINGS WITH FILL	**$ 23,400,000**
2.0 METER PLANTINGS WITH FILL	**$ 21,000,000**
0.5 METER PLANTINGS WITHOUT FILL	**$ 28,000,000**
1.0 METER PLANTINGS WITHOUT FILL	**$ 23,300,000**
2.0 METER PLANTINGS WITHOUT FILL	**$ 21,000,000**

Notes:

Price Level, Oct 07
Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment
Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"
Quantities listed within the Estimate represent Major Elements of the Project
Structural Removal Cost includes minor Site Restoration (filling septic tanks, removal outside structures, pavements & utilities)
Utility Removal Cost includes, sewer, storm drain, water, gas, power, cable, phone, traffic signaling

Estimate Excludes:

- Operational & Maintenance Cost
- Project Escalation
- Relocations, Environment, HTRW & Real Estate Cost (except PCA)
- Historical Preservation
- Asbestos Removal during Structure Removal

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: **Bayou Cumbest** ***Area 31*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$380,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	693,909	cy	12.00	8,326,908
b. Removal of structures (1,500 sf avg size @ 18 ea =)	27,000	sf	3.50	94,500
b. Disposal Fee	1,000	cy	2.50	2,500
c. Removal of roads (24' wide assumed)	6,439	lf	14.00	90,146
d. Removal of utilities	6,439	lf	41.00	263,999
2. Herbicide, hand application (untouched areas from excavation)	32	acre	3,100	99,200
3. Filling of existing ditches and channels (from req'd. excavation)	2,023	cy	5.00	10,115
4. Plantings a. 0.5 meter spacing	110	acre	57,600	6,336,000
Misc Site Items	1	ls	allow	100,000
Current Contract Cost, FY 07				$ 15,703,368
CONTINGENCY		@	**25.0%**	3,925,842
				$ 19,629,210
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				4,806,603
				$24,460,813
30 Account, Plan, Engr.& Design		@	**8.0%**	1,956,865
				$ 26,417,678
31 Account, Constr. Management		@	**6.0%**	1,585,061
				$ 28,002,739
ESCALATION		@	**0.0%**	
				$ 28,002,739 rounded
TOTAL PROJECT COST, Oct- 07				**$ 28,000,000**

Environmental Restoration, 5 Sites Costs - cumbest .5 meter spacing w fill

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT:	**Mississippi Coastal Improvement Program "MsCIP"**	ITEM NO.		DATE	25-Jul-08
LOCATION:	**Mississippi**	SHEET NO.	1	OF	1
		PREPARED:	Joseph H. Ellsworth	CHECKED:	Gary A. Payton
WORK ITEM:	**Bayou Cumbest** ***Area 34***	BASIS of ESTIMATE:	info furnished per Project Delivery Team		
	Jackson County	FILE NAME:			
	1.0 METER PLANTINGS WITH FILL		mscip-comprehensive-study-compbined-cost-est-25jul08.xls		

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$300,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	693,909	cy	12.00	8,326,908
b. Removal of structures (1,500 sf avg size @ 18 ea =)	27,000	sf	3.50	94,500
b. Disposal Fee	1,000	cy	2.50	2,500
c. Removal of roads (24' wide assumed)	6,439	lf	14.00	90,146
d. Removal of utilities	6,439	lf	41.00	263,999
2. Herbicide, hand application (untouched areas from excavation)	32	acre	3,100	99,200
3. Filling of existing ditches and channels (from req'd. excavation)	2,023	cy	5.00	10,115
4. Plantings b. 1.0 meter spacing	110	acre	28,800	3,168,000
Misc Site Items	1	ls	allow	100,000
		Current Contract Cost, FY 07		$ 12,455,368
CONTINGENCY		@	**25.0%**	3,113,842
				$ 15,569,210
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				4,806,603
				$20,400,813
30 Account, Plan, Engr.& Design		@	**8.0%**	1,632,065
				$ 22,032,878
31 Account, Constr. Management		@	**6.0%**	1,321,973
				$ 23,354,851
ESCALATION		@	**0.0%**	
				$ 23,354,851 rounded
TOTAL PROJECT COST, Oct- 07				**$ 23,400,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT:	**Mississippi Coastal Improvement Program "MsCIP"**	ITEM NO.		DATE	25-Jul-08
LOCATION:	**Mississippi**	SHEET NO.	1	OF	1
		PREPARED:	Joseph H. Ellsworth	CHECKED:	Gary A. Payton
WORK ITEM:	**Bayou Cumbest** ***Area 31***	BASIS of ESTIMATE:	info furnished per Project Delivery Team		
	Jackson County	FILE NAME:			

mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$260,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	693,909	cy	12.00	8,326,908
b. Removal of structures (1,500 sf avg size @ 18 ea =)	27,000	sf	3.50	94,500
b. Disposal Fee	1,000	cy	2.50	2,500
c. Removal of roads (24' wide assumed)	6,439	lf	14.00	90,146
d. Removal of utilities	6,439	lf	41.00	263,999
2. Herbicide, hand application (untouched areas from excavation)	32	acre	3,100	99,200
3. Filling of existing ditches and channels (from req'd. excavation)	2,023	cy	5.00	10,115
4. Plantings c. 2.0 meter spacing	110	acre	14,400	1,584,000
Misc Site Items	1	ls	allow	100,000
Current Contract Cost, FY 07				$ 10,831,368
CONTINGENCY		@	**25.0%**	2,707,842
				$ 13,539,210
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				4,806,603
				$18,370,813
30 Account, Plan, Engr.& Design		@	**8.0%**	1,469,665
				$ 19,840,478
31 Account, Constr. Management		@	**6.0%**	1,190,429
				$ 21,030,907
ESCALATION		@	**0.0%**	
				$ 21,030,907
				rounded
TOTAL PROJECT COST, Oct- 07				**$ 21,000,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT:	**Mississippi Coastal Improvement Program "MsCIP"**	ITEM NO.		DATE	25-Jul-08
LOCATION:	**Mississippi**	SHEET NO.	1	OF	1
		PREPARED:	Joseph H. Ellsworth	CHECKED:	Gary A. Payton
WORK ITEM:	**Bayou Cumbest** ***Area 31***	BASIS of ESTIMATE:	info furnished per Project Delivery Team		
	Jackson County	FILE NAME:			

mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization		1	job	allow	$380,000
1. Removals:	a. Excavation existing Area from -0.5 to +2.0	693,909	cy	12.00	8,326,908
	b. Removal of structures (1,500 sf avg size @ 18 ea =)	27,000	sf	3.50	94,500
	b. Disposal Fee	1,000	cy	2.50	2,500
	c. Removal of roads (24' wide assumed)	6,439	lf	14.00	90,146
	d. Removal of utilities	6,439	lf	41.00	263,999
2. Herbicide, hand application (untouched areas from excavation)		32	acre	3,100	99,200
3. Plantings	a. 0.5 meter spacing	110	acre	57,600	6,336,000
Misc Site Items		1	ls	allow	100,000
		Current Contract Cost, FY 07			$ 15,693,253
	CONTINGENCY		@	**25.0%**	3,923,313
					$ 19,616,566
	01 Account, Lands & Damage		PCA	**LS**	25,000
	01 Account, Lands & Damage (land + admin + 25% contingency)				4,806,603
					$24,448,169
	30 Account, Plan, Engr.& Design		@	**8.0%**	1,955,854
					$ 26,404,023
	31 Account, Constr. Management		@	**6.0%**	1,584,241
					$ 27,988,264
	ESCALATION		@	**0.0%**	
					$ 27,988,264 rounded
	TOTAL PROJECT COST, Oct- 07				**$ 28,000,000**

Environmental Restoration, 5 Sites Costs - cumbest.5 meter spacing wo fill

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: **Bayou Cumbest** ***Area 31*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$300,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	693,909	cy	12.00	8,326,908
b. Removal of structures (1,500 sf avg size @ 18 ea =)	27,000	sf	3.50	94,500
b. Disposal Fee	1,000	cy	2.50	2,500
c. Removal of roads (24' wide assumed)	6,439	lf	14.00	90,146
d. Removal of utilities	6,439	lf	41.00	263,999
2. Herbicide, hand application (untouched areas from excavation)	32	acre	3,100	99,200
3. Plantings b. 1.0 meter spacing	110	acre	28,800	3,168,000
Misc Site Items	1	ls	allow	100,000
		Current Contract Cost, FY 07		$ 12,445,253
CONTINGENCY		@	**25.0%**	3,111,313
				$ 15,556,566
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				4,806,603
				$20,388,169
30 Account, Plan, Engr.& Design		@	**8.0%**	1,631,054
				$ 22,019,223
31 Account, Constr. Management		@	**6.0%**	1,321,153
				$ 23,340,376
ESCALATION		@	**0.0%**	
				$ 23,340,376 rounded
TOTAL PROJECT COST, Oct- 07				**$ 23,300,000**

COMPREHENSIVE STUDY "Environmental Restoration" Cost Estimate

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: **Bayou Cumbest** ***Area 31*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization	1	job	allow	$260,000
1. Removals: a. Excavation existing Area from -0.5 to +2.0	693,909	cy	12.00	8,326,908
b. Removal of structures (1,500 sf avg size @ 18 ea =)	27,000	sf	3.50	94,500
b. Disposal Fee	1,000	cy	2.50	2,500
c. Removal of roads (24' wide assumed)	6,439	lf	14.00	90,146
d. Removal of utilities	6,439	lf	41.00	263,999
2. Herbicide, hand application (untouched areas from excavation)	32	acre	3,100	99,200
3. Plantings c. 2.0 meter spacing	110	acre	14,400	1,584,000
Misc Site Items	1	ls	allow	100,000
		Current Contract Cost, FY 07		$ 10,821,253
CONTINGENCY		@	**25.0%**	2,705,313
				$ 13,526,566
01 Account, Lands & Damage		PCA	**LS**	25,000
01 Account, Lands & Damage (land + admin + 25% contingency)				4,806,603
				$18,358,169
30 Account, Plan, Engr.& Design		@	**8.0%**	1,468,654
				$ 19,826,823
31 Account, Constr. Management		@	**6.0%**	1,189,609
				$ 21,016,432
ESCALATION		@	**0.0%**	
				$ 21,016,432
				rounded
TOTAL PROJECT COST, Oct- 07				**$ 21,000,000**

COMPREHENSIVE STUDY " Bayou Cumbest Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: **Bayou Cumbest**

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
DATE 25-Jul-08

DESCRIPTION		ESTIMATED AMOUNT
ENVIRONMENTAL RESTORATION		
Jackson County Replanting Effort	**Bayou Cumbest Area 30**	
0.5 METER PLANTINGS WITH FILL	(monitoring only 5 yrs @ $7,000)	$35,000
1.0 METER PLANTINGS WITH FILL		$ 2,400,000
2.0 METER PLANTINGS WITH FILL		$ 2,400,000
0.5 METER PLANTINGS WITHOUT FILL	(monitoring only 5 yrs @ $7,000)	$35,000
1.0 METER PLANTINGS WITHOUT FILL		$ 2,400,000
2.0 METER PLANTINGS WITHOUT FILL		$ 2,400,000

****THESE REPLANTING COSTS WILL OCCUR IN YEARS 3 AND 5 OF THE PERIOD OF ANALYSIS.***

Notes:

Price Level, Oct 07
Unit Cost based on Historical Data, Recent Pricing, & Estimator's Judgment
Cost Estimate Type is PROGRAMMING & PLANNING "Parametric Type"
Quantities listed within the Estimate represent Major Elements of the Project
Estimate Excludes Project Escalation

COMPREHENSIVE STUDY " Bayou Cumbest Environmental Restoration - O & M " SUMMARY

PROJECT:	**Mississippi Coastal Improvement Program "MsCIP"**	ITEM NO.	DATE 25-Jul-08
LOCATION:	**Mississippi**	SHEET NO. 1	OF 1
		PREPARED: Joseph H. Ellsworth	CHECKED: Gary A. Payton
WORK ITEM:	**Bayou Cumbest** ***Replanting 25% of area***	BASIS of ESTIMATE:	Info furnished per Project Delivery Team
	Jackson County ***Years 3 and 5***	FILE NAME:	mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (2 ea)			1	job	allow	$40,000
Re-Plantings	b. 1.0 meter spacing	at year 3	28	acre	28,800	806,400
Re-Plantings	b. 1.0 meter spacing	at year 5	28	acre	28,800	806,400
Monitoring	b. 1.0 meter spacing		5	yrs	7,000	35,000
Misc Site Items			1	ls	allow	10,000
		Current Contract Cost, OCT 07				$1,697,800
		CONTINGENCY		@	**25.0%**	424,450
						$ 2,122,250
		30 Account, Plan, Engr.& Design		@	**8.0%**	169,780
						$ 2,292,030
		31 Account, Constr. Management		@	**6.0%**	137,522
						$ 2,429,552
		ESCALATION		@	**0.0%**	
						$ 2,429,552 rounded
		TOTAL PROJECT COST, OCT 07				**$ 2,400,000**

COMPREHENSIVE STUDY " Bayou Cumbest Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: **Bayou Cumbest** ***Replanting 50% of area*** BASIS of ESTIMATE: info furnished per Project Delivery Team
Jackson County ***in Years 3 and 5*** FILE NAME:
mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION			Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (2 ea)			1	job	allow	$40,000
Re-Plantings	b. 2.0 meter spacing	at year 3	55	acre	14,400	792,000
Re-Plantings	b. 2.0 meter spacing	at year 5	55	acre	14,400	792,000
Monitoring	b. 2.0 meter spacing		5	yrs	7,000	35,000
Misc Site Items			1	ls	allow	10,000
			Current Contract Cost, OCT 07			$1,669,000
		CONTINGENCY		@	**25.0%**	417,250
						$ 2,086,250
		30 Account, Plan, Engr.& Design		@	**8.0%**	166,900
						$ 2,253,150
		31 Account, Constr. Management		@	**6.0%**	135,189
						$ 2,388,339
		ESCALATION		@	**0.0%**	
						$ 2,388,339
						rounded
					TOTAL PROJECT COST, OCT 07	**$ 2,400,000**

COMPREHENSIVE STUDY " Bayou Cumbest Environmental Restoration - O & M " SUMMARY

PROJECT:	**Mississippi Coastal Improvement Program "MsCIP"**	ITEM NO.	DATE 25-Jul-08
LOCATION:	**Mississippi**	SHEET NO. 1	OF 1
		PREPARED: Joseph H. Ellsworth	CHECKED: Gary A. Payton
WORK ITEM:	**Bayou Cumbest** ***Replanting 25% of area***	BASIS of ESTIMATE Info furnished per Project Delivery Team	
	Jackson County ***in Years 3 and 5***	FILE NAME:	
		mscip-comprehensive-study-compbined-cost-est-25jul08.xls	

DESCRIPTION			Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (2 ea)			1	job	allow	$40,000
Re-Plantings	b. 1.0 meter spacing	at year 3	28	acre	28,800	806,400
Re-Plantings	b. 1.0 meter spacing	at year 5	28	acre	28,800	806,400
Monitoring	b. 1.0 meter spacing		5	yrs	7,000	35,000
Misc Site Items			1	ls	allow	10,000
			Current Contract Cost, OCT 07			$1,697,800
		CONTINGENCY		@	**25.0%**	424,450
						$ 2,122,250
		30 Account, Plan, Engr.& Design		@	**8.0%**	169,780
						$ 2,292,030
		31 Account, Constr. Management		@	**6.0%**	137,522
						$ 2,429,552
		ESCALATION		@	**0.0%**	
						$ 2,429,552
						rounded
			TOTAL PROJECT COST, OCT 07			**$ 2,400,000**

COMPREHENSIVE STUDY " Bayou Cumbest Environmental Restoration - O & M " SUMMARY

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: **Bayou Cumbest** ***Replanting 50% of area*** ***Jackson County*** ***in Years 3 and 5***

ITEM NO.
SHEET NO. 1 OF 1
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls
DATE 25-Jul-08

DESCRIPTION			Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (2 ea)			1	job	allow	$40,000
Re-Plantings	b. 2.0 meter spacing	at year 3	55	acre	14,400	792,000
Re-Plantings	b. 2.0 meter spacing	at year 5	55	acre	14,400	792,000
Monitoring	b. 2.0 meter spacing		5	yrs	7,000	35,000
Misc Site Items			1	ls	allow	10,000
			Current Contract Cost, OCT 07			$1,669,000
		CONTINGENCY		@	**25.0%**	417,250
						$ 2,086,250
		30 Account, Plan, Engr.& Design		@	**8.0%**	166,900
						$ 2,253,150
		31 Account, Constr. Management		@	**6.0%**	135,189
						$ 2,388,339
		ESCALATION		@	**0.0%**	
						$ 2,388,339
						rounded
			TOTAL PROJECT COST, OCT 07			**$ 2,400,000**

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 1 OF 2
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Deer Island -Aquatic Ecosystem Restoration*** BASIS of ESTIMATE: info furnished per Project Delivery Team
FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Mobilization, Preparatory Work, Demobilization (Dredge Plant,16")	1	job	allow	$250,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipment)	1	job	allow	150,000
Seaward Shoreline				
Beach Fill, in-place, 16" dia dredge	400,000	cy	3.50	1,400,000
Grade / Shape Berm, small Doser-Trackhoe Work	120	days	4,000	480,000
Environmental Planting	100	ac	45,000	4,500,000
Misc. Site Items	1	ls	allow	16,000
Repair/replace Containment Dike				
Fill, in-place, 16" dia dredge	4,200	cy	3.50	14,700
Grade / Shape Berm, small Doser-Trackhoe Work	120	days	4,000	480,000
Misc. Site Items	1	ls	allow	1,200
Add Material to Containment Area				
Fill, in-place, 16" dia dredge	100,000	cy	3.50	350,000
Grade / Shape Berm, small Doser-Trackhoe Work	15	days	4,000	60,000
Environmental Planting	10	ac	45,000	450,000
Misc. Site Items	1	ls	allow	2,200
Lengthen Stone Containment Dikes				
Analyze Stone Containment Dikes	1	ls	1.00	50,000
Fill, in-place, 16" dia dredge	91,000	cy	3.50	318,500
Grade / Shape Berm, small Doser-Trackhoe Work	30	days	4,000	120,000
Filter Fabric	1,500	sy	3.00	4,500
Riprap	3,000	cy	110.00	330,000
Misc. Site Items	1	ls	allow	2,100
Create Additional Marsh Area				
Beach Fill, in-place, 16" dia dredge	300,000	cy	3.50	1,050,000
Grade / Shape Berm, small Doser-Trackhoe Work	60	days	4,000	240,000
Environmental Planting	20	ac	45,000	900,000
Misc. Site Items	1	ls	allow	5,500
			Subtotal	**$ 11,174,700**

COMPREHENSIVE STUDY " Environmental Restoration " COST ESTIMATE

PROJECT: **Mississippi Coastal Improvements Program "MsCIP"** ITEM NO. DATE 25-Jul-08
LOCATION: **Mississippi** SHEET NO. 2 OF 2
PREPARED: Joseph H. Ellsworth CHECKED: Gary A. Payton
WORK ITEM: ***Deer Island -Aquatic Ecosystem Restoration*** BASIS of ESTIMATE: info furnished per Project Delivery Team
- FILE NAME: mscip-comprehensive-study-compbined-cost-est-25jul08.xls

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Subtotal, brought forward				**$ 11,174,700**
Current Contract Cost, Oct 07				$ 11,174,700
CONTINGENCY		@	**25.0%**	2,793,675
				$ 13,968,375
01 Account, Lands & Damage		PCA	**LS**	25,000
				$ 13,993,375
30 Account, Plan, Engr.& Design		@	**8.0%**	1,119,470
				$ 15,112,845
31 Account, Constr. Management		@	**6.0%**	906,771
				$ 16,019,616
ESCALATION		@	**0.0%**	0
				$ 16,019,616
				rounded
TOTAL PROJECT COST, Oct 07				**$ 16,000,000**

Notes:

Unit Dredge Cost based on Current Dredge Project, Harrison County Beaches, Ms.

Nonstructural Summary Cost (ABFE-2 Level of Protection)									
ECONOMIC REACH	TOTAL PARCELS	ACQUISITION PARCELS	ACQUISITION COST	DEMOLITION COST	RELOCATION PARCELS	RELOCATION COST	FLOOD PROOFING PARCEL	FLOOD PROOFING COST	NONSTRUCTURAL TOTAL
1	1391	997	$187,669,171.88	$6,449,046.00	0	$0.00	394	$101,229,150.00	$295,347,367.88
2	13206	9911	$2,895,031,206.25	$95,757,925.00	1	$392,586.21	3294	$1,566,973,598.33	$4,558,155,315.80
3	2578	2202	$653,107,621.88	$15,583,815.00	0	$0.00	376	$269,175,578.00	$937,867,014.88
4	938	922	$113,922,240.63	$6,385,676.00	0	$0.00	16	$24,642,670.00	$144,950,586.63
5	2833	2714	$232,321,346.88	$6,041,447.00	0	$0.00	119	$64,055,584.00	$302,418,377.88
6	1158	567	$103,859,775.00	$3,433,000.00	1	$8,492,694.34	590	$272,099,608.68	$387,885,078.02
7	682	450	$31,275,743.75	$1,934,430.00	0	$0.00	232	$149,936,910.00	$183,147,083.75
8	5356	3623	$464,556,882.50	$11,531,450.00	3	$25,478,083.02	1730	$573,389,674.75	$1,074,956,090.27
9	60	44	$16,010,782.50	$122,000.00	0	$0.00	16	$13,361,448.00	$29,494,230.50
10	2007	1945	$423,333,807.50	$9,247,426.00	0	$0.00	62	$20,028,706.00	$452,609,939.50
11	8	0	$0.00	$0.00	0	$0.00	8	$1,727,008.00	$1,727,008.00
12	2183	1047	$175,416,295.00	$4,198,530.00	0	$0.00	1136	$361,865,652.75	$541,480,477.75
13	650	650	$578,114,005.00	$5,007,538.00	0	$0.00	0	$0.00	$583,121,543.00
15	94	85	$43,548,305.00	$806,538.00	0	$0.00	9	$22,725,000.00	$67,079,843.00
16	199	78	$16,255,190.00	$144,538.00	0	$0.00	121	$31,715,348.00	$48,115,076.00
18	1507	1502	$398,263,330.00	$11,148,202.00	0	$0.00	5	$1,138,504.00	$410,550,036.00
19	46	46	$292,633,610.00	$94,453.00	0	$0.00	0	$0.00	$292,728,063.00
20	3448	1397	$227,316,640.00	$11,116,442.00	1	$8,492,694.34	2050	$712,073,298.74	$958,999,075.08
21	2527	2108	$294,785,977.81	$7,012,294.00	0	$0.00	419	$157,364,440.99	$459,162,712.81
22	153	61	$25,918,662.50	$412,000.00	0	$0.00	92	$36,587,106.00	$62,917,768.50
23	44	0	$0.00	$0.00	0	$0.00	44	$19,986,176.00	$19,986,176.00
24	398	220	$64,527,300.63	$702,520.00	0	$0.00	178	$47,664,846.00	$112,894,666.63
26	989	37	$9,035,335.94	$175,000.00	0	$0.00	952	$272,934,675.34	$282,145,011.28
27	1082	53	$12,684,943.75	$196,000.00	0	$0.00	1029	$226,725,426.34	$239,606,370.09
28	1083	961	$88,942,778.75	$1,351,918.00	0	$0.00	122	$47,989,150.00	$138,283,846.75
29	315	147	$22,302,837.50	$1,091,991.00	0	$0.00	168	$51,396,802.00	$74,791,630.50
30	557	90	$28,802,550.00	$656,453.00	0	$0.00	467	$160,944,119.00	$190,403,122.00
31	498	51	$14,626,215.31	$320,614.00	0	$0.00	447	$168,990,104.00	$183,936,933.31
32	209	1	$216,228.13	$0.00	0	$0.00	208	$51,710,800.00	$51,927,028.13

Non-Structural Costs - NS_ABFE-2_bReach_Consise_200710

Nonstructural Summary Cost (ABFE-2 Level of Protection)									
ECONOMIC REACH	TOTAL PARCELS	ACQUISITION PARCELS	ACQUISITION COST	DEMOLITION COST	RELOCATION PARCELS	RELOCATION COST	FLOOD PROOFING PARCEL	FLOOD PROOFING COST	NONSTRUCTURAL TOTAL
35	1418	12	$636,228.13	$46,000.00	0	$0.00	1406	$350,816,536.00	$351,498,764.13
36	34	32	$3,761,409.38	$73,076.00	0	$0.00	2	$5,050,000.00	$8,884,485.38
38	128	50	$20,859,328.13	$565,538.00	0	$0.00	78	$15,883,024.00	$37,307,890.13
39	6	0	$0.00	$0.00	0	$0.00	6	$991,302.00	$991,302.00
43	1	0	$0.00	$0.00	0	$0.00	1	$170,304.00	$170,304.00
48	2	0	$0.00	$0.00	0	$0.00	2	$366,298.00	$366,298.00
50	1343	495	$87,303,122.50	$1,944,538.00	0	$0.00	848	$215,363,629.00	$304,611,289.50
51	786	0	$0.00	$0.00	0	$0.00	786	$267,859,601.33	$267,859,601.33
52	7124	285	$100,808,144.06	$2,143,067.00	1	$8,492,694.34	6838	$1,966,832,623.52	$2,078,276,528.93
53	759	399	$111,009,291.56	$2,006,043.00	0	$0.00	360	$204,582,670.00	$317,598,004.56
54	817	9	$1,048,409.06	$66,453.00	0	$0.00	808	$327,127,401.50	$328,242,263.56
Total	**58617**	**33191**	**$7,739,904,716.91**	**$207,765,961.00**	**7**	**$51,348,752.25**	**25419**	**$8,783,474,774.27**	**$16,782,494,204.46**

COST APPENDIX

PART 2

PART 2

RECOMMENDED ALTERNATIVES

Part 2 of the Cost Appendix contains updated cost estimates for the recommended alternatives in the Comprehensive Plan and Integrated Programmatic Environmental Impact Statement. Selected structural and environmental options included in the Engineering Appendix and Part 1 of the Cost Appendix were used as the basis for the selected alternatives. All recommended alternatives other than the Homeowners Assistance Relocation Program (HARP) have Total Projects Cost Summaries included herein. Part 2 also includes an Escalation Derivations Chart used for the updated costs, Gnatt charts with brief project descriptions, and results of a Cost Risk Analysis completed for the Barrier Island Restoration Plan. The HARP is a program based on purchase of 1800 to 2000 properties in coastal Mississippi out of 17,000 that were identified as being in high hazard areas. These 17,000 properties were identified in the "Preliminary Estimate of Project Cost for the Floodproofing of Residential Structures" and is based on a price level equivalent to 1 October, 2007. This document is also included. The costs for the structural and environmental alternatives were completed by Mobile District and the costs for the nonstructural alternatives were completed by Huntington District.

TOTAL PROJECT **** TOTAL PROJECT COST SUMMARY ****

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Barier Islands DISTRICT: MOBILE

LOCATION: Mississippi Coastal Barrier Islands P.O.C.: Joseph H. Ellsworth

ACCOUNT NUM	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... COST ($K)	CNTG ($K)	FULL ($K)
17---	BEACH REPLENISHMENT (Barrier Islands) ***(Barrier Islands)***	326,279,000	107,543,280	33%	433,822,280	326,279,000	107,543,280	433,822,280	353,465,241	116,490,463	469,955,704
30---	PLANNING, ENGINEERING & DESIGN	13,051,160	4,301,731	33%	17,352,891	13,051,160	4,301,731	17,352,891	13,490,461	4,448,199	17,938,660
31---	CONSTRUCTION MANAGEMENT	19,576,740	6,452,597	33%	26,029,337	19,576,740	6,452,597	26,029,337	21,207,914	6,989,428	28,197,342
	TOTAL PROJECT COST =======>	**358,906,900**	**118,297,608**		**477,204,508**	**358,906,900**	**118,297,608**	**477,204,508**	**388,163,616**	**127,928,090**	**516,091,706**

rounded

100% TOTAL FEDERAL COSTS ============> **$516,000,000**

0% TOTAL NON - FEDERAL COSTS ======>

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

**** TOTAL CONTRACT COST SUMMARY ****

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Barier Islands

DISTRICT: MOBILE

LOCATION: Mississippi Coastal Barrier Islands

P.O.C.: Joseph H. Ellsworth

ACCOUNT No.	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
	Contract 1													
17---	DREDGING (Hopper)	183,829,000	58,825,280	32%	242,654,280	0.0%	183,829,000	58,825,280	242,654,280	Apr 12	7.9%	198,351,491	63,472,477	261,823,968
30---	PLANNING, ENGINEERING & DESIGN, 4%	7,353,160	2,353,011	32%	9,706,171	0.0%	7,353,160	2,353,011	9,706,171	Apr 09	1.6%	7,470,811	2,390,659	9,861,470
31---	CONSTRUCTION MANAGEMENT, 6% +-	11,029,740	3,529,517	32%	14,559,257	0.0%	11,029,740	3,529,517	14,559,257	Apr 12	7.9%	11,901,089	3,808,349	15,709,438
	Contract # 1 Subtotal	202,211,900	64,707,808		266,919,708		202,211,900	64,707,808	266,919,708			217,723,391	69,671,485	287,394,876
	Contract 2													
17---	DREDGING (Hopper)	78,350,000	28,206,000	36%	106,556,000	0.0%	78,350,000	28,206,000	106,556,000	Apr 12	7.9%	84,539,650	30,434,274	114,973,924
30---	PLANNING, ENGINEERING & DESIGN, 4%	3,134,000	1,128,240	36%	4,262,240	0.0%	3,134,000	1,128,240	4,262,240	Oct 10	4.7%	3,281,298	1,181,267	4,462,565
31---	CONSTRUCTION MANAGEMENT, 6% +-	4,701,000	1,692,360	36%	6,393,360	0.0%	4,701,000	1,692,360	6,393,360	Apr 12	7.9%	5,072,379	1,826,056	6,898,435
	Contract # 2 Subtotal	86,185,000	31,026,600		117,211,600		86,185,000	31,026,600	117,211,600			92,893,327	33,441,597	126,334,924
	Contract 3													
17---	DREDGING (Hopper)	64,100,000	20,512,000	32%	84,612,000	0.0%	64,100,000	20,512,000	84,612,000	Apr13	10.1%	70,574,100	22,583,712	93,157,812
30---	PLANNING, ENGINEERING & DESIGN, 4%	2,564,000	820,480	32%	3,384,480	0.0%	2,564,000	820,480	3,384,480	Apr 11	6.8%	2,738,352	876,273	3,614,625
31---	CONSTRUCTION MANAGEMENT, 6% +-	3,846,000	1,230,720	32%	5,076,720	0.0%	3,846,000	1,230,720	5,076,720	Apr 13	10.1%	4,234,446	1,355,023	5,589,469
	Contract # 3 Subtotal	70,510,000	22,563,200		93,073,200		70,510,000	22,563,200	93,073,200			77,546,898	24,815,008	102,361,906

Some quantity of high quality sand may be available in the old channel alignment at the west end of West Ship Island. If there is deemed a sufficient quantity of sand to use from this area, this sand could be pumped to areas on the northern shore of West Ship Island that has been included in the areas to be filled near Fort Massachusetts.

West and East Ship Island also have two major historic sites that are in danger from the continuing erosion of the barrier islands. The presence of these historic sites led to the inclusion of the barrier islands off the coast of Mississippi as a National Seashore. Current studies by the Corps indicate that restoring the two islands to a single island, pre-Camille condition may prevent the rapid erosion of the beaches that is now occurring at these sites and aid in the reduction of erosion that is endangering Historic Fort Massachusetts on West Ship Island. The placement of sand on the northern side of West Ship Island under the filling of Camille Cut will be considered a priority to provide protection to the Fort as early as possible in the course of this work. The addition of sheet pile for minimizing erosional loss of the sand during placement will be allowed as long as the sheet pile is removed. It can be assumed that a 2000 foot running length will be used as the fill progresses across the open pass. The transfer of heavy equipment from barges to both of the islands can be done in selected locations where deeper water is close to the existing shorelines.

The pre-Camille footprint of Ship Island was obtained from historical records and this data showed that the island was breached during Hurricane Camille in 1969 forming two separate islands as mentioned above. This breach had been partially filled with a sand spit extending westward from East Ship Island when Hurricane Katrina again opened the breach in 2005. As happened during Hurricane Camille, the new breach was formed leaving two islands with approximately three miles of open water between the remaining portions. West Ship Island has been experiencing severe erosion in some areas because of the loss of sand in the system from the ebb tidal flows through the breach. East Ship Island is also losing land mass as the sand in its system migrates into the breach area. Currents studies (USGS, 2007 and Rosati, 2007) indicate that West and East Ship will probably not recover from their current severely eroded state.

The first step in the barrier restoration process would be to fill the three mile breach in Ship Island, Camille Cut, to a 1000-foot width and a height that would require approximately 13-million cubic yards of sand including loss during placement and the re-nourishment of some erosion along the northern shore. The other two measures would be to add sand into the littoral system with about 5-million cubic yards going into the area east of East Ship Island and the rest (4-million cubic yards) going to the area east of Petit Bois Island. Placing more sand at Ship Island is assumed because of the accelerated erosion that has taken place there. The quantities of material assumed for the littoral placements would be subject to change after additional sediment transport modeling if this modeling indicates this adjustment.

West Ship has migrated westward along the littoral drift zone with the western end of the island now terminating against the deep-water, Gulfport navigation channel that prevents further drift. Studies (Rosati, 2007) have confirmed that West Ship Island is the last active island system in the littoral zone that originates in northwest Florida. The same type of land loss exists for Petit Bois Island where the east end is migrating westward and the western end is now terminated against the Pascagoula navigation channel. Records indicate that over 22 million cubic yards of sediment have been removed for maintenance from the Pascagoula Channel since it was created. This quantity of sand was used as the basis of adding sand back into the littoral system since, theoretically, this sand would have continued its transport

Estimated by	CESAM-EN-E, Cost Engineering Branch
Designed by	CESAM-EN-E, Mobile District, Corps of Engineers
Prepared by	Joseph Ellsworth
Preparation Date	8/14/2008
Effective Date of Pricing	8/14/2008
Estimated Construction Time	Days

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report file: barrier islands-feasibilty-report.mrp

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along the littoral system. Three measures were adopted to return this sand into the system.

Price Level July 08
FEASIBILITY STUDY

Estimated by	CESAM-EN-E, Cost Engineering Branch
Designed by	CESAM-EN-E, Mobile District, Corps of Engineers
Prepared by	Joseph Ellsworth
Preparation Date	8/14/2008
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Date	Author	Note
	Joseph H. Ellsworth	The addition of sand into the littoral system on the eastern ends of East Ship and Petit Bois Islands will provide a sediment source for the islands and help mitigate any affects from the maintenance of the navigation channels. The additional sediment transport modeling will include modeling to predict the optimal location for the placement of sand into the littoral zone near the islands to provide a source of sand for the natural healing on the breach. The quantity of sand required for these options are considerably less than the total restoration of the islands, but still substantial. To fill the breach, the sand would have strict requirements on color, grain size, and roundness. In discussions with the USGS, a potential source of sand was identified at St. Bernard Shoals which is a submerged chain of barrier islands approximately 45 miles south of the Mississippi barrier islands. Both quality and quantity are assumed to be available, but further investigations are required to verify the source. Activity from oil and gas production in the local area must also be considered. As described above approximately 13,000,000 cubic yards of the high quality sand are needed to fill the breach. An additional 5,000,000 cubic yards of sand is being proposed for placement into the littoral zone east of East Ship Island. This sand would still have physical compatibility characteristics to the sand in the littoral system that must be considered. The last measure of the plan would be to add approximately 4,000,000 cubic yards of compatible sand into the littoral zone east of Petit Bois Island. The source of this sand is also proposed to be from the St. Bernard Shoals. The placement of sand to fill Camille Cut and the two large littoral zone placements are planned as one-time events to restore some of the islands land surface that may have been lost to erosion from mans past activities or from mass erosion during storm events. This decision was based on an agreement with the NPS that allows them to mitigate ay damage from mans activities or to perform necessary means to preserve historic sites. This agreement has a positive aspect to MsCIP with the replacement of sand that has been lost from the littoral system. This sand addition will extend the life of the islands and the closure of Camille Cut will help maintain the boundaries of the estuary. It is understandably difficult to quantify either of these sand loss causes because the barrier islands themselves are dynamic systems that are undergoing constant change. The detailed cost estimate will be based as follows: Barrier Island Comprehensive Plan Cost Items Contract 1: Fill Camille Cut by Direct Placement – 13,000,000 cy (10,200,000 cy measured in place in place with estimated 30% loss during handling) placed to create a 1,000 foot wide fill for the existing breach with 60-foot wide swath of plantings along both shores (477,500 total plants). Source of sand borrow from St. Bernard Shoals. Assume using 2,000 running feet of sheet pile to add placement. See LOD-1, Option G in the Engineering Appendix. Award Jan 2010 Period of Performance – 4 years Contract 2 Little Dog Keys Pass Littoral Placement – 5,000,000 cy (measured in the dredge hopper) placed in an area approximately 1.5 square miles in up to 5 foot lift. Source of sand borrow from St. Bernard Shoals. See LOD-1, Option C1 in the Engineering Appendix. Award Jan 2011 Period of Performance – 2 years Contract 3 Petit Bois Island Littoral Placement – 4,000,000 cy (measured on the barges) placed in one area of approximately 2 square miles in up to a 3 foot lift. Source of sand borrow from St. Bernard Shoals. See LOD-1, Option C2 in the Engineering Appendix for quantities, but the source area has changed as indicated above. Award Jan 2012 Period of Performance – 2 years
7/28/2008	Joseph H. Ellsworth	BASIS of COST ESTIMATE and RATIONALE Feasibility Estimate is based on Historical Data, Recent Pricing, and Estimator's Judgment. Estimate is structured and priced as a general prime dredging contractor. Anticipated bidding conditions and construction duration with reasonable schedules are considered Normal. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Current Contract Cost (price level Aug 08).

Date	Author	Note

Project Life is assumed as 50 years in Cost Estimate.

17 Feature Account, Beach Replenishment (Barrier Islands) - was developed using CEDEP. Reference CEDEP for Cost Derivation.

30 Feature Account, Planning, Engineering & Design was developed and assigned at 4% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Eight percent was used in the Interim MsCIP projects which was reviewed and approved and included in the Chief's Report.

31 Feature Account, Construction Management was developed and assigned at 6% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Six percent was used in the Interim MsCIP projects which was reviewed & approved and included in the Chief's Report.

Contingency was jointly developed and assigned by the Project Delivery Team. The Contingency percentage at 33% (80% confidence level) weighted average reflects the possibility of changes in quantity estimates and unknowns associated with the unit price. The contingency factor used is different for each contract. A risk analysis was performed by Walla Walla District for each contract within project. A risk analysis report is included in maint report.

Markups for subcontractors are included in the unit prices and include such items as field overheads, home office expenses, profit, bond and insurance.

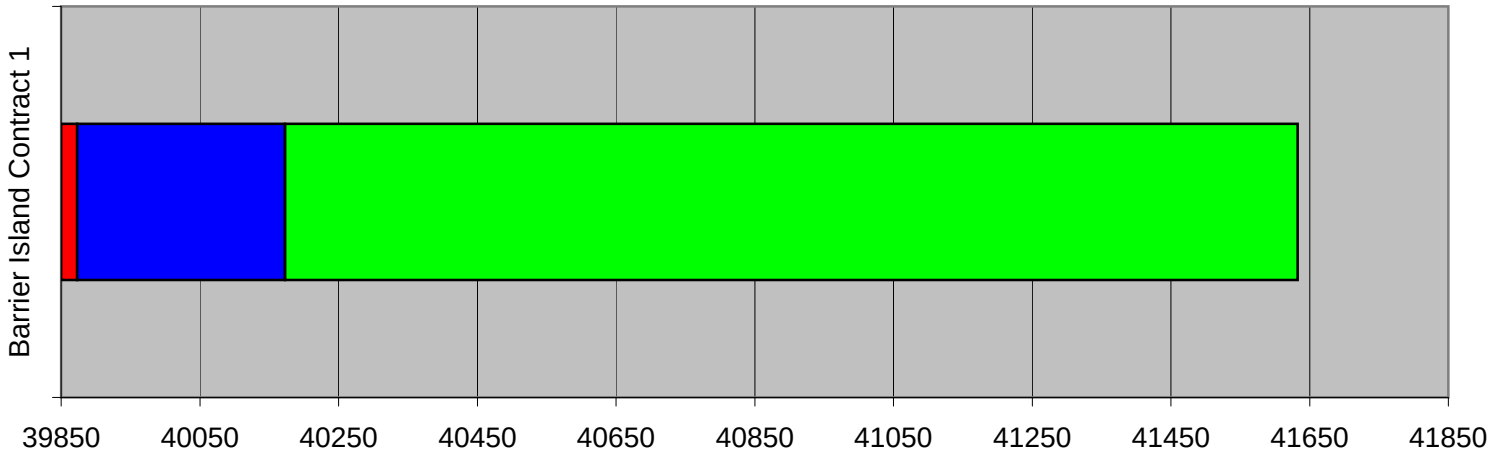
Mobilization & Demobilization are derived within the CEDEP estimates.

Unit Prices, for such items as closure piling and planting is based on Historical Data, Recent Pricing, Estimator’s Judgment, and Cost derivation using MCACES / MII estimating systems.

Description	Quantity	UOM	ContractCost
Contract Cost Summary Report			**326,279,000**
			14.14
01 Contract 1 - Fill Camille Cut by Direct Placement	**13,000,000.00**	**CY**	**183,829,000**
(Note: SCOPE OF WORK Contract 1: Fill Camille Cut by Direct Placement – 13,000,000 cy (10,200,000 cy measured in place in place with estimated 30% loss during handling) placed to create a 1,000 foot wide fill for the existing breach with 60-foot wide swath of plantings along both shores (477,500 total plants). Source of sand borrow from St. Bernard Shoals. Assume using 2,000 running feet of sheet pile to add placement. See LOD-1, Option G in the Engineering Appendix. Award Jan 2010 Period of Performance – 4 years CONTRACT NO. 1 FILL CAMILLE CUT CONNECTING WEST AND EAST SHIP ISLANDS Work will commence January 2010. The work will be scheduled for 4 years. The material will be obtained by hopper dredge from the St. Bernard shoals some 45 miles to the south. The material will be transported to the -30 contour and pumped into the work area. Small dozer equipment will be required to shape the material above water. A template 1000 feet wide for the full length of the closure will be established and the Contractor shall be paid in increments completed placement. Approximately 3,250,000 c.y. of material will be placed each year. Sheet pile will be required to secure the end of a placement at the end of each year. Assume that you purchase and install 60,000 square feet of sheet pile at the end of year 1. At the start of year 2 you must recover the 60,000 square feet and store the material. Assume 10 percent or 6,000 square feet must be replaced. At the end of year 2, Install 60,000 square feet of sheet pile. At the beginning of year 3, recover 60,000 SF of sheet pile. Assume 10 percent or 6,000 SF of sheet pile must be replaced. At the end of year 3 install 60,000 SF of sheet pile. At the beginning of year 4 recover 60,000 SF of sheet pile and salvage or discard. Summary---- Purchase 72,000 SF of sheet pile. Install 180,000 SF of sheet pile. Recover 180,000 SF of sheet pile. Fill quantity is 13,000,000 c.y. Plant 477,500 sea oats on the created surface Assume 1major mob and demob and 3 intermediate mob and demob.)			
17 Federal Costs	**1.00**	**LS**	**183,829,000**
			14.14
017 Beach Replenishment Dredging	**13,000,000.00**	**CY**	**183,829,000**
Mobilization, Demobilization, Preparatory Work	**1.00**	**LS**	**13,800,000**
(Note: Reference CEDEP for Cost Derivation. Mob / Demob to and from job (1 initial mob/demob plus three intermediate mob/demob equal 4 events).)			
			950,000.00
USR Mob & Demob - Marine Equipment	4.00	EA	3,800,000
(Note: Cost from CEDEP.)			
USR Mob & Demob - Land Base Equipment	4.00	LS	10,000,000
(Note: Cost from CEDEP. Land based equipment includes dosers, marshbuggies, backhoe, crane for piling, light plant, etc.)			
			12.64
Hopper Dredging	**13,000,000.00**	**CY**	**164,350,000**
(Note: Referenc CEDEP for Cost Derivation.)			
			12.25
USR Sand Borrow (by Hopper Dredge)	13,000,000.00	CY	159,250,000
(Note: Referenc CEDEP for Cost Derivation.)			
			10,000.00
USR Grading & Shaping	390.00	ACR	3,900,000
(Note: Land base Equipment, Marshbuggies, dosers, ect. Unit Cost base on Historical data.)			
			200,000.00
USR GIS Support During Construction	4.00	YR	800,000
			100,000.00
USR Control & Placement Surveys	4.00	YR	400,000
(Note: Survey Cost base on historical cost from Operation Field Office.)			
Beach & Dune Planting	**1.00**	**LS**	**1,719,000**
			3.00
USR Sea Oats	573,000.00	EA	1,719,000
(Note: Plants are planted in a 60 foot swath at 30 in centers along shores at the newly created 1,000 foot wide fill. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 477,500 plants plus 20% replacement			

Description	Quantity	UOM	ContractCost
= 573,000 plants. Material price fob job site @ $1.12/ea, Fertilizer @0.10/ea, Labor Cost @ $1.25/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.99/plant. Use $3.00 / plant.)			
Temporary Breach Closure	**1.00**	**LS**	**3,960,000**
			22.00
USR Temporary Sheet Pile Closure	180,000.00	SF	3,960,000
(Note: Assume that you purchase and install 60,000 square feet of sheet pile at the end of year 1. At the start of year 2 you must recover the 60,000 square feet and store the material. Assume 10 percent or 6,000 square feet must be replaced. At the end of year 2, Install 60,000 square feet of sheet pile. At the beginning of year 3, recover 60,000 SF of sheet pile. Assume 10 percent or 6,000 SF of sheet pile must be replaced. At the end of year 3 install 60,000 SF of sheet pile. At the beginning of year 4 recover 60,000 SF of sheet pile and salvage or discard. Summary----Purchase 72,000 SF of sheet pile. Install 180,000 SF of sheet pile. Recover 180,000 SF of sheet pile.)			
			15.67
02 Contract 2 - Little Dog Key Pass Littoral Placement by Direct Placement	**5,000,000.00**	**CY**	**78,350,000**
(Note: SCOPE OF WORK Contract 2 Little Dog Keys Pass Littoral Placement – 5,000,000 cy (measured in the dredge hopper) placed in an area approximately 1.5 square miles in up to 5 foot lift. Source of sand borrow from St. Bernard Shoals. See LOD-1, Option C1 in the Engineering Appendix. Award Jan 2011 Period of Performance – 2 years CONTRACT NO. 2 FILL 1.5 SQUARE MILE AREA OFFSHORE OF EAST SHIP ISLAND LITTLE DOG KEYS PASS Work will commence January 2011. The work will be scheduled for 2 years. The material will be obtained by hopper dredge from the St. Bernard shoals some 45 miles to the south. The material will be transported to the -30 contour and pumped into the work area. The template crest will remain below water and no shaping of the material will be required. Approximately 2,500,000 c.y. of material will be placed each year. No other effort is required for this project. Summary----Fill 5,000,000 c.y.)			
17 Federal Costs	**1.00**	**LS**	**78,350,000**
			15.67
017 Beach Replenishment Dredging	**5,000,000.00**	**CY**	**78,350,000**
Mobilization, Demobilization, Preparatory Work	**1.00**	**LS**	**1,500,000**
(Note: Reference CEDEP for Cost Derivation. Mob / Demob to and from job (1 initial mob/demob plus one mob/demob equal 2 events).)			
			750,000.00
USR Mob & Demob - Marine Equipment	2.00	EA	1,500,000
(Note: Cost from CEDEP.)			
			15.37
Hopper Dredging	**5,000,000.00**	**CY**	**76,850,000**
(Note: Referenc CEDEP for Cost Derivation.)			
			15.25
USR Sand Borrow (by Hopper Dredge)	5,000,000.00	CY	76,250,000
(Note: Referenc CEDEP for Cost Derivation.)			
			200,000.00
USR GIS Support During Construction	2.00	YR	400,000
			100,000.00
USR Control & Placement Surveys	2.00	YR	200,000
(Note: Survey Cost base on historical cost from Operation Field Office.)			
			16.03
03 Contract 3 - Petit Bois Island Littoral Placement	**4,000,000.00**	**CY**	**64,100,000**
(Note: SCOPE OF WORK Contract 3 Petit Bois Island Littoral Placement – 4,000,000 cy (measured on the barges) placed in one area of approximately 2 square miles in up to a 3 foot lift. Source of sand borrow from St. Bernard Shoals. See LOD-1, Option C2 in the Engineering Appendix for quantities, but the source area has changed as indicated above. Award Jan 2012 Period of Performance – 2 years CONTRACT NO. 3 FILL 2 SQUARE MILE AREA OFFSHORE EAST OF PETIT BOIS ISLAND Work will commence January 2012. The work will be scheduled for 2 years. The material will be obtained by hopper dredge from the St. Bernard shoals some 45 miles to the south. The material will be transported to the -30 contour and pumped into the work area. The template crest will remain below water and no shaping of the material will be required. Approximately 2,000,000 c.y. of material will be placed each year. No other effort is required for this project. Summary----Fill 4,000,000 c.y.)			
17 Federal Costs	**1.00**	**LS**	**64,100,000**

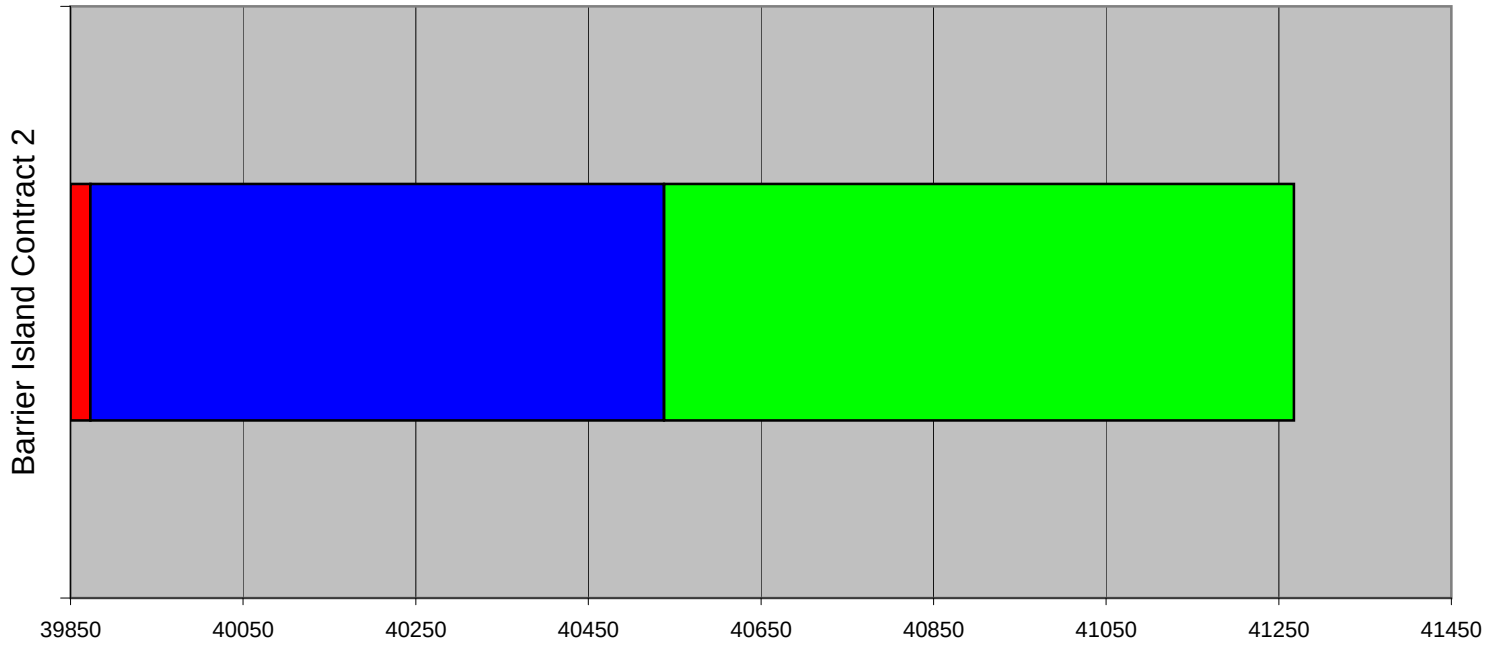
Description	Quantity	UOM	ContractCost
			16.03
017 Beach Replenishment Dredging	**4,000,000.00**	**CY**	**64,100,000**
Mobilization, Demobilization, Preparatory Work	**1.00**	**LS**	**1,500,000**
(Note: Reference CEDEP for Cost Derivation. Mob / Demob to and from job (1 initial mob/demob plus one mob/demob equal 2 events).)			
			750,000.00
USR Mob & Demob - Marine Equipment	2.00	EA	1,500,000
(Note: Cost from CEDEP.)			
			15.65
Hopper Dredging	**4,000,000.00**	**CY**	**62,600,000**
(Note: Referenc CEDEP for Cost Derivation.)			
			15.50
USR Sand Borrow (by Hopper Dredge)	4,000,000.00	CY	62,000,000
(Note: Reference CEDEP for Cost Derivation.)			
			200,000.00
USR GIS Support During Construction	2.00	YR	400,000
			100,000.00
USR Control & Placement Surveys	2.00	YR	200,000
(Note: Survey Cost base on historical cost from Operation Field Office.)			



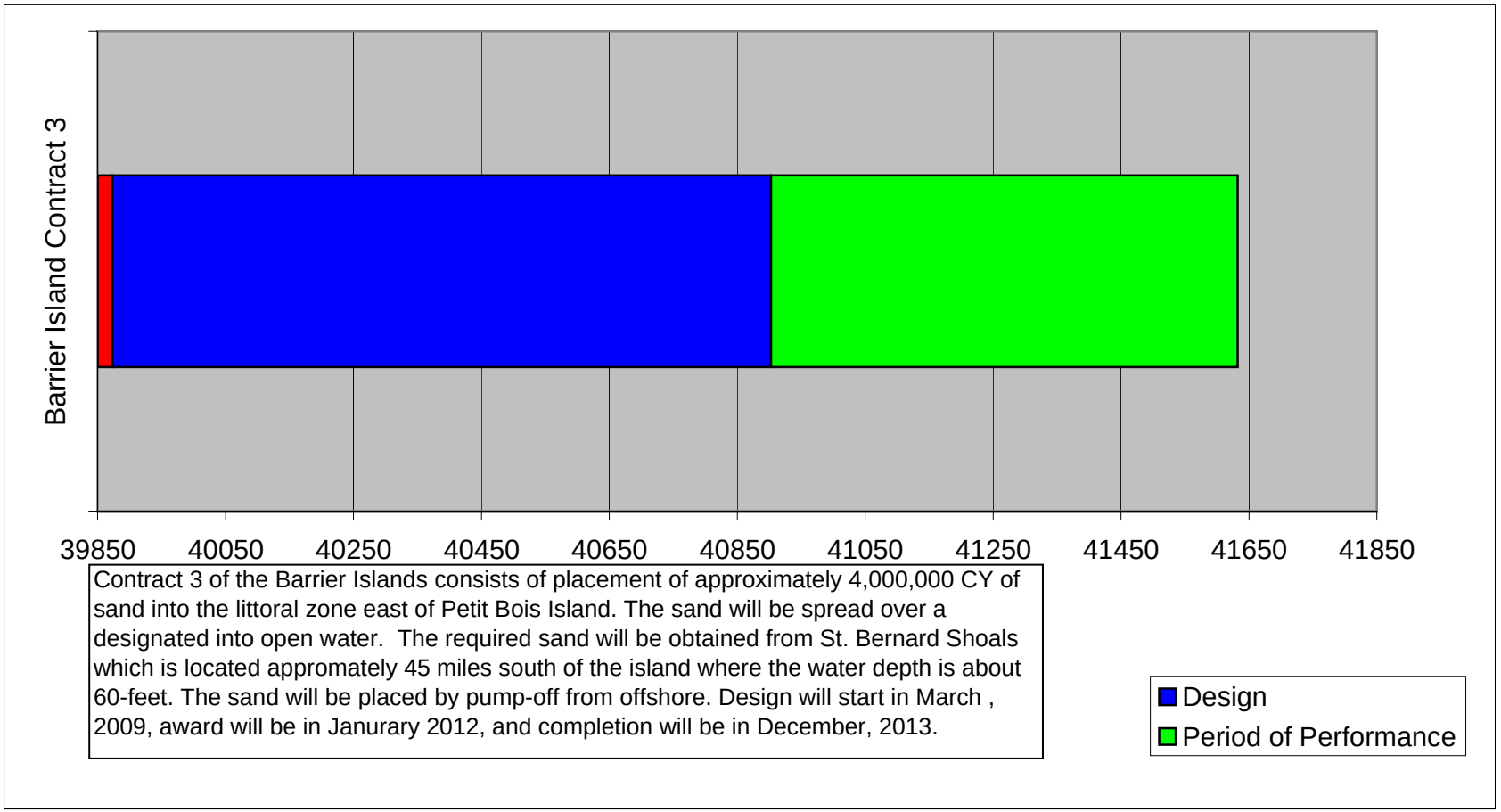
Contract 1 of the Barrier Islands consists of direct placement of approximately 13,000,000 CY of sand to fill the breach in Ship Island known as Camille Cut and along the north shore of the existing land surface. All of the constructed beach will be planted with a 60-foot wide swath of sea oats. The required sand will be obtained from St. Bernard Shoals which is located appromately 45 miles south of the island where the water depth is about 60-feet. The sand will be placed by pump-off from offshore. Design will start in March , 2009, award will be in Janurary 2010, and completion will be in December, 2011.

Design

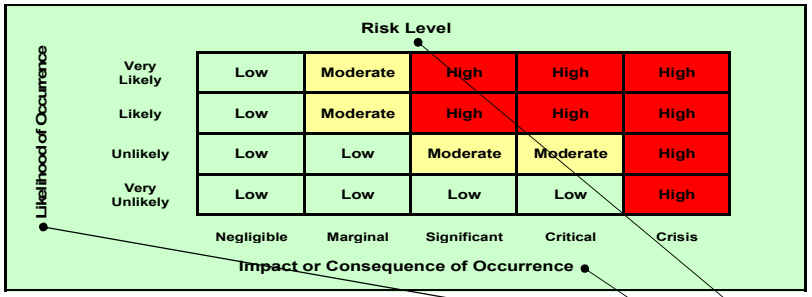
Period of Performance



Contract 2 of the Barrier Islands consists of placement of approximately 5,000,000 CY of sand into the littoral zone between Ship and Horn Island. The sand will be spread over a designated into open water. The required sand will be obtained from St. Bernard Shoals which is located appromately 45 miles south of the island where the water depth is about 60-feet. The sand will be placed by pump-off from offshore. Design will start in March , 2009, award will be in Janurary 2011, and completion will be in January, 2012.


Barrier Island Contract 3
39850
40050
40250
40450
40650
40850
41050
41250
41450
41650
41850
Contract 3 of the Barrier Islands consists of placement of approximately 4,000,000 CY of sand into the littoral zone east of Petit Bois Island. The sand will be spread over a designated into open water. The required sand will be obtained from St. Bernard Shoals which is located appromately 45 miles south of the island where the water depth is about 60-feet. The sand will be placed by pump-off from offshore. Design will start in March , 2009, award will be in Janurary 2012, and completion will be in December, 2013.
Design
Period of Performance

MsCIP Barrier Island Restoration - PDT Risk Register (Draft)



Risk No.	Risk/Opportunity Event	Discussion and Concerns	Project Cost				Project Schedule				Variance Distribution	Correlation to Other(s)	Responsibility/POC	Affected Project Component	Project Implications
			Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)					
	Internal Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)														
I-1	Project competing with other programs	Project competing with other programs (CG funds) in other geographic locations, such as New Orleans, East Coast, and elsewhere.	Very Likely	Critical	High		Very Likely	Critical	High		Uniform	I-2, E-3, E-4	Project Mgr.	Project Schedule	Cost & Schedule
I-2	Project Schedule in question	Assumed funding received in emergency stimulus supplemental. However, still have 1.5 years before actual work can begin. Could be affected by COE receipt of funding as well at KTR's ability and availability to execute.	Likely	Significant	High		Likely	Critical	High		Triangular	I-1, I-6, I-16, E-4	Project Mgr.	Project Schedule	Cost & Schedule
I-3	Pressure to deliver project on accelerated schedule	Project is critical -- sponsor pressure to complete as soon as possible.	Likely	Marginal	Moderate		Likely	Marginal	Moderate		Triangular		Project Mgr.	Project Schedule	Cost & Schedule
I-4	Acquisition Strategy	PDT does not have a finalized strategy on contract type (IDIQ, rental-hour, etc.). However, confident that it will go full and open, sealed bid.	Unlikely	Marginal	Low		Unlikely	Marginal	Low		Uniform	I-6	Contracting	Project Cost & Schedule	Cost & Schedule
I-5	Validation of borrow sources (quality of material)	Still awaiting final sample results, indicating quality and suitability of material at all sites.	Unlikely	Significant	Moderate		Unlikely	Significant	Moderate		Triangular	I-6	Civil Design	Contract Cost & Schedule	Cost & Schedule
I-6	Identification of closer sources of material	Possible source 4-5 miles offshore. Otherwise, will have to rely on source that is significantly further away (45+ miles).	Likely	Significant	High		Likely	Significant	High		Triangular	I-2, I-4, I-5, I-12, I-16, I-17, E-1	Civil Design	Contract Cost & Schedule	Cost & Schedule
I-7	In-water pipeline conflicts	There are existing underground/in-water pipelines in the area. They will have to be mapped by geo-hazard survey. Could present challenges to KTR (depth concerns, esp. as related to weather).	Unlikely	Significant	Moderate		Unlikely	Significant	Moderate		Triangular	I-9	Civil Design	Contract Cost & Schedule	Cost & Schedule
I-8	Environmental work windows (turtle nesting periods)	Rigid windows established in the region that forbid operations during certain periods of the year.	Unlikely	Marginal	Low		Unlikely	Marginal	Low		Triangular		Planning/Environmental	Contract Cost & Schedule	Cost & Schedule
I-9	Incomplete data and surveys	The plan is currently based on worst case scenario, in terms of the source locations. More data could identify more favorable scenarios.	Likely	Significant	High		Likely	Significant	High		Triangular	I-7	Civil Design	Contract Cost & Schedule	Cost & Schedule
I-10	Historical sites	NPS owned and operated historical sites, located on Ship Islands (Contract 1). Design of project has taken into consideration to preserve these resources.	Very Unlikely	Significant	Low		Very Unlikely	Significant	Low		Triangular		Planning/Archaeology	Contract Cost & Schedule	Cost & Schedule
I-11	Endangered species	Gulf sturgeon and piping plover in the area. COE has begun consultation regarding issues. Design has accounted for issues to mitigate these concerns.	Unlikely	Significant	Moderate		Unlikely	Significant	Moderate		Triangular		Planning/Environmental	Contract Cost & Schedule	Cost & Schedule
I-12	Supplemental NEPA document	Will draft a supplemental NEPA document after borrow sites are identified.	Unlikely	Marginal	Low		Unlikely	Marginal	Low		Triangular	I-6	Project Mgr.	Contract Cost & Schedule	Cost & Schedule

I-13	Level of review assumed	PDT has already anticipated HQ level review required. Therefore, risk of unanticipated higher level reviews is mitigated.	Likely	Negligible	Low		Likely	Negligible	Low		Triangular		Project Mgr.	Project Schedule	Schedule
I-14	Sites in National Parks	Sites are in National Parks, but NPS is a partner in this program.	Very Unlikely	Negligible	Low		Very Unlikely	Negligible	Low		Triangular		Project Mgr.	Contract Cost & Schedule	Cost & Schedule
I-15	EIS not complete	EIS not complete. Also, there are other studies that have not been completed regarding geotechnical data and benthic studies.	Very Likely	Negligible	Low		Very Likely	Negligible	Low		Triangular		Project Mgr.	Project Schedule	Schedule
I-16	Construction schedules	Unforeseen or competing events (such as storms or emergencies) could impact schedule for contractors to complete the work as planned and schedules.	Likely	Marginal	Moderate		Likely	Significant	High		Triangular	I-6, I-17	Cost Engr.	Contract Schedule	Schedule
I-17	Dredge methodology	Estimate currently assumes that the work under Contract 1 will be performed by the Glen Edwards. The number of dredges and crew would increase significantly if this is not true.	Likely	Significant	High		Likely	Significant	High		Uniform	I-6, I-16, E-1	Cost Engr.	Contract Cost & Schedule	Cost & Schedule
	External Risks (External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)														
E-1	Limited number of contractors available to bid on Contract 1	Only large hopper dredge contractors would be available to bid on Contract 1, as currently configured.	Likely	Significant	High		Likely	Marginal	Moderate		Triangular	I-6, I-17, E-6	Cost Engr.	Contract Cost	Cost
E-2	Unusually severe weather	Risk of severe storms or hurricanes impacting the area.	Likely	Marginal	Moderate		Likely	Significant	High		Uniform		N/A	Contract Schedule	Schedule
E-3	Inadequate incremental (or full) funding	Risk of not receiving planned funding stream amounts or in a timely fashion.	Likely	Marginal	Moderate		Likely	Significant	High		Uniform	I-1, E-4	Project Mgr.	Project Cost & Schedule	Cost & Schedule
E-4	HQ-Level priority changes	Risk of program being tabled or postponed in favor of other programs.	Unlikely	Significant	Moderate		Unlikely	Significant	Moderate		Uniform	I-1, I-2	Project Mgr.	Project Cost & Schedule	Cost & Schedule
E-5	Fuel prices	Risk of continued high or exorbitant increased in fuel costs.	Likely	Significant	High		Likely	Negligible	Low		Triangular		Cost Engr.	Contract Cost	Cost
E-6	Availability of contractors/bid climate	Risk captures risk of competing programs and economic climate limiting competition for bidding on this program.	Unlikely	Significant	Moderate		Unlikely	Significant	Moderate		Uniform	E-1	Cost Engr.	Contract Cost & Schedule	Cost & Schedule

*Likelihood, Impact, and Risk Level to be verified through market research and analysis (conducted by cost engineer).

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.

6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a
7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.

MS Coastal Barrier Islands Risk Summary

Background:

The project delivery team (PDT) conducted the initial risk development meeting on July 31,2008, identifying 23 separate risk items. Of these items, six are identified to be at a High Cost Risk level, nine at a Moderate Cost Risk level, and eight at a Low Cost Risk. In developing the Risk Analysis for the project, the High Cost Risk Items are the focus of attention.

The current scope of the project is to move 22 million yards of sand to restore the Barrier Islands off the coast of Mississippi. A gap in one of the islands will be repaired, additional sand will be placed around a Civil War era fort, and an offshore placement will be made to provide material to naturally wash ashore on the islands. The placement areas are all within a National Park Service (NPS) boundary. USACE and NPS are working together closely on this project and have agreed on the scope and conduct of the work proposed. The project scope and quantity of material to be moved and placed is fixed by agreement with NPS at 22 million yards. Once placed and accepted, the material will not be replenished under this program if damaged.

Risk Register Development:

The estimates prepared for the feasibility study are based on the assumptions that the program will be authorized and receive adequate funding to execute three contracts to complete the project over a 4-year period. The intent is to allow contractors flexibility in schedule to minimize impact to the other normally scheduled dredging activities in the Gulf Region. The borrow source is identified as being approximately 45nm away in the open ocean. Several other closer deposits may be suitable for borrow sources. However, the survey has not been completed to determine the suitability of the sand deposits. The PDT has a high degree of confidence that the other potential areas identified as borrow sources will be suitable for usage. It should be noted that the PDT has developed the project in an attempt to mitigate many of the factors identified within the risk analysis. The high cost risk items identified by the team are:

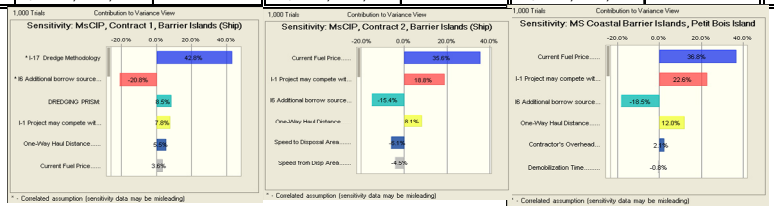
- Project Competing with other Programs
- Project Schedule
- Borrow source location
- Incomplete data and survey
- Dredge Methodology
- Fuel Pricing

In examining these High Cost Risk items (Project Competing with other Programs), Project Schedule risk has been mitigated through the development of the current proposed contract structure and period of performance. The potential for local inflation rates higher than the national average is still of concern with respect to the project schedule. The Borrow Source and survey are interdependent, as the survey will determine the suitability of other borrow sources and are combined to one element for analysis. Dredge Methodology is directly correlated to the borrow source, as the distance to the source will have significant impact on the equipment used. Methodology has the largest impact on the proposed contract for Camille. Fuel price fluctuations are identified within the risk cells embedded into the CEDEP estimate with a range of $4 to $7.

Results:

Overall, the risk profile of the project is approximately 33%. Each of the three contracts was modeled separately, and the totals were summed to determine the overall risk for the project. The sensitivity of each of the contracts showed that the dredge methodology, fuel price, borrow source, and competing projects are the largest contributors to risk.

	MS Coastal Barrier Islands, Camille Cut		MS Coastal Barrier Islands, Little Dog Key		MS Coastal Barrier Islands, Petit Bois Island		Contracts Total	
Estimate Value	$ 159,823,265		$ 77,183,712		$ 61,893,712		$ 298,900,689	
Confidence Level	Value	Contingency	Value	Contingency	Value	Contingency	Value	Contingency
0%	$ 79,659,080	-50%	$51,459,528	-33%	$43,678,348	-29%	$174,796,957	-42%
5%	$ 112,207,908	-30%	$64,097,124	-17%	$52,334,170	-15%	$228,639,201	-24%
10%	$ 120,594,695	-25%	$68,353,330	-11%	$55,531,571	-10%	$244,479,597	-18%
15%	$ 127,189,613	-20%	$72,022,410	-7%	$57,681,945	-7%	$256,893,968	-14%
20%	$ 134,923,638	-16%	$74,357,360	-4%	$59,463,970	-4%	$268,744,968	-10%
25%	$ 140,706,707	-12%	$76,186,275	-1%	$60,732,675	-2%	$277,625,657	-7%
30%	$ 145,307,869	-9%	$78,282,612	1%	$62,202,103	0%	$285,792,584	-4%
35%	$ 150,815,322	-6%	$80,365,616	4%	$63,959,544	3%	$295,140,482	-1%
40%	$ 156,458,134	-2%	$83,128,367	8%	$65,545,824	6%	$305,132,324	2%
45%	$ 161,179,491	1%	$85,992,902	11%	$67,308,142	9%	$314,480,535	5%
50%	$ 165,495,002	4%	$87,913,270	14%	$68,989,461	11%	$322,397,733	8%
55%	$ 171,771,138	7%	$90,552,755	17%	$70,585,665	14%	$332,909,558	11%
60%	$ 177,352,779	11%	$93,566,971	21%	$72,397,194	17%	$343,316,943	15%
65%	$ 183,233,921	15%	$95,912,501	24%	$73,968,858	20%	$353,115,280	18%
70%	$ 193,089,097	21%	$98,255,487	27%	$76,391,987	23%	$367,736,571	23%
75%	$ 200,924,444	26%	$101,227,528	31%	$78,675,008	27%	$380,826,980	27%
80%	$ 211,699,310	32%	$104,947,146	36%	$81,403,285	32%	$398,049,741	33%
85%	$ 230,141,316	44%	$109,516,093	42%	$84,283,115	36%	$423,940,524	42%
90%	$ 259,669,489	62%	$114,742,953	49%	$89,039,651	44%	$463,452,093	55%
95%	$ 302,341,278	89%	$120,777,288	56%	$97,670,653	58%	$520,789,219	74%
100%	$ 387,945,623	143%	$172,245,883	123%	$125,955,954	104%	$686,147,460	130%



TOTAL PROJECT **** TOTAL PROJECT COST SUMMARY ****

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Mainland Beaches & Dunes -Environmental Restoration DISTRICT: MOBILE

LOCATION: Harrison County, Mississippi P.O.C.: Joseph H. Ellsworth

	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08				AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08			.....FULLY FUNDED ESTIMATE.....		
ACCOUNT NUMI	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages	75,000	18,750	25%	93,750	75,000	18,750	93,750	76,950	19,238	96,188
17---	BEACH Replenishment (Environmental Restoration) ***(Mainland Beaches & Dunes)***	16,244,000	4,061,000	25%	20,305,000	16,244,000	4,061,000	20,305,000	17,446,056	4,361,515	21,807,571
30---	PLANNING, ENGINEERING & DESIGN	1,299,520	324,880	25%	1,624,400	1,299,520	324,880	1,624,400	1,333,308	333,327	1,666,635
31---	CONSTRUCTION MANAGEMENT	974,640	243,660	25%	1,218,300	974,640	243,660	1,218,300	1,046,763	261,691	1,308,454
	TOTAL PROJECT COST =======>	**18,593,160**	**4,648,290**		**23,241,450**	**18,593,160**	**4,648,290**	**23,241,450**	**19,903,077**	**4,975,771**	**24,878,848**

rounded

65% **TOTAL FEDERAL COSTS ============>** **$16,185,000**

35% **TOTAL NON - FEDERAL COSTS ======>** **$8,715,000**

TOTAL PROJECT COSTS ============> **$24,900,000**

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Mainland Beaches & Dunes -Environmental Restoration DISTRICT: MOBILE

LOCATION: Harrison County, Mississippi P.O.C.: Joseph H. Ellsworth

ACCOUNT No.	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages (PCA, 3 ea)	75,000	18,750	25%	93,750	0.0%	75,000	18,750	93,750	Apr 09	2.6%	76,950	19,238	96,188
	Subtotal	75,000	18,750		93,750		75,000	18,750	93,750			76,950	19,238	96,188
17---	BEACH Replenishment (Environmental Restoration) ***(Jackson County, Ms)***	1,178,000	294,500	25%	1,472,500	0.0%	1,178,000	294,500	1,472,500	Jan 12	7.4%	1,265,172	316,293	1,581,465
17---	BEACH Replenishment (Environmental Restoration) ***(Harrison County, Ms)***	10,079,000	2,519,750	25%	12,598,750	0.0%	10,079,000	2,519,750	12,598,750	Jan 12	7.4%	10,824,846	2,706,212	13,531,058
17---	BEACH Replenishment (Environmental Restoration) ***(Hancock County, Ms)***	4,987,000	1,246,750	25%	6,233,750	0.0%	4,987,000	1,246,750	6,233,750	Jan 12	7.4%	5,356,038	1,339,010	6,695,048
	Subtotal	16,244,000	4,061,000		20,305,000		16,244,000	4,061,000	20,305,000			17,446,056	4,361,515	21,807,571
30---	PLANNING, ENGINEERING & DESIGN, 8%+-	1,299,520	324,880	25%	1,624,400	0.0%	1,299,520	324,880	1,624,400	Apr 09	2.6%	1,333,308	333,327	1,666,635
31---	CONSTRUCTION MANAGEMENT, 6% +-	974,640	243,660	25%	1,218,300	0.0%	974,640	243,660	1,218,300	Jan 12	7.4%	1,046,763	261,691	1,308,454

Period of Performance – 4 years

Award Date – March 2009

This alternative consists of combining Option K from each of the three counties under LOD-2 which was "60-foot Wide by 2-foot Berm w/ Plants and Fencing" into a single contract. The sand for Jackson & Hancock berm construction will be obtained from inland, commercial sources and will be trucked to the project. Sand for Harrison berm will be by small dredge from near shore borrow. The fencing will wooden dune fencing and will be constructed on both sides of the berm for the entire length. The project will consist of placing the sand into the 60 foot wide by 2-foot high berm, adding the plants on top of the berm on 30-inch centers, then adding the fencing on each side of the planted berm. There will be a one-year warranty for 75% survival rate that is included in the Period of Performance shown below.

Price Level ly Aug 08

FEASIBILITY STUDY

Estimated by	CESAM-EN-E, Cost Engineering Branch
Designed by	CESAM-EN-E, Mobile District, Corps of Engineers
Prepared by	Joseph Ellsworth
Preparation Date	8/14/2008
Effective Date of Pricing	8/14/2008
Estimated Construction Time	Days

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project file:mainland-feasibility-14aug08.mlp

report file: feasibilty standard report.mrp

output file: mainland-feasibility-14aug08.doc

Date	Author	Note

Joseph H. Ellsworth

BASIS of COST ESTIMATE and RATIONALE

Feasibility Estimate is based on Historical Data, Recent Pricing, and Estimator's Judgment. Estimate is structured and priced as a General Prime contractor supported by major subcontractors. Anticipated bidding conditions and construction duration with reasonable schedules are considered Normal. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Current Contract Cost (price level Aug 08). The Non-structural and Real Estate Cost were prepared by the Savannah & Huntington Districts.

Price Level of Estimate is Aug 08.

Project Life is assumed as 50 years in Cost Estimate.

30 Feature Account, Planning, Engineering & Design was developed and assigned at 8% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Eight percent was used in the Interim MsCIP projects which was reviewed and approved and included in the Chief's Report.

31 Feature Account, Construction Management was developed and assigned at 6% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Six percent was used in the Interim MsCIP projects which was reviewed & approved and included in the Chief's Report.

Contingency was jointly developed and assigned by the Project Delivery Team. The Contingency percentage at 25% reflects the possibility of changes in quantity estimates and unknowns associated with the unit price. The contingency factor used does not vary throughout the cost estimate. It was determined and agreed upon by the Project Delivery Team that a high rate be used primarily due to risk, degree of confidence, and the project not being of the normal design.

Markups for subcontractors are included in the unit prices and include such items as field overheads, home office expenses, profit, bond and insurance.

Mobilization Preparatory Work & Demobilization are derived within the estimate generally at 2.5 % +- of construction cost excluding the Misc Items cost. Dredging cost is derived by CEDEP.

Miscellaneous Items represent cost where quantities were not available, such items as signage, construction site/staging restoration, silt fencing, site access, etc. These cost are derived within the estimate at .25 percent (.25%) of construction cost excluding Mob & Demob Cost

Unit Prices, for such items as site work, planting, fencing, etc., were based on Historical Data, Recent Pricing, Estimator's Judgment, and Cost derivation using MCACES / MII estimating systems.

8/5/2008 Joseph H. Ellsworth

Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Where quantities were not available, assumptions were made based on historical information and Estimator's judgment.

Beach & Dune Planting (Sea Oats & Grass) and Fencing are based on recent cost provided by the Local sponsor, Harrison County Public Works, Ms. Quantities were derived

Date	Author	Note

from using historical photographs of the barrier islands and estimating that beach & dune area. The Corps worked with the National Park Service and also the State of Mississippi, Department of Marine Resources in order to come up with this required acre estimates. Sea oats are typically concentrated on the top of the dune and some on the slopes; thus, the team estimated that only approximately 140 plants would be planted per acre.

The following Contractor Markups are applied to the Cost to Prime Direct Cost:

Contractor's Field Overhead @ 12%

Contractor's Home Office (G&A) @ 8%

Profit @ 10%

Bond @ 1.2%

Miss. Gross Receipts Tax @ 3.5%

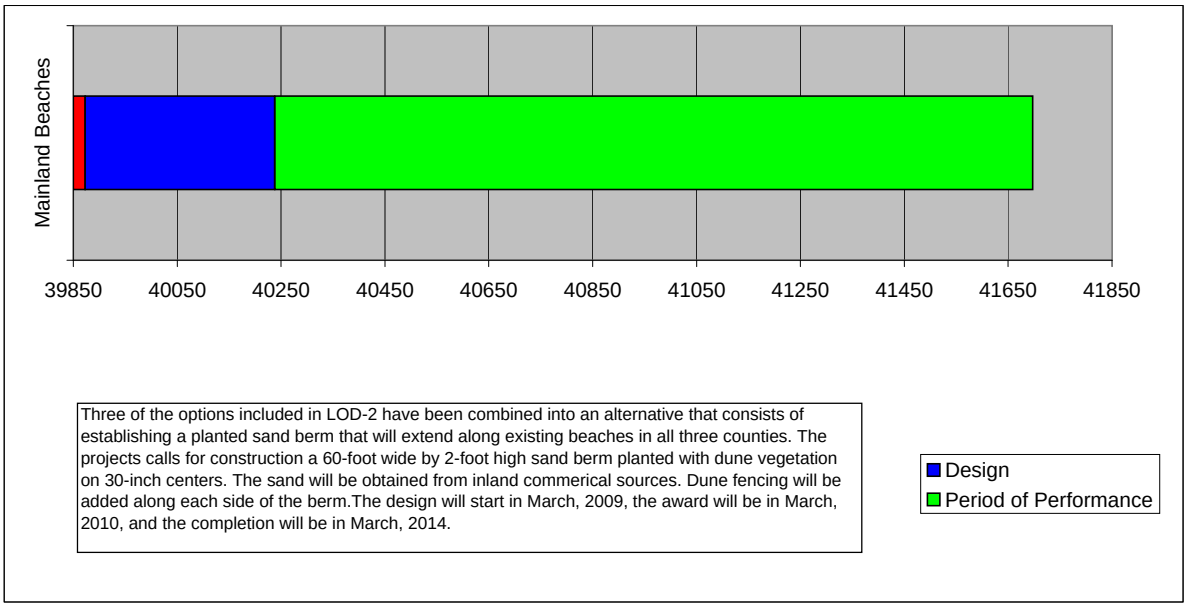
Listed are all Cost Engineering Personnel that worked on the Feasibility Cost Estimate.
Joseph H. Ellsworth, Lead Cost Engineer
Gary Payton, Cost Engineer
George F. Rush, Civil Engineer, Dredging
Michael A. McKown, Geo Tech Engineer
Lloyd Oliver, Structural Engineer
Richard W. Harvey, Mechanical Engineer
John R. Thomas, Real Estate Specialist
Donald A. Whitmore, Civil Engineer- Non-Structural Estimates
Jennifer L. Jacobson, Environmentalist

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
Contract Cost Summary Report			**11,655,510**	**1,398,661**	**1,044,334**	**1,409,850**	**186,100**	**549,306**	**16,243,761**
01 Mainland Beaches - Environmental Restoration	**1.00**	**LS**	**11,655,510**	**1,398,661**	**1,044,334**	**1,409,850**	**186,100**	**549,306**	**16,243,761**
17 Federal & Non-Federal Costs	**1.00**	**LS**	**11,655,510**	**1,398,661**	**1,044,334**	**1,409,850**	**186,100**	**549,306**	**16,243,761**
017 Mainland Beaches & Dunes	**1.00**	**LS**	**11,655,510**	**1,398,661**	**1,044,334**	**1,409,850**	**186,100**	**549,306**	**16,243,761**
01 Jackson County	**1.00**	**LS**	**845,027**	**101,403**	**75,714**	**102,214**	**13,492**	**39,825**	**1,177,677**
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	15,000	1,800	1,344	1,814	240	707	20,905
			9.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*13.59*
USR Construct Sand (dunes), Washed material from Upland Commerical Borrow Site	45,496.00	CY	443,586	53,230	39,745	53,656	7,083	20,906	618,206
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)									
			3.50	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*4.88*
USR Sand (dune) Construction, Grade & Shape	45,496.00	CY	159,236	19,108	14,268	19,261	2,542	7,505	221,920
			1.60	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*2.23*
USR Sea Oats	111,672.00	EA	178,675	21,441	16,009	21,613	2,853	8,421	249,012
(Note: Plants are planted in a 60 foot swath at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 93,060 plants plus 20% replacement = 111,672 plants. Material price fob job site @ $0.28/ea, Fertilizer @0.10/ea, Labor Cost @ $0.90/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $1.55/plant. Use $1.60 / plant.)									
			2.50	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.48*
USR Fencing (both toes)	18,612.00	LF	46,530	5,584	4,169	5,628	743	2,193	64,847
USR Miscellaneous Site Items	1.00	LS	2,000	240	179	242	32	94	2,787
01 Harrison County	**1.00**	**LS**	**7,232,164**	**867,860**	**648,002**	**874,803**	**115,474**	**340,841**	**10,079,143**
USR Mobilization & Demobilization (Dredge Plant)	1.00	LS	290,000	34,800	25,984	35,078	4,630	13,667	404,160
USR Mobilization & Demobilization (Land Base Equipment)	1.00	LS	32,000	3,840	2,867	3,871	511	1,508	44,597
			5.50	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*7.67*
USR Construct Sand (dune), Dredge from near Shore Borrow Site	659,824.00	CY	3,629,032	435,484	325,161	438,968	57,944	171,031	5,057,619
(Note: Unit Price base on recent on-going similar project on Miss Coast project.)									
			1.60	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*2.23*
USR Sea Oats	1,619,570.00	EA	2,591,312	310,957	232,182	313,445	41,375	122,124	3,611,395
(Note: Plants are planted in a 60 foot swath at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 1,349,641 plants plus 20% replacement = 1,619,570 plants. Material price fob job site @ $0.28/ea, Fertilizer @0.10/ea, Labor Cost @ $0.90/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $1.55/plant. Use $1.60 / plant.)									
			2.50	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.48*
USR Fencing (both toes)	269,928.00	LF	674,820	80,978	60,464	81,626	10,775	31,803	940,466
USR Miscellaneous Site Items	1.00	LS	15,000	1,800	1,344	1,814	240	707	20,905
01 Hancock County	**1.00**	**LS**	**3,578,319**	**429,398**	**320,617**	**432,833**	**57,134**	**168,641**	**4,986,942**
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	30,000	3,600	2,688	3,629	479	1,414	41,810
			9.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*13.59*
USR Construct Sand (dunes), Washed material from Upland Commerical Borrow Site	194,578.00	CY	1,897,136	227,656	169,983	229,478	30,291	89,409	2,643,953
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)									
			3.50	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*4.88*
USR Sand (dune) Construction, Grade & Shape	194,578.00	CY	681,023	81,723	61,020	82,377	10,874	32,096	949,111

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
			1.60	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*2.23*
USR Sea Oats	477,600.00	EA	764,160	91,699	68,469	92,433	12,201	36,014	1,064,976
(Note: Plants are planted in a 60 foot swath at 30 in centers. Planted in a 60 foot swath at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 398,000 plants plus 20% replacement = 477,600 plants. Material price fob job site @ $0.28/ea, Fertilizer @0.10/ea, Labor Cost @ $0.90/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $1.55/plant. Use $1.60 / plant.)									
			2.50	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.48*
USR Fencing (both toes)	79,600.00	LF	199,000	23,880	17,830	24,071	3,177	9,379	277,337
USR Miscellaneous Site Items	1.00	LS	7,000	840	627	847	112	330	9,756

Description	Quantity	UOM	SubBidCost	CostToPrime
Project Direct Costs Report			**11,655,510**	**11,655,510**
01 Mainland Beaches - Environmental Restoration	**1.00**	**LS**	**11,655,510**	**11,655,510**
17 Federal & Non-Federal Costs	**1.00**	**LS**	**11,655,510**	**11,655,510**
017 Mainland Beaches & Dunes	**1.00**	**LS**	**11,655,510**	**11,655,510**
01 Jackson County	**1.00**	**LS**	**845,027**	**845,027**
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	15,000	15,000
			9.75	*9.75*
USR Construct Sand (dunes), Washed material from Upland Commerical Borrow Site	45,496.00	CY	443,586	443,586
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)				
			3.50	*3.50*
USR Sand (dune) Construction, Grade & Shape	45,496.00	CY	159,236	159,236
			1.60	*1.60*
USR Sea Oats	111,672.00	EA	178,675	178,675
(Note: Plants are planted in a 60 foot swath at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 93,060 plants plus 20% replacement = 111,672 plants. Material price fob job site @ $0.28/ea, Fertilizer @0.10/ea, Labor Cost @ $0.90/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $1.55/plant. Use $1.60 / plant.)				
			2.50	*2.50*
USR Fencing (both toes)	18,612.00	LF	46,530	46,530
USR Miscellaneous Site Items	1.00	LS	2,000	2,000
01 Harrison County	**1.00**	**LS**	**7,232,164**	**7,232,164**
USR Mobilization & Demobilization (Dredge Plant)	1.00	LS	290,000	290,000
USR Mobilization & Demobilization (Land Base Equipment)	1.00	LS	32,000	32,000
			5.50	*5.50*
USR Construct Sand (dune), Dredge from near Shore Borrow Site	659,824.00	CY	3,629,032	3,629,032
(Note: Unit Price base on recent on-going similar project on Miss Coast project.)				
			1.60	*1.60*
USR Sea Oats	1,619,570.00	EA	2,591,312	2,591,312
(Note: Plants are planted in a 60 foot swath at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 1,349,641 plants plus 20% replacement = 1,619,570 plants. Material price fob job site @ $0.28/ea, Fertilizer @0.10/ea, Labor Cost @ $0.90/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $1.55/plant. Use $1.60 / plant.)				
			2.50	*2.50*
USR Fencing (both toes)	269,928.00	LF	674,820	674,820
USR Miscellaneous Site Items	1.00	LS	15,000	15,000
01 Hancock County	**1.00**	**LS**	**3,578,319**	**3,578,319**
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	30,000	30,000
			9.75	*9.75*
USR Construct Sand (dunes), Washed material from Upland Commerical Borrow Site	194,578.00	CY	1,897,136	1,897,136
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)				
			3.50	*3.50*
USR Sand (dune) Construction, Grade & Shape	194,578.00	CY	681,023	681,023
			1.60	*1.60*
USR Sea Oats	477,600.00	EA	764,160	764,160

Description	Quantity	UOM	SubBidCost	CostToPrime
(Note: Plants are planted in a 60 foot swath at 30 in centers. Planted in a 60 foot swath at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 398,000 plants plus 20% replacement = 477,600 plants. Material price fob job site @ $0.28/ea, Fertilizer @0.10/ea, Labor Cost @ $0.90/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $1.55/plant. Use $1.60 / plant.)				
			2.50	*2.50*
USR Fencing (both toes)	79,600.00	LF	199,000	199,000
USR Miscellaneous Site Items	1.00	LS	7,000	7,000


Mainland Beaches
39850
40050
40250
40450
40650
40850
41050
41250
41450
41650
41850
Three of the options included in LOD-2 have been combined into an alternative that consists of establishing a planted sand berm that will extend along existing beaches in all three counties. The projects calls for construction a 60-foot wide by 2-foot high sand berm planted with dune vegetation on 30-inch centers. The sand will be obtained from inland commerical sources. Dune fencing will be added along each side of the berm.The design will start in March, 2009, the award will be in March, 2010, and the completion will be in March, 2014.
Design
Period of Performance

TOTAL PROJECT **** TOTAL PROJECT COST SUMMARY ****

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Forest Heights Level -Environmental Restoration DISTRICT: MOBILE

LOCATION: Harrison County, Mississippi P.O.C.: Joseph H. Ellsworth

	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08				AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08			.....FULLY FUNDED ESTIMATE.....		
ACCOUNT NUMI	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages	2,674,000	668,500	25%	3,342,500	2,674,000	668,500	3,342,500	2,716,784	679,196	3,395,980
11---	Levees & Floodwalls *(Forest Heights Level)*	7,497,000	1,874,250	25%	9,371,250	7,497,000	1,874,250	9,371,250	7,796,880	1,949,220	9,746,100
30---	PLANNING, ENGINEERING & DESIGN	599,760	149,940	25%	749,700	599,760	149,940	749,700	621,951	155,488	777,439
31---	CONSTRUCTION MANAGEMENT	449,820	112,455	25%	562,275	449,820	112,455	562,275	472,761	118,190	590,951
	TOTAL PROJECT COST =======>	**11,220,580**	**2,805,145**		**14,025,725**	**11,220,580**	**2,805,145**	**14,025,725**	**11,608,376**	**2,902,094**	**14,510,470**

rounded

65% **TOTAL FEDERAL COSTS ============>** **$9,425,000**

35% **TOTAL NON - FEDERAL COSTS ======>** **$5,075,000**

TOTAL PROJECT COSTS ============> **$14,500,000**

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

****** TOTAL CONTRACT COST SUMMARY ******

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Forest Heights Level -Environmental Restoration

DISTRICT: MOBILE

LOCATION: Harrison County, Mississippi

P.O.C.: Joseph H. Ellsworth

	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08					AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT No.	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages (price level, Oct 07)	2,674,000	668,500	25%	3,342,500	0.0%	2,674,000	668,500	3,342,500	Jun 09	1.6%	2,716,784	679,196	3,395,980
	Subtotal	2,674,000	668,500		3,342,500		2,674,000	668,500	3,342,500			2,716,784	679,196	3,395,980
11---	Levees & Floodwalls	7,497,000	1,874,250	25%	9,371,250	0.0%	7,497,000	1,874,250	9,371,250	Jun 09	4.0%	7,796,880	1,949,220	9,746,100
30---	PLANNING, ENGINEERING & DESIGN, 8%+-	599,760	149,940	25%	749,700	0.0%	599,760	149,940	749,700	Jun 10	3.7%	621,951	155,488	777,439
31---	CONSTRUCTION MANAGEMENT, 6% +-	449,820	112,455	25%	562,275	0.0%	449,820	112,455	562,275	Jan 09	5.1%	472,761	118,190	590,951
	Subtotal	8,546,580	2,136,645		10,683,225		8,546,580	2,136,645	10,683,225			8,891,592	2,222,898	11,114,490

The project will also include selective clearing and snagging from the mouth of adjacent Turkey Creek upstream 4.5 miles. Selective clearing and snagging would remove obstructions such as debris dams and excessive sedimentation that hinders the flow through the Turkey Creek channel. The main purpose of the selective clearing and snagging is to make sure that induced damages do not occur due to the construction of the recommended levees. The selective clearing and snagging work will follow Stream Obstruction Removal Guidelines established by the American Fisheries Society.

The levee project consists of an earthen dike around the northern, western, and southern side of the neighborhood, and a concrete "t"-wall structure along the eastern side. The structure will constructed to elevation 21 ft NAVD88. A pumping station will be included to relieve the interior flooding. New culverts will be installed in the levee. The earthen part of the levee will have a 12-ft top width and 1 vertical to 3 horizontal sideslopes. Ditches next to the levee will convey water ponding against the levee to the outlets. Closure gates will be installed on the two existing access streets to the subdivision. An emergency access/egress street will be included on the north side of the neighborhood. An overflow section will be included to provide for controlled overtopping.

Forest Heights Work Description

Price Level Aug 08

FEASIBILITY STUDY

Estimated by	CESAM-EN-E, Cost Engineering Branch
Designed by	CESAM-EN-E, Mobile District, Corps of Engineers
Prepared by	Joseph H. Ellsworth
Preparation Date	8/7/2008
Effective Date of Pricing	8/7/2008
Estimated Construction Time	1,080 Days

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project file:forest-feasibility-aug08.mlp

report file: feasibilty standard report.mrp

output file: forest-cumbest-feasibility-aug08.doc

Date	Author	Note
	Joseph H. Ellsworth	BASIS of COST ESTIMATE and RATIONALE Feasibility Estimate is based on Historical Data, Recent Pricing, and Estimator's Judgment. Estimate is structured and priced as a General Prime contractor supported by major subcontractors. Anticipated bidding conditions and construction duration with reasonable schedules are considered Normal. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Current Contract Cost (price level Aug 08). Price Level of Estimate is Aug 08. Project Life is assumed as 50 years in Cost Estimate. 30 Feature Account, Planning, Engineering & Design was developed and assigned at 8% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Eight percent was used in the Interim MsCIP projects which was reviewed and approved and included in the Chief's Report. 31 Feature Account, Construction Management was developed and assigned at 6% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Six percent was used in the Interim MsCIP projects which was reviewed & approved and included in the Chief's Report. Contingency was jointly developed and assigned by the Project Delivery Team. The Contingency percentage at 25% reflects the possibility of changes in quantity estimates and unknowns associated with the unit price. The contingency factor used does not vary throughout the cost estimate. It was determined and agreed upon by the Project Delivery Team that a high rate be used primarily due to risk, degree of confidence, and the project not being of the normal design. Markups for subcontractors are included in the unit prices and include such items as field overheads, home office expenses, profit, bond and insurance. Mobilization Preparatory Work & Demobilization are derived within the estimate generally at 2.5 % +- of construction cost excluding the Misc Items cost. Miscellaneous Items represent cost where quantities were not available, such items as signage, construction site/staging restoration, silt fencing, site access, etc. These cost are derived within the estimate at .25 percent+- (.25%) of construction cost excluding Mob & Demob Cost Unit Prices, for such items as site work, earthwork, etc., were based on Historical Data, Recent Pricing, Estimator's Judgment, and Cost derivation using MCACES / MII estimating systems.
8/5/2008	Joseph H. Ellsworth	Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Where quantities were not available, assumptions were made based on historical information and Estimator's judgment. The following Contractor Markups are applied to the Cost to Prime Direct Cost: Contractor's Field Overhead @ 12%

Date	Author	Note
		Contractor's Home Office (G&A) @ 8%
		Profit @ 10%
		Bond @ 1.2%
		Miss. Gross Receipts Tax @ 3.5%
		Listed are all Cost Engineering Personnel that worked on the Feasibility Cost Estimate. Joseph H. Ellsworth, Lead Cost Engineer Gary Payton, Cost Engineer George F. Rush, Civil Engineer, Dredging Michael A. McKown, Geo Tech Engineer Lloyd Oliver, Structural Engineer Richard W. Harvey, Mechanical Engineer John R. Thomas, Real Estate Specialist Donald A. Whitmore, Civil Engineer- Non-Structural Estimates Jennifer L. Jacobson, Environmentalist

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
Contract Cost Summary Report			**5,379,528**	**645,543**	**482,006**	**650,708**	**85,893**	**253,529**	**7,497,207**
01 Forest Heights, Harrison County - Environmental Restoration	**1.00**	**LS**	**5,379,528**	**645,543**	**482,006**	**650,708**	**85,893**	**253,529**	**7,497,207**
11 Federal & Non-Federal Costs	**1.00**	**LS**	**5,379,528**	**645,543**	**482,006**	**650,708**	**85,893**	**253,529**	**7,497,207**
011 Levees & Floodwalls	**1.00**	**LS**	**5,379,528**	**645,543**	**482,006**	**650,708**	**85,893**	**253,529**	**7,497,207**
01 Levee Restoration	**1.00**	**LS**	**5,379,528**	**645,543**	**482,006**	**650,708**	**85,893**	**253,529**	**7,497,207**
Removals	**1.00**	**LS**	**17,033**	**2,044**	**1,526**	**2,060**	**272**	**803**	**23,738**
			3.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*5.23*
USR Asphalt removal 2" Thick(cross overs)	700.00	SY	2,625	315	235	318	42	124	3,658
			6.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*9.41*
USR 8" Water line removal	150.00	LF	1,013	122	91	122	16	48	1,411
			6.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*9.41*
USR 6" Sewer line removal	150.00	LF	1,013	122	91	122	16	48	1,411
			2.50	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.48*
USR 2" Gas line removal	150.00	LF	375	45	34	45	6	18	523
			9.25	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*12.89*
USR Electric line removal-3 phase 1440v	175.00	LF	1,619	194	145	196	26	76	2,256
			9.25	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*12.89*
USR 24" Storm drain removal	125.00	LF	1,156	139	104	140	18	54	1,611
			3.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*4.18*
USR Demolished structures (avg. 1,500sf/ea @ 2 ea)	3,000.00	SF	9,000	1,080	806	1,089	144	424	12,543
			2.10	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*2.93*
USR Disposal Fee-off site	111.00	CY	233	28	21	28	4	11	325
New Work	**1.00**	**LS**	**1,931,020**	**231,722**	**173,019**	**233,576**	**30,832**	**91,006**	**2,691,176**
USR Mobilization, Preparatory Work, Demobilization	1.00	LS	100,000	12,000	8,960	12,096	1,597	4,713	139,366
			21.25	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*29.62*
USR Vinyl sheet piling	39,550.00	SF	840,438	100,853	75,303	101,659	13,419	39,609	1,171,280
			12.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*17.77*
USR Compacted fill (levee)	51,000.00	CY	650,250	78,030	58,262	78,654	10,382	30,645	906,224
			75.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*104.52*
USR New asphalt 2" (at tunnels) 134cy, figure 2.0 tons/cy	20.00	TON	1,500	180	134	181	24	71	2,090
			45.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*62.71*
USR Base material 12" (cross overs)	100.00	CY	4,500	540	403	544	72	212	6,271
			76.50	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*106.61*
USR Riprap (12")	170.00	CY	13,005	1,561	1,165	1,573	208	613	18,124
			136.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*189.54*
USR Grouted riprap	125.00	CY	17,000	2,040	1,523	2,056	271	801	23,692
			1.70	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*2.37*
USR Filter fabric	500.00	SY	850	102	76	103	14	40	1,185
			1,825.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*2,543.42*
USR Grassing(seeding)	10.00	ACR	18,250	2,190	1,635	2,208	291	860	25,434

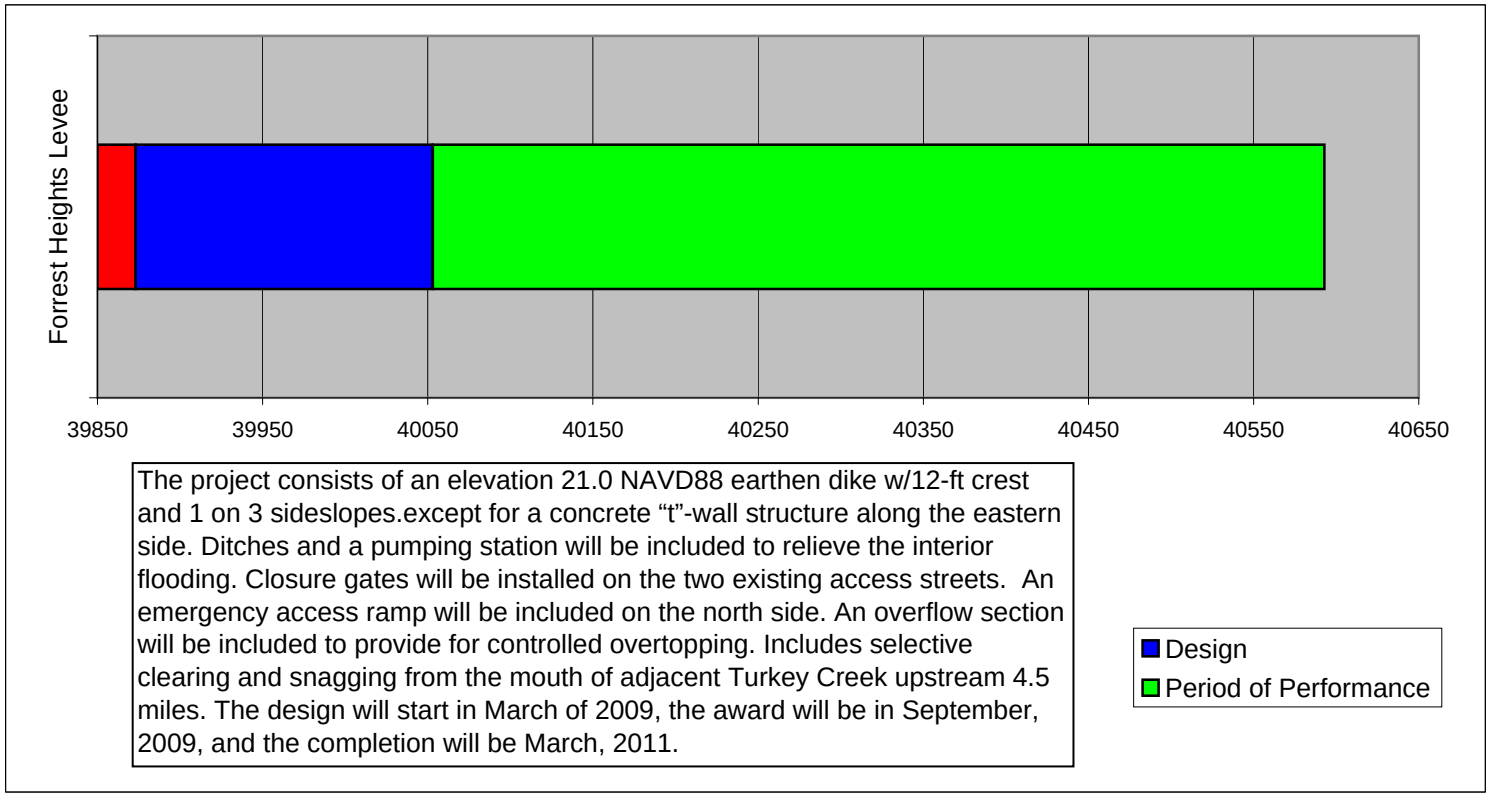
Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
			4,250.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*5,923.03*
USR Clearing and grubbing, off-site disposal	10.00	ACR	42,500	5,100	3,808	5,141	679	2,003	59,230
			40.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*55.75*
USR Crushed aggregate 6" thick(levee wearing surface)	2,000.00	CY	80,000	9,600	7,168	9,677	1,277	3,770	111,492
			17.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*23.69*
USR Selective clearing and snagging, soil removal and disposal	220.00	CY	3,740	449	335	452	60	176	5,212
			21,250.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*29,615.17*
USR Clearing and snagging(from mouth of Turkey Creek upstream)	5.00	MI	106,250	12,750	9,520	12,852	1,696	5,007	148,076
			34.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*48.43*
USR New 8" water line	150.00	LF	5,213	626	467	631	83	246	7,264
			40.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*56.79*
USR New 6" sewer line	150.00	LF	6,113	734	548	739	98	288	8,519
			17.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*23.69*
USR New 2" gas line	150.00	LF	2,550	306	228	308	41	120	3,554
			37.50	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*52.26*
USR New electrical line-3 phase 1440v	175.00	LF	6,563	788	588	794	105	309	9,146
			100.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*139.37*
USR New 24" storm drain	125.00	LF	12,500	1,500	1,120	1,512	200	589	17,421
			5,500.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*7,665.10*
USR Mitigation non-tidal	3.60	ACR	19,800	2,376	1,774	2,395	316	933	27,594
			1,800,646.25						*2,509,479.93*
Pump Stations	**1.00**	**EA**	**1,800,646**	**216,078**	**161,338**	**217,806**	**28,750**	**84,862**	**2,509,480**
			595.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*829.22*
USR Structural concrete, complete all sites	194.00	CY	115,430	13,852	10,343	13,962	1,843	5,440	160,870
			6.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*8.36*
USR Form work, complete all sites	4,996.00	SF	29,976	3,597	2,686	3,626	479	1,413	41,776
			925.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*1,289.13*
USR Steel reinforcement, complete all sites	12.00	TON	11,100	1,332	995	1,343	177	523	15,470
			12.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*17.77*
USR Excavation	300.00	CY	3,825	459	343	463	61	180	5,331
			4.25	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*5.92*
USR Backfill	233.00	CY	990	119	89	120	16	47	1,380
			100,000.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*139,365.52*
USR Trash screens and miscellaneous metal items, all sites	2.00	EA	200,000	24,000	17,920	24,192	3,193	9,426	278,731
			222,200.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*309,670.18*
USR Pumps by installation site, P-1, pumps	2.00	EA	444,400	53,328	39,818	53,755	7,096	20,944	619,340
USR Pumps by installation site, P-1, discharge piping(42" Dia.; 154lf)	1.00	LS	30,800	3,696	2,760	3,726	492	1,452	42,925
USR Pumps by installation site, P-1, energy dissipation	1.00	LS	90,000	10,800	8,064	10,886	1,437	4,242	125,429
			242,000.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*337,264.55*
USR Pumps by installation site, P-1, electrical	2.00	EA	484,000	58,080	43,366	58,545	7,728	22,810	674,529

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
			900.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*1,254.29*
USR Concrete box culvert(5 ea) 4' x 3'	155.00	CY	139,500	16,740	12,499	16,874	2,227	6,574	194,415
			13,500.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*18,814.34*
USR Flap gates (4w x 3h)	5.00	EA	67,500	8,100	6,048	8,165	1,078	3,181	94,072
			31,500.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*43,900.14*
USR Cutoff valves (4w x 3h)	5.00	EA	157,500	18,900	14,112	19,051	2,515	7,423	219,501
			10.25	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*14.28*
USR Ditch excavation	2,500.00	CY	25,625	3,075	2,296	3,100	409	1,208	35,712
Structural	**1.00**	**LS**	**1,560,825**	**187,299**	**139,850**	**188,797**	**24,921**	**73,559**	**2,175,252**
			700.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*975.56*
USR Concrete wall	1,826.00	CY	1,278,200	153,384	114,527	154,611	20,409	60,240	1,781,370
			4,800.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*6,689.54*
USR Structural steel gates	6.00	TON	28,800	3,456	2,580	3,484	460	1,357	40,137
			925.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*1,289.13*
USR #6 Rebar (box culverts)	49.00	TON	45,325	5,439	4,061	5,483	724	2,136	63,167
USR Misc. removals at Russell Blvd. Entrance	1.00	LS	8,500	1,020	762	1,028	136	401	11,846
USR ATFP, signage, pavement marking, traffic control, etc.	1.00	LS	200,000	24,000	17,920	24,192	3,193	9,426	278,731
Levee Ramp(length of road-1950lf)	**1.00**	**LS**	**70,004**	**8,400**	**6,272**	**8,468**	**1,118**	**3,299**	**97,561**
			12.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*16.72*
USR Fill material(off-site)	2,167.00	CY	26,004	3,120	2,330	3,145	415	1,226	36,241
			45.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*62.71*
USR Gravel wearing surface	795.00	CY	35,775	4,293	3,205	4,327	571	1,686	49,858
			100.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*139.37*
USR 24" Dia. RCP	30.00	LF	3,000	360	269	363	48	141	4,181
			2,150.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*2,996.36*
USR Clear & grub(off-site)	1.50	ACR	3,225	387	289	390	51	152	4,495
			4,000.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*5,574.62*
USR Off-site disposal	0.50	ACR	2,000	240	179	242	32	94	2,787

Description	Quantity	UOM	SubBidCost	CostToPrime
Project Direct Costs Report			**5,379,528**	**5,379,528**
01 Forest Heights, Harrison County - Environmental Restoration	**1.00**	**LS**	**5,379,528**	**5,379,528**
11 Federal & Non-Federal Costs	**1.00**	**LS**	**5,379,528**	**5,379,528**
011 Levees & Floodwalls	**1.00**	**LS**	**5,379,528**	**5,379,528**
01 Levee Restoration	**1.00**	**LS**	**5,379,528**	**5,379,528**
Removals	**1.00**	**LS**	**17,033**	**17,033**
USR Asphalt removal 2" Thick(cross overs)	700.00	SY	*3.75* 2,625	*3.75* 2,625
USR 8" Water line removal	150.00	LF	*6.75* 1,013	*6.75* 1,013
USR 6" Sewer line removal	150.00	LF	*6.75* 1,013	*6.75* 1,013
USR 2" Gas line removal	150.00	LF	*2.50* 375	*2.50* 375
USR Electric line removal-3 phase 1440v	175.00	LF	*9.25* 1,619	*9.25* 1,619
USR 24" Storm drain removal	125.00	LF	*9.25* 1,156	*9.25* 1,156
USR Demolished structures (avg. 1,500sf/ea @ 2 ea)	3,000.00	SF	*3.00* 9,000	*3.00* 9,000
USR Disposal Fee-off site	111.00	CY	*2.10* 233	*2.10* 233
New Work	**1.00**	**LS**	**1,931,020**	**1,931,020**
USR Mobilization, Preparatory Work, Demobilization	1.00	LS	100,000	100,000
USR Vinyl sheet piling	39,550.00	SF	*21.25* 840,438	*21.25* 840,438
USR Compacted fill (levee)	51,000.00	CY	*12.75* 650,250	*12.75* 650,250
USR New asphalt 2" (at tunnels) 134cy, figure 2.0 tons/cy	20.00	TON	*75.00* 1,500	*75.00* 1,500
USR Base material 12" (cross overs)	100.00	CY	*45.00* 4,500	*45.00* 4,500
USR Riprap (12")	170.00	CY	*76.50* 13,005	*76.50* 13,005
USR Grouted riprap	125.00	CY	*136.00* 17,000	*136.00* 17,000
USR Filter fabric	500.00	SY	*1.70* 850	*1.70* 850
USR Grassing(seeding)	10.00	ACR	*1,825.00* 18,250	*1,825.00* 18,250

Description	Quantity	UOM	SubBidCost	CostToPrime
			4,250.00	*4,250.00*
USR Clearing and grubbing, off-site disposal	10.00	ACR	42,500	42,500
			40.00	*40.00*
USR Crushed aggregate 6" thick(levee wearing surface)	2,000.00	CY	80,000	80,000
			17.00	*17.00*
USR Selective clearing and snagging, soil removal and disposal	220.00	CY	3,740	3,740
			21,250.00	*21,250.00*
USR Clearing and snagging(from mouth of Turkey Creek upstream)	5.00	MI	106,250	106,250
			34.75	*34.75*
USR New 8" water line	150.00	LF	5,213	5,213
			40.75	*40.75*
USR New 6" sewer line	150.00	LF	6,113	6,113
			17.00	*17.00*
USR New 2" gas line	150.00	LF	2,550	2,550
			37.50	*37.50*
USR New electrical line-3 phase 1440v	175.00	LF	6,563	6,563
			100.00	*100.00*
USR New 24" storm drain	125.00	LF	12,500	12,500
			5,500.00	*5,500.00*
USR Mitigation non-tidal	3.60	ACR	19,800	19,800
			1,800,646.25	*1,800,646.25*
Pump Stations	**1.00**	**EA**	**1,800,646**	**1,800,646**
			595.00	*595.00*
USR Structural concrete, complete all sites	194.00	CY	115,430	115,430
			6.00	*6.00*
USR Form work, complete all sites	4,996.00	SF	29,976	29,976
			925.00	*925.00*
USR Steel reinforcement, complete all sites	12.00	TON	11,100	11,100
			12.75	*12.75*
USR Excavation	300.00	CY	3,825	3,825
			4.25	*4.25*
USR Backfill	233.00	CY	990	990
			100,000.00	*100,000.00*
USR Trash screens and miscellaneous metal items, all sites	2.00	EA	200,000	200,000
			222,200.00	*222,200.00*
USR Pumps by installation site, P-1, pumps	2.00	EA	444,400	444,400
USR Pumps by installation site, P-1, discharge piping(42" Dia.; 154lf)	1.00	LS	30,800	30,800
USR Pumps by installation site, P-1, energy dissipation	1.00	LS	90,000	90,000
			242,000.00	*242,000.00*
USR Pumps by installation site, P-1, electrical	2.00	EA	484,000	484,000

Description	Quantity	UOM	SubBidCost	CostToPrime
			900.00	*900.00*
USR Concrete box culvert(5 ea) 4' x 3'	155.00	CY	139,500	139,500
			13,500.00	*13,500.00*
USR Flap gates (4w x 3h)	5.00	EA	67,500	67,500
			31,500.00	*31,500.00*
USR Cutoff valves (4w x 3h)	5.00	EA	157,500	157,500
			10.25	*10.25*
USR Ditch excavation	2,500.00	CY	25,625	25,625
Structural	**1.00**	**LS**	**1,560,825**	**1,560,825**
			700.00	*700.00*
USR Concrete wall	1,826.00	CY	1,278,200	1,278,200
			4,800.00	*4,800.00*
USR Structural steel gates	6.00	TON	28,800	28,800
			925.00	*925.00*
USR #6 Rebar (box culverts)	49.00	TON	45,325	45,325
USR Misc. removals at Russell Blvd. Entrance	1.00	LS	8,500	8,500
USR ATFP, signage, pavement marking, traffic control, etc.	1.00	LS	200,000	200,000
Levee Ramp(length of road-1950lf)	**1.00**	**LS**	**70,004**	**70,004**
			12.00	*12.00*
USR Fill material(off-site)	2,167.00	CY	26,004	26,004
			45.00	*45.00*
USR Gravel wearing surface	795.00	CY	35,775	35,775
			100.00	*100.00*
USR 24" Dia. RCP	30.00	LF	3,000	3,000
			2,150.00	*2,150.00*
USR Clear & grub(off-site)	1.50	ACR	3,225	3,225
			4,000.00	*4,000.00*
USR Off-site disposal	0.50	ACR	2,000	2,000



The project consists of an elevation 21.0 NAVD88 earthen dike w/12-ft crest and 1 on 3 sideslopes.except for a concrete “t”-wall structure along the eastern side. Ditches and a pumping station will be included to relieve the interior flooding. Closure gates will be installed on the two existing access streets. An emergency access ramp will be included on the north side. An overflow section will be included to provide for controlled overtopping. Includes selective clearing and snagging from the mouth of adjacent Turkey Creek upstream 4.5 miles. The design will start in March of 2009, the award will be in September, 2009, and the completion will be March, 2011.

TOTAL PROJECT **** TOTAL PROJECT COST SUMMARY ****

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Turkey Creek -Environmental Restoration, Restore Wetlands DISTRICT: MOBILE

LOCATION: Harrison County, Mississippi P.O.C.: Joseph H. Ellsworth

ACCOUNT NUMI	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages	777,000	194,250	25%	971,250	777,000	194,250	971,250	803,418	200,855	1,004,273
06---	Fish & Wildlife -Restore Wetlands ***(Turkey Creek)***	4,105,000	1,026,250	25%	5,131,250	4,105,000	1,026,250	5,131,250	4,343,090	1,085,773	5,428,863
30---	PLANNING, ENGINEERING & DESIGN	328,400	82,100	25%	410,500	328,400	82,100	410,500	333,654	83,414	417,068
31---	CONSTRUCTION MANAGEMENT	246,300	61,575	25%	307,875	246,300	61,575	307,875	260,585	65,146	325,731
	TOTAL PROJECT COST =======>	**5,456,700**	**1,364,175**		**6,820,875**	**5,456,700**	**1,364,175**	**6,820,875**	**5,740,747**	**1,435,188**	**7,175,935**

rounded

65% **TOTAL FEDERAL COSTS ============>** **$4,680,000**

35% **TOTAL NON - FEDERAL COSTS ======>** **$2,520,000**

TOTAL PROJECT COSTS ============> **$7,200,000**

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Turkey Creek -Environmental Restoration, Restore Wetlands DISTRICT: MOBILE

LOCATION: Harrison County, Mississippi P.O.C.: Joseph H. Ellsworth

	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08					AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT No.	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages (price level, Oct 07)	777,000	194,250	25%	971,250	0.0%	777,000	194,250	971,250	Apr 09	3.4%	803,418	200,855	1,004,273
	Subtotal	777,000	194,250		971,250		777,000	194,250	971,250			803,418	200,855	1,004,273
06---	Fish & Wildlife -Restore Wetlands	4,105,000	1,026,250	25%	5,131,250	0.0%	4,105,000	1,026,250	5,131,250	Apr 11	5.8%	4,343,090	1,085,773	5,428,863
30---	PLANNING, ENGINEERING & DESIGN, 8%+-	328,400	82,100	25%	410,500	0.0%	328,400	82,100	410,500	Apr 09	1.6%	333,654	83,414	417,068
31---	CONSTRUCTION MANAGEMENT, 6% +-	246,300	61,575	25%	307,875	0.0%	246,300	61,575	307,875	Apr 11	5.8%	260,585	65,146	325,731
	Subtotal	4,679,700	1,169,925		5,849,625		4,679,700	1,169,925	5,849,625			4,937,329	1,234,333	6,171,662

2. Maintain vegetation (Mandatory) by mowing 1st year and Burn 1st year; Burn every 3 years for life of project.

1. Filling in ditches (Mandatory to achieve overall restoration project).

The restoration site is primarily comprised of a degraded pine savannah wetland. Several miles of ditches have been excavated throughout the site. Additionally, an elevated railway berm fragments the wetland habitat substantially altering hydrology of the wetlands located to the north. The following measures were developed:
Turkey Creek Proposed Action

Price Level Aug 08

FEASIBILITY STUDY

Estimated by	CESAM-EN-E, Cost Engineering Branch
Designed by	CESAM-EN-E, Mobile District, Corps of Engineers
Prepared by	Russell Haynes
Preparation Date	8/8/2008
Effective Date of Pricing	8/8/2008
Estimated Construction Time	Days

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project file: turkey-feasibility-aug08.mlp

report file: feasibilty standard report.mrp

output file: turkey-feasibility-aug08.doc

Date	Author	Note

Joseph H. Ellsworth

BASIS of COST ESTIMATE and RATIONALE

Feasibility Estimate is based on Historical Data, Recent Pricing, and Estimator's Judgment. Estimate is structured and priced as a General Prime contractor supported by major subcontractors. Anticipated bidding conditions and construction duration with reasonable schedules are considered Normal. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Current Contract Cost (price level Aug 08). The Non-structural and Real Estate Cost were prepared by the Savannah & Huntington Districts.

Price Level of Estimate is Aug 08.

Project Life is assumed as 50 years in Cost Estimate.

01 Feature Account, Real Estate Cost was prepared by the Savannah District COE.

30 Feature Account, Planning, Engineering & Design was developed and assigned at 8% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Eight percent was used in the Interim MsCIP projects which was reviewed and approved and included in the Chief's Report.

31 Feature Account, Construction Management was developed and assigned at 6% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Six percent was used in the Interim MsCIP projects which was reviewed & approved and included in the Chief's Report.

Contingency was jointly developed and assigned by the Project Delivery Team. The Contingency percentage at 25% reflects the possibility of changes in quantity estimates and unknowns associated with the unit price. The contingency factor used does not vary throughout the cost estimate. It was determined and agreed upon by the Project Delivery Team that a high rate be used primarily due to risk, degree of confidence, and the project not being of the normal design.

Markups for subcontractors are included in the unit prices and include such items as field overheads, home office expenses, profit, bond and insurance.

Mobilization Preparatory Work & Demobilization are derived within the estimate generally at 2.5 % +- of construction cost excluding the Misc Items cost.

Miscellaneous Items represent cost where quantities were not available, such items as signage, construction site/staging restoration, silt fencing, site access, etc. These cost are derived within the estimate at .25 percent (.25%) of construction cost excluding Mob & Demob Cost

Unit Prices, for such items as site work, earthwork, stone protection, concrete, reinforcing, etc., were based on Historical Data, Recent Pricing, Estimator's Judgment, and Cost derivation using MCACES / MII estimating systems.

8/5/2008 Joseph H. Ellsworth

The following Contractor Markups are applied to the Cost to Prime Direct Cost:

Contractor's Field Overhead @ 12%

Date	Author	Note

Contractor's Home Office (G&A) @ 8%

Profit @ 10%

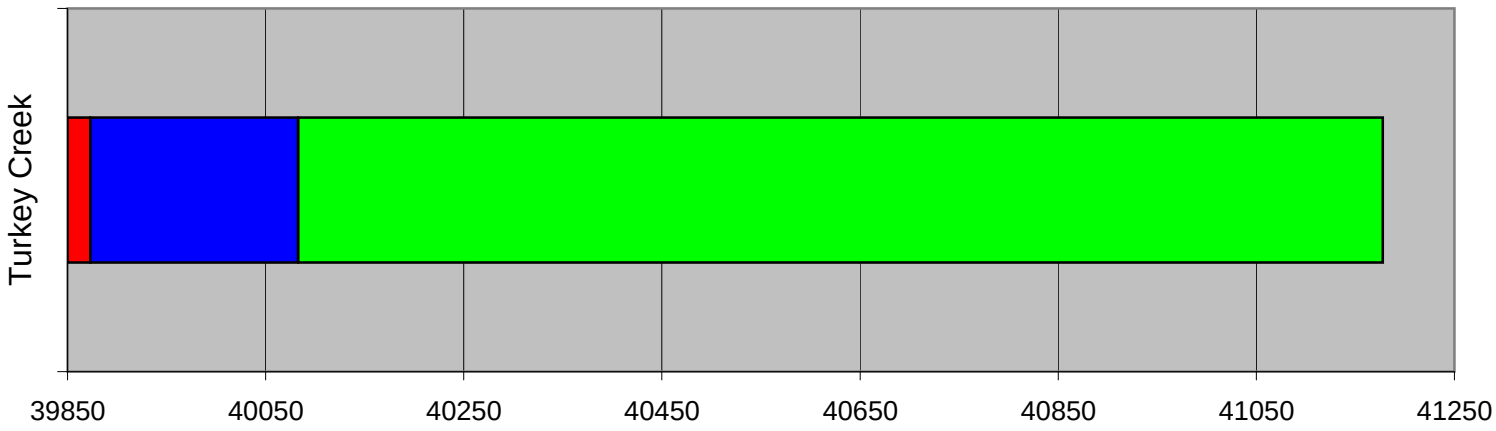
Bond @ 1.2%

Miss. Gross Receipts Tax @ 3.5%

Listed are all Cost Engineering Personnel that worked on the Feasibility Cost Estimate.
Joseph H. Ellsworth, Lead Cost Engineer
Gary Payton, Cost Engineer
George F. Rush, Civil Engineer, Dredging
Michael A. McKown, Geo Tech Engineer
Lloyd Oliver, Structural Engineer
Richard W. Harvey, Mechanical Engineer
John R. Thomas, Real Estate Specialist
Donald A. Whitmore, Civil Engineer- Non-Structural Estimates
Jennifer L. Jacobson, Environmentalist

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
Contract Cost Summary Report			**2,945,368**	**353,444**	**263,905**	**356,272**	**47,028**	**138,811**	**4,104,827**
01 Turkey Creek, Harrison County - Environmental Restoration	**1.00**	**LS**	**2,945,368**	**353,444**	**263,905**	**356,272**	**47,028**	**138,811**	**4,104,827**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**2,945,368**	**353,444**	**263,905**	**356,272**	**47,028**	**138,811**	**4,104,827**
006 Fish & Wildlife	**1.00**	**LS**	**2,945,368**	**353,444**	**263,905**	**356,272**	**47,028**	**138,811**	**4,104,827**
01 Environmental Restoration	**1.00**	**LS**	**2,945,368**	**353,444**	**263,905**	**356,272**	**47,028**	**138,811**	**4,104,827**
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	20,000	2,400	1,792	2,419	319	943	27,873
			9.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*13.59*
USR Fill in ditches(from off-site borrow)	102,078.00	CY	995,261	119,431	89,175	120,387	15,891	46,905	1,387,050
			130.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*181.18*
USR Burn vegetation	689.00	ACR	89,570	10,748	8,025	10,834	1,430	4,221	124,830
			75.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*104.52*
USR Mow vegetation(annually)	689.00	ACR	51,675	6,201	4,630	6,251	825	2,435	72,017
			3.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*4.18*
USR Remove structures(1,500 sf avg size@12 ea)	18,000.00	SF	54,000	6,480	4,838	6,532	862	2,545	75,257
			2.15	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.00*
USR Disposal Fee	667.00	CY	1,434	172	128	173	23	68	1,999
			12.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*16.72*
USR Remove roads(assume 24' wide)	35,924.00	LF	431,088	51,731	38,625	52,144	6,883	20,317	600,788
			35.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*48.78*
USR Remove utilties	35,924.00	LF	1,257,340	150,881	112,658	152,088	20,076	59,256	1,752,298
USR Misc site items	1.00	LS	45,000	5,400	4,032	5,443	719	2,121	62,714

Description	Quantity	UOM	SubBidCost	CostToPrime
Project Direct Costs Report			**2,945,368**	**2,945,368**
01 Turkey Creek, Harrison County - Environmental Restoration	**1.00**	**LS**	**2,945,368**	**2,945,368**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**2,945,368**	**2,945,368**
006 Fish & Wildlife	**1.00**	**LS**	**2,945,368**	**2,945,368**
01 Environmental Restoration	**1.00**	**LS**	**2,945,368**	**2,945,368**
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	20,000	20,000
			9.75	*9.75*
USR Fill in ditches(from off-site borrow)	102,078.00	CY	995,261	995,261
			130.00	*130.00*
USR Burn vegetation	689.00	ACR	89,570	89,570
			75.00	*75.00*
USR Mow vegetation(annually)	689.00	ACR	51,675	51,675
			3.00	*3.00*
USR Remove structures(1,500 sf avg size@12 ea)	18,000.00	SF	54,000	54,000
			2.15	*2.15*
USR Disposal Fee	667.00	CY	1,434	1,434
			12.00	*12.00*
USR Remove roads(assume 24' wide)	35,924.00	LF	431,088	431,088
			35.00	*35.00*
USR Remove utilties	35,924.00	LF	1,257,340	1,257,340
USR Misc site items	1.00	LS	45,000	45,000



The restoration is comprised of restoration of a degraded pine savannah wetland. Several miles of ditches at the site will be filled. Additionally, an elevated railway berm that fragments the wetland habitat will be removed along with roadbeds and any other fill. Invasive vegetation will be controlled by mowing and burning. The design will start in March of 2009, the award will be in October, 2009, and the completion will be October, 2012.

Design

Period of Performance

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Dantzler -Environmental Restoration, Restore Wetlands DISTRICT: MOBILE

LOCATION: Jackson County, Mississippi P.O.C.: Joseph H. Ellsworth

ACCOUNT NUMI	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages	25,000	6,250	25%	31,250	25,000	6,250	31,250	25,400	6,350	31,750
06---	Fish & Wildlife -Restore Wetlands ***(Dantzler)***	1,495,000	373,750	25%	1,868,750	1,495,000	373,750	1,868,750	1,605,630	401,408	2,007,038
30---	PLANNING, ENGINEERING & DESIGN	119,600	29,900	25%	149,500	119,600	29,900	149,500	123,666	30,917	154,583
31---	CONSTRUCTION MANAGEMENT	89,700	22,425	25%	112,125	89,700	22,425	112,125	96,338	24,084	120,422
	TOTAL PROJECT COST =======>	**1,729,300**	**432,325**		**2,161,625**	**1,729,300**	**432,325**	**2,161,625**	**1,851,034**	**462,759**	**2,313,793**

rounded

65% **TOTAL FEDERAL COSTS ==========>** **$1,495,000**

35% **TOTAL NON - FEDERAL COSTS ======>** **$805,000**

TOTAL PROJECT COSTS ==========> **$2,300,000**

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

****** TOTAL CONTRACT COST SUMMARY ******

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Dantzler -Environmental Restoration, Restore Wetlands
DISTRICT: MOBILE

LOCATION: Jackson County, Mississippi
P.O.C.: Joseph H. Ellsworth

ACCOUNT No.	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages (PCA)	25,000	6,250	25%	31,250	0.0%	25,000	6,250	31,250	Jun 09	1.6%	25,400	6,350	31,750
	Subtotal	25,000	6,250		31,250		25,000	6,250	31,250			25,400	6,350	31,750
06---	Fish & Wildlife -Restore Wetlands	1,495,000	373,750	25%	1,868,750	0.0%	1,495,000	373,750	1,868,750	Jan 12	7.4%	1,605,630	401,408	2,007,038
30---	PLANNING, ENGINEERING & DESIGN, 8%+-	119,600	29,900	25%	149,500	0.0%	119,600	29,900	149,500	Jun 09	3.4%	123,666	30,917	154,583
31---	CONSTRUCTION MANAGEMENT, 6% +-	89,700	22,425	25%	112,125	0.0%	89,700	22,425	112,125	Jan 12	7.4%	96,338	24,084	120,422
	Subtotal	1,704,300	426,075		2,130,375		1,704,300	426,075	2,130,375			1,825,634	456,409	2,282,043

3. Filling in 100% of existing artificial ditches. (Mandatory)

2. 100% removal of exotics and plantation pine; maintain removal of exotic plant species in all areas over project lifetime. (Mandatory in all plans).

1. Maintain native savanna vegetation. (Mandatory) by mowing 1st year and Burn 1st year; Burn every 3 years for life of project.

The restoration site contains 385 acres to be restored to wet pine savanna. This area was planted in plantation pine during the 1960s and ditches and stormwater lines were constructed in the early 1970s in anticipation of residential development of the site. The long-term exclusion of fire and the invasion of non-native species such as Cogongrass and Chinese Tallowtree have severely degraded the site. The following measures were developed:
Dantzler Proposed Action

Price Level ly Aug 08
FEASIBILITY STUDY

Estimated by CESAM-EN-E, Cost Engineering Branch
Designed by CESAM-EN-E, Mobile District, Corps of Engineers
Prepared by Joseph Ellsworth
Preparation Date 8/6/2008
Effective Date of Pricing 8/6/2008
Estimated Construction Time 1,080 Days

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project file: dantzler-feasibility-aug08.mlp

report file: feasibilty standard report.mrp

output file: dantzler-feasibility-aug08.doc

Date	Author	Note

Joseph H. Ellsworth

BASIS of COST ESTIMATE and RATIONALE

Feasibility Estimate is based on Historical Data, Recent Pricing, and Estimator's Judgment. Estimate is structured and priced as a General Prime contractor supported by major subcontractors. Anticipated bidding conditions and construction duration with reasonable schedules are considered Normal. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Current Contract Cost (price level Aug 08). The Non-structural and Real Estate Cost were prepared by the Savannah & Huntington Districts.

Price Level of Estimate is Aug 08.

Project Life is assumed as 50 years in Cost Estimate.

01 Feature Account, Real Estate Cost was prepared by the Savannah District COE.

06 Feature Account, Preservation - Mitigation-Tidal quantites were based on impacts of new footprint plus mitigated factor which was determined and coordinated by other agencies. Unit cost were derived and based on historical data.

30 Feature Account, Planning, Engineering & Design was developed and assigned at 8% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Eight percent was used in the Interim MsCIP projects which was reviewed and approved and included in the Chief's Report.

31 Feature Account, Construction Management was developed and assigned at 6% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Six percent was used in the Interim MsCIP projects which was reviewed & approved and included in the Chief's Report.

Contingency was jointly developed and assigned by the Project Delivery Team. The Contingency percentage at 25% reflects the possibility of changes in quantity estimates and unknowns associated with the unit price. The contingency factor used does not vary throughout the cost estimate. It was determined and agreed upon by the Project Delivery Team that a high rate be used primarily due to risk, degree of confidence, and the project not being of the normal design.

Markups for subcontractors are included in the unit prices and include such items as field overheads, home office expenses, profit, bond and insurance.

Mobilization Preparatory Work & Demobilization are derived within the estimate generally at 2.5 % +- of construction cost excluding the Misc Items cost.

Miscellaneous Items represent cost where quantities were not available, such items as signage, construction site/staging restoration, silt fencing, site access, etc. These cost are derived within the estimate at .25 percent (.25%) of construction cost excluding Mob & Demob Cost

Unit Prices, for such items as site work, earthwork, stone protection, concrete, reinforcing, etc., were based on Historical Data, Recent Pricing, Estimator's Judgment, and Cost derivation using MCACES / MII estimating systems.

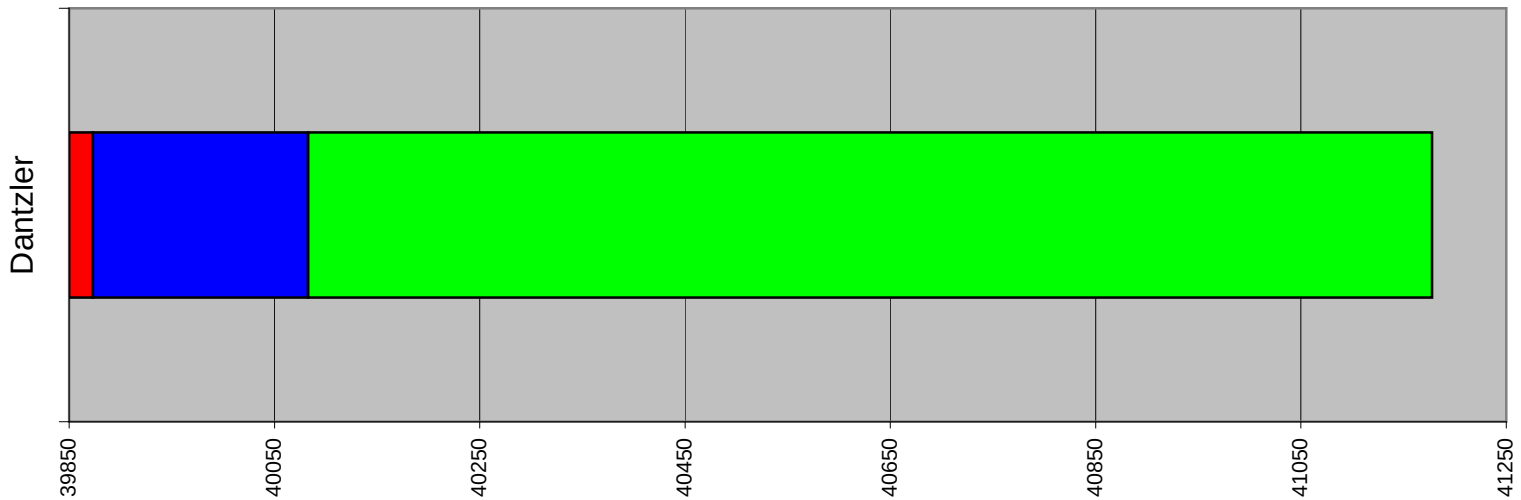
8/5/2008 Joseph H. Ellsworth

The following Contractor Markups are applied to the Cost to Prime Direct Cost:

Date	Author	Note
		Contractor's Field Overhead @ 12% Contractor's Home Office (G&A) @ 8% Profit @ 10% Bond @ 1.2% Miss. Gross Receipts Tax @ 3.5% Listed are all Cost Engineering Personnel that worked on the Feasibility Cost Estimate. Joseph H. Ellsworth, Lead Cost Engineer Gary Payton, Cost Engineer George F. Rush, Civil Engineer, Dredging Michael A. McKown, Geo Tech Engineer Lloyd Oliver, Structural Engineer Richard W. Harvey, Mechanical Engineer John R. Thomas, Real Estate Specialist Donald A. Whitmore, Civil Engineer- Non-Structural Estimates Jennifer L. Jacobson, Environmentalist
8/6/2008		New Project Note Listed are all Cost Engineering Personnel that worked on the Feasibility Cost Estimate. Joseph H. Ellsworth

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
Contract Cost Summary Report			**1,072,885**	**128,746**	**96,130**	**129,776**	**17,130**	**50,563**	**1,495,232**
Dantzler, Area A & B - Environmental Restoration	**1.00**	**LS**	**1,072,885**	**128,746**	**96,130**	**129,776**	**17,130**	**50,563**	**1,495,232**
Federal & Non-Federal Costs	**1.00**	**LS**	**1,072,885**	**128,746**	**96,130**	**129,776**	**17,130**	**50,563**	**1,495,232**
Fish & Wildlife	**1.00**	**LS**	**1,072,885**	**128,746**	**96,130**	**129,776**	**17,130**	**50,563**	**1,495,232**
			35,000.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*48,777.93*
Mobilization, Preparatory Work, & Demobilization	1.00	ACR	35,000	4,200	3,136	4,234	559	1,649	48,778
			9.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*13.59*
Fill Existing Ditches with Off-Site Commerical Borrow (Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)	66,560.00	CY	648,960	77,875	58,147	78,498	10,362	30,584	904,426
			130.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*181.18*
Burn Existing Vegetatin (surface only burn)	385.00	CY	50,050	6,006	4,484	6,054	799	2,359	69,752
			75.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*104.52*
Mow (bush-hog) Existing Vegetatin (initiallly)	385.00	CY	28,875	3,465	2,587	3,493	461	1,361	40,242
			12.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*16.72*
Remove Existing Roads (assume 24' width)	5,000.00	LF	60,000	7,200	5,376	7,258	958	2,828	83,619
			35.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*48.78*
Remove Existing Utilities	5,000.00	LF	175,000	21,000	15,680	21,168	2,794	8,247	243,890
Miscellaneous Site Items	1.00	LS	75,000	9,000	6,720	9,072	1,198	3,535	104,524

Description	Quantity	UOM	SubBidCost	CostToPrime
Project Direct Costs Report			**1,072,885**	**1,072,885**
01 Dantzler, Area A & B - Environmental Restoration	**1.00**	**LS**	**1,072,885**	**1,072,885**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**1,072,885**	**1,072,885**
006 Fish & Wildlife	**1.00**	**LS**	**1,072,885**	**1,072,885**
			2,786.71	*2,786.71*
01 Restore Wetlands	**385.00**	**ACR**	**1,072,885**	**1,072,885**
			35,000.00	*35,000.00*
USR Mobilization, Preparatory Work, & Demobilization	1.00	ACR	35,000	35,000
			9.75	*9.75*
USR Fill Existing Ditches with Off-Site Commerical Borrow (Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)	66,560.00	CY	648,960	648,960
			130.00	*130.00*
USR Burn Existing Vegetatin (surface only burn)	385.00	CY	50,050	50,050
			75.00	*75.00*
USR Mow (bush-hog) Existing Vegetatin (initiallly)	385.00	CY	28,875	28,875
			12.00	*12.00*
USR Remove Existing Roads (assume 24' width)	5,000.00	LF	60,000	60,000
			35.00	*35.00*
USR Remove Existing Utilities	5,000.00	LF	175,000	175,000
USR Miscellaneous Site Items	1.00	LS	75,000	75,000



The restoration site contains 385 acres to be restored to wet pine savanna. The long-term exclusion of fire and the invasion of non-native species such as Cogongrass and Chinese Tallowtree have severely degraded the site and will be removed along with other exotic plant species. Existing ditches will be filled. The site will be mowed and burned as part of the vegetation maintenance. The design will start in March of 2009, the award will be in October, 2009, and the completion will be October, 2012.

Design

Period of Performance

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Admiral Island -Environmental Restoration, Restore Wetlands DISTRICT: MOBILE
LOCATION: Hancock County, Mississippi P.O.C.: Joseph H. Ellsworth

		CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08				AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08			.....FULLY FUNDED ESTIMATE.....		
ACCOUNT NUMI	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages	25,000	6,250	25%	31,250	25,000	6,250	31,250	25,400	6,350	31,750
06---	Fish & Wildlife -Restore Wetlands ***(Admiral Island)***	15,179,000	3,794,750	25%	18,973,750	15,179,000	3,794,750	18,973,750	16,302,246	4,075,562	20,377,808
30---	PLANNING, ENGINEERING & DESIGN	1,214,320	303,580	25%	1,517,900	1,214,320	303,580	1,517,900	1,255,607	313,902	1,569,509
31---	CONSTRUCTION MANAGEMENT	910,740	227,685	25%	1,138,425	910,740	227,685	1,138,425	978,135	244,534	1,222,669
	TOTAL PROJECT COST =======>	**17,329,060**	**4,332,265**		**21,661,325**	**17,329,060**	**4,332,265**	**21,661,325**	**18,561,388**	**4,640,348**	**23,201,736**

rounded

65% **TOTAL FEDERAL COSTS ============>** **$15,080,000**

35% **TOTAL NON - FEDERAL COSTS ======>** **$8,120,000**

TOTAL PROJECT COSTS ============> **$23,200,000**

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Admiral Island -Environmental Restoration, Restore Wetlands DISTRICT: MOBILE

LOCATION: Hancock County, Mississippi P.O.C.: Joseph H. Ellsworth

ACCOUNT No.	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages (PCA)	25,000	6,250	25%	31,250	0.0%	25,000	6,250	31,250	Jun 09	1.6%	25,400	6,350	31,750
	Subtotal	25,000	6,250		31,250		25,000	6,250	31,250			25,400	6,350	31,750
06---	Fish & Wildlife -Restore Wetlands	15,179,000	3,794,750	25%	18,973,750	0.0%	15,179,000	3,794,750	18,973,750	Jan 12	7.4%	16,302,246	4,075,562	20,377,808
30---	PLANNING, ENGINEERING & DESIGN, 8%+-	1,214,320	303,580	25%	1,517,900	0.0%	1,214,320	303,580	1,517,900	Jun 09	3.4%	1,255,607	313,902	1,569,509
31---	CONSTRUCTION MANAGEMENT, 6% +-	910,740	227,685	25%	1,138,425	0.0%	910,740	227,685	1,138,425	Jan 12	7.4%	978,135	244,534	1,222,669
	Subtotal	17,304,060	4,326,015		21,630,075		17,304,060	4,326,015	21,630,075			18,535,988	4,633,998	23,169,986

4.□ative Vegetation Planting at 1 meter spacing

3.Ÿilling in 100% of existing artificial ditches/channels.

2.‘00% removal of exotics from non-excavated areas and maintain removal of exotic plant species in all areas over project lifetime. (Mandatory in all plans).

1.žxcavation of old fill material (includes 90-95% removal of existing exotic species in excavated areas) (Mandatory).

The restoration site contains 62 acres of emergent tidal marsh to be restored. The remaining 61 acres of scrub shrub wetland habitat would remain. The tidal marshes in this area were ditched during the 1960s causing changes in the natural hydrology and subsequent changes in the species composition. Hurricane Katrina left extensive debris fields and sedimentation in the area and destroyed many native trees and vegetation. Due to the loss of native species this area has a severe infestation of the invasive Chinese Tallow tree, which is invading the marshes and the adjacent flatwoods. For increased habitat diversity, higher elevations containing shrub/scrub wetland plant species would remain in order to enhance diversity within the restoration site. The following measures were developed:
Admiral Island Proposed Action

Price Level ly Aug 08

FEASIBILITY STUDY

Estimated by	CESAM-EN-E, Cost Engineering Branch
Designed by	CESAM-EN-E, Mobile District, Corps of Engineers
Prepared by	Joseph Ellsworth
Preparation Date	8/14/2008
Effective Date of Pricing	8/14/2008
Estimated Construction Time	Days

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project file:mscip-admiral-feasibility-14aug08.mlp

report file: mscip-feasibilty standard report selections.mrp

output file: mscip-admiral-feasibility-14aug08.doc

Date	Author	Note

Joseph H. Ellsworth

BASIS of COST ESTIMATE and RATIONALE

Feasibility Estimate is based on Historical Data, Recent Pricing, and Estimator's Judgment. Estimate is structured and priced as a General Prime contractor supported by major subcontractors. Anticipated bidding conditions and construction duration with reasonable schedules are considered Normal. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Current Contract Cost (price level Aug 08).

Price Level of Estimate is Aug 08.

Project Life is assumed as 50 years in Cost Estimate.

06 Feature Account, Preservation - Mitigation-Tidal quantites were based on impacts of new footprint plus mitigated factor which was determined and coordinated by other agencies. Unit cost were derived and based on historical data.

30 Feature Account, Planning, Engineering & Design was developed and assigned at 8% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Eight percent was used in the Interim MsCIP projects which was reviewed and approved and included in the Chief's Report.

31 Feature Account, Construction Management was developed and assigned at 6% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Six percent was used in the Interim MsCIP projects which was reviewed & approved and included in the Chief's Report.

Contingency was jointly developed and assigned by the Project Delivery Team. The Contingency percentage at 25% reflects the possibility of changes in quantity estimates and unknowns associated with the unit price. The contingency factor used does not vary throughout the cost estimate. It was determined and agreed upon by the Project Delivery Team that a high rate be used primarily due to risk, degree of confidence, and the project not being of the normal design.

Markups for subcontractors are included in the unit prices and include such items as field overheads, home office expenses, profit, bond and insurance.

Mobilization Preparatory Work & Demobilization are derived within the estimate generally at 2.5 % +- of construction cost excluding the Misc Items cost.

Miscellaneous Items represent cost where quantities were not available, such items as signage, construction site/staging restoration, silt fencing, site access, etc. These cost are derived within the estimate at .25 percent+- (.25%) of construction cost excluding Mob & Demob Cost

Unit Prices, for such items as site work, earthwork, etc., were based on Historical Data, Recent Pricing, Estimator's Judgment, and Cost derivation using MCACES / MII estimating systems.

8/5/2008 Joseph H. Ellsworth

Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Where quantities were not available, assumptions were made based on historical information and Estimator's judgment.

The following Contractor Markups are applied to the Cost to Prime Direct Cost:

Date	Author	Note

Contractor's Field Overhead @ 12%

Contractor's Home Office (G&A) @ 8%

Profit @ 10%

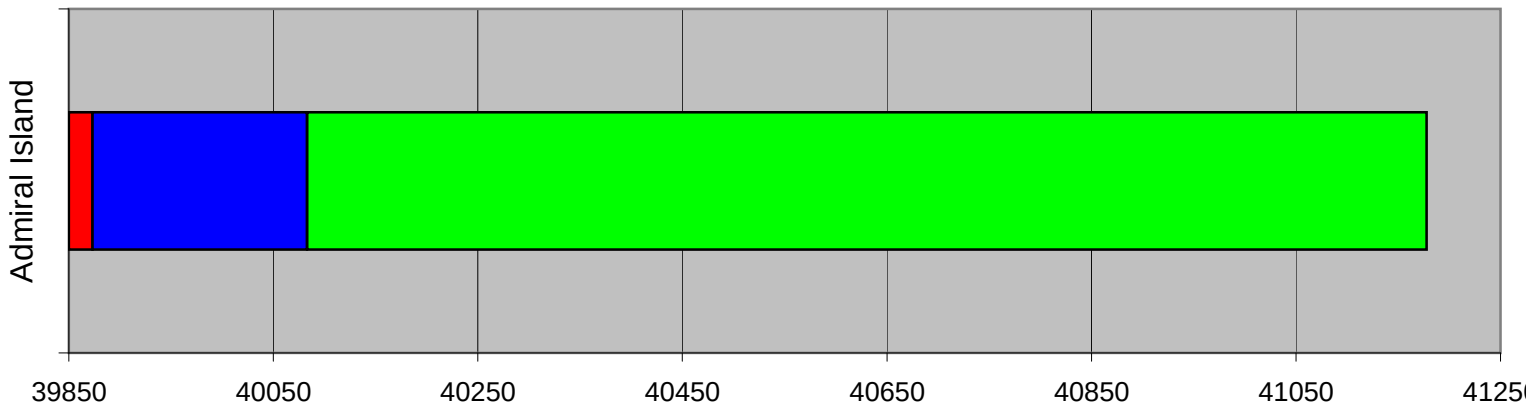
Bond @ 1.2%

Miss. Gross Receipts Tax @ 3.5%

Listed are all Cost Engineering Personnel that worked on the Feasibility Cost Estimate.
Joseph H. Ellsworth, Lead Cost Engineer
Gary Payton, Cost Engineer
George F. Rush, Civil Engineer, Dredging
Michael A. McKown, Geo Tech Engineer
Lloyd Oliver, Structural Engineer
Richard W. Harvey, Mechanical Engineer
John R. Thomas, Real Estate Specialist
Donald A. Whitmore, Civil Engineer- Non-Structural Estimates
Jennifer L. Jacobson, Environmentalist

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
Contract Cost Summary Report			**10,891,401**	**1,306,968**	**975,870**	**1,317,424**	**173,900**	**513,295**	**15,178,857**
01 Admiral Island, Hancock County - Environmental Restoration	**1.00**	**LS**	**10,891,401**	**1,306,968**	**975,870**	**1,317,424**	**173,900**	**513,295**	**15,178,857**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**10,891,401**	**1,306,968**	**975,870**	**1,317,424**	**173,900**	**513,295**	**15,178,857**
006 Fish & Wildlife	**1.00**	**LS**	**10,891,401**	**1,306,968**	**975,870**	**1,317,424**	**173,900**	**513,295**	**15,178,857**
01 Restore Wetlands	**1.00**	**LS**	**10,891,401**	**1,306,968**	**975,870**	**1,317,424**	**173,900**	**513,295**	**15,178,857**
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	200,000	24,000	17,920	24,192	3,193	9,426	278,731
			10.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*13.94*
USR Excavation of existing area from -.5 to +2.0	916,483.00	CY	9,164,830	1,099,780	821,169	1,108,578	146,332	431,924	12,772,613
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)									
			12.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*16.72*
USR Removal of roads(assume 24' wide)	3,500.00	LF	42,000	5,040	3,763	5,080	671	1,979	58,534
			35.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*48.78*
USR Remove utilties	3,500.00	LF	122,500	14,700	10,976	14,818	1,956	5,773	170,723
			2,700.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3,762.87*
USR Herbicide, application from truck	62.00	ACR	167,400	20,088	14,999	20,249	2,673	7,889	233,298
			4.25	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*5.92*
USR Filing of existing ditches & channels	7,000.00	CY	29,750	3,570	2,666	3,599	475	1,402	41,461
			2.15	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.00*
USR Environmental Planting	518,568.00	EA	1,114,921	133,791	99,897	134,861	17,802	52,544	1,553,816
(Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 432,140 plants plus 20% replacement = 518,568 plants. Material price fob job site @ $0.78/ea, Fertilizer @0.10/ea, Labor Cost @ $0.90/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.16 / plant. Use $2.15 / plant.)									
USR Misc site items	1.00	LS	50,000	6,000	4,480	6,048	798	2,356	69,683

Description	Quantity	UOM	SubBidCost	CostToPrime
Project Direct Costs Report			**10,891,401**	**10,891,401**
01 Admiral Island, Hancock County - Environmental Restoration	**1.00**	**LS**	**10,891,401**	**10,891,401**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**10,891,401**	**10,891,401**
006 Fish & Wildlife	**1.00**	**LS**	**10,891,401**	**10,891,401**
01 Restore Wetlands	**1.00**	**LS**	**10,891,401**	**10,891,401**
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	200,000	200,000
			10.00	*10.00*
USR Excavation of existing area from -.5 to +2.0	916,483.00	CY	9,164,830	9,164,830
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)				
			12.00	*12.00*
USR Removal of roads(assume 24' wide)	3,500.00	LF	42,000	42,000
			35.00	*35.00*
USR Remove utilties	3,500.00	LF	122,500	122,500
			2,700.00	*2,700.00*
USR Herbicide, application from truck	62.00	ACR	167,400	167,400
			4.25	*4.25*
USR Filing of existing ditches & channels	7,000.00	CY	29,750	29,750
			2.15	*2.15*
USR Environmental Planting	518,568.00	EA	1,114,921	1,114,921
(Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 432,140 plants plus 20% replacement = 518,568 plants. Material price fob job site @ $0.78/ea, Fertilizer @0.10/ea, Labor Cost @ $0.90/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.16 / plant. Use $2.15 / plant.)				
USR Misc site items	1.00	LS	50,000	50,000



The restoration site contains 62 acres of emergent tidal marsh to be restored by removing fill and planting native vegetation on 1-meter spacing and filling existing ditches. The remaining 61 acres of scrub shrub wetland habitat would remain. Due to the loss of native species this area has a severe infestation of the invasive Chinese Tallow tree, which is invading the marshes and the adjacent flatwoods. For increased habitat diversity, higher elevations containing shrub/scrub wetland plant species would remain in order to enhance diversity within the restoration site with 100% removal of exotics from non-excavated areas. The design will start in March of 2009, the award will be in October, 2009, and the completion will be October, 2012.

Design
Period of Performance

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Bayou Cumbest -Environmental Restoration, Restore Wetlands DISTRICT: MOBILE

LOCATION: Jackson County, Mississippi P.O.C.: Joseph H. Ellsworth

ACCOUNT NUMI	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages	4,831,603	1,207,901	25%	6,039,504	4,831,603	1,207,901	6,039,504	4,933,067	1,233,267	6,166,334
06---	Fish & Wildlife -Restore Wetlands ***(Bayou Cumbest)***	13,564,000	3,391,000	25%	16,955,000	13,564,000	3,391,000	16,955,000	14,567,736	3,641,934	18,209,670
30---	PLANNING, ENGINEERING & DESIGN	1,085,120	271,280	25%	1,356,400	1,085,120	271,280	1,356,400	1,107,908	276,977	1,384,885
31---	CONSTRUCTION MANAGEMENT	813,840	203,460	25%	1,017,300	813,840	203,460	1,017,300	874,064	218,516	1,092,580
	TOTAL PROJECT COST =======>	**20,294,563**	**5,073,641**		**25,368,204**	**20,294,563**	**5,073,641**	**25,368,204**	**21,482,775**	**5,370,694**	**26,853,469**

rounded

65%	**TOTAL FEDERAL COSTS ==========>**	**$17,485,000**
35%	**TOTAL NON - FEDERAL COSTS ======>**	**$9,415,000**
	TOTAL PROJECT COSTS ==========>	**$26,900,000**

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Bayou Cumbest -Environmental Restoration, Restore Wetlands DISTRICT: MOBILE

LOCATION: Jackson County, Mississippi P.O.C.: Joseph H. Ellsworth

ACCOUNT No.	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages (price level, Oct 07)	4,831,603	1,207,901	25%	6,039,504	0.0%	4,831,603	1,207,901	6,039,504	Sep 09	2.1%	4,933,067	1,233,267	6,166,334
	Subtotal	4,831,603	1,207,901		6,039,504		4,831,603	1,207,901	6,039,504			4,933,067	1,233,267	6,166,334
06---	Fish & Wildlife -Restore Wetlands	13,564,000	3,391,000	25%	16,955,000	0.0%	13,564,000	3,391,000	16,955,000	Jan 12	7.4%	14,567,736	3,641,934	18,209,670
30---	PLANNING, ENGINEERING & DESIGN, 8%+-	1,085,120	271,280	25%	1,356,400	0.0%	1,085,120	271,280	1,356,400	Sep 09	2.1%	1,107,908	276,977	1,384,885
31---	CONSTRUCTION MANAGEMENT, 6% +-	813,840	203,460	25%	1,017,300	0.0%	813,840	203,460	1,017,300	Jan 12	7.4%	874,064	218,516	1,092,580
	Subtotal	15,462,960	3,865,740		19,328,700		15,462,960	3,865,740	19,328,700			16,549,708	4,137,427	20,687,135

4. Native Vegetation Planting at 1 meter spacing

3. Filling in 100% of existing artificial ditches/channels

2. 100% removal of exotics from non-excavated areas and maintain removal of exotic species (Chinese Tallow, Phragmites, Cogon Grass) in all areas over project lifetime. (Mandatory in all plans).

1. Excavation of old fill material (includes 90-95% removal of existing exotic species in excavated areas) (Mandatory)

The restoration project consists of 110 acres to be restored to tidal marsh and while the remaining 38 acres would remain scrub/shrub wetland habitat. The area presently consists of previously filled marsh areas that were developed into a residential community. The majority of residences were severely damaged or completely destroyed during the hurricanes of 2005. The following measures were developed:

Bayou Cumbest

Price Level ly Aug 08

FEASIBILITY STUDY

Estimated by	CESAM-EN-E, Cost Engineering Branch
Designed by	CESAM-EN-E, Mobile District, Corps of Engineers
Prepared by	Joseph Ellsworth
Preparation Date	8/14/2008
Effective Date of Pricing	8/14/2008
Estimated Construction Time	Days

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project file:mscip-bayou cumbest-feasibility-14aug08.mlp

report file: mscip-feasibilty standard report selections.mrp

output file: mscip-bayou cumbest-feasibility-14aug08.doc

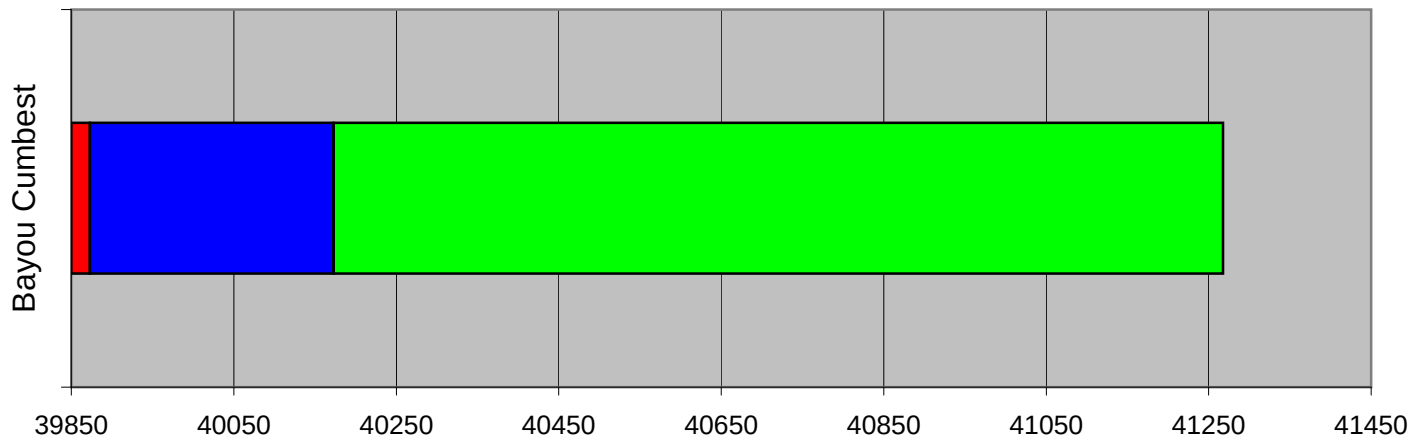
Date	Author	Note
	Joseph H. Ellsworth	BASIS of COST ESTIMATE and RATIONALE Feasibility Estimate is based on Historical Data, Recent Pricing, and Estimator's Judgment. Estimate is structured and priced as a General Prime contractor supported by major subcontractors. Anticipated bidding conditions and construction duration with reasonable schedules are considered Normal. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Current Contract Cost (price level Aug 08). Price Level of Estimate is Aug 08. Project Life is assumed as 50 years in Cost Estimate. 30 Feature Account, Planning, Engineering & Design was developed and assigned at 8% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Eight percent was used in the Interim MsCIP projects which was reviewed and approved and included in the Chief's Report. 31 Feature Account, Construction Management was developed and assigned at 6% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Six percent was used in the Interim MsCIP projects which was reviewed & approved and included in the Chief's Report. Contingency was jointly developed and assigned by the Project Delivery Team. The Contingency percentage at 25% reflects the possibility of changes in quantity estimates and unknowns associated with the unit price. The contingency factor used does not vary throughout the cost estimate. It was determined and agreed upon by the Project Delivery Team that a high rate be used primarily due to risk, degree of confidence, and the project not being of the normal design. Markups for subcontractors are included in the unit prices and include such items as field overheads, home office expenses, profit, bond and insurance. Mobilization Preparatory Work & Demobilization are derived within the estimate generally at 2.5 % +- of construction cost excluding the Misc Items cost. Miscellaneous Items represent cost where quantities were not available, such items as signage, construction site/staging restoration, silt fencing, site access, etc. These cost are derived within the estimate at .25 percent +-(.25%) of construction cost excluding Mob & Demob Cost Unit Prices, for such items as site work, earthwork, planting, etc., were based on Historical Data, Recent Pricing, Estimator's Judgment, and Cost derivation using MCACES / MII estimating systems.
8/5/2008	Joseph H. Ellsworth	The following Contractor Markups are applied to the Cost to Prime Direct Cost: Contractor's Field Overhead @ 12% Contractor's Home Office (G&A) @ 8% Profit @ 10% Bond @ 1.2% Miss. Gross Receipts Tax @ 3.5% Listed are all Cost Engineering Personnel that worked on the Feasibility Cost Estimate.

Date	Author	Note

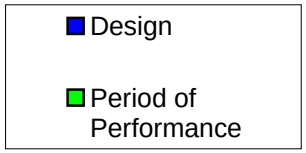
Joseph H. Ellsworth, Lead Cost Engineer
Gary Payton, Cost Engineer
George F. Rush, Civil Engineer, Dredging
Michael A. McKown, Geo Tech Engineer
Lloyd Oliver, Structural Engineer
Richard W. Harvey, Mechanical Engineer
John R. Thomas, Real Estate Specialist
Donald A. Whitmore, Civil Engineer- Non-Structural Estimates
Jennifer L. Jacobson, Environmentalist

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
Contract Cost Summary Report			**9,732,957**	**1,167,955**	**872,073**	**1,177,298**	**155,403**	**458,699**	**13,564,385**
01 Bayou Cumbest Area 34, Environmental Restoration	**1.00**	**LS**	**9,732,957**	**1,167,955**	**872,073**	**1,177,298**	**155,403**	**458,699**	**13,564,385**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**9,732,957**	**1,167,955**	**872,073**	**1,177,298**	**155,403**	**458,699**	**13,564,385**
006 Fish & Wildlife	**1.00**	**LS**	**9,732,957**	**1,167,955**	**872,073**	**1,177,298**	**155,403**	**458,699**	**13,564,385**
			88,481.43						*123,312.59*
01 Restore Wetlands	**110.00**	**ACR**	**9,732,957**	**1,167,955**	**872,073**	**1,177,298**	**155,403**	**458,699**	**13,564,385**
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	250,000	30,000	22,400	30,240	3,992	11,782	348,414
			10.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*13.94*
USR Removal Excavation Existing Area From -0.5 to+2.0	693,909.00	CY	6,939,090	832,691	621,742	839,352	110,795	327,028	9,670,699
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)									
			3.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*4.18*
USR Removal of Structures Avg. 1500SF@18EA	27,000.00	SF	81,000	9,720	7,258	9,798	1,293	3,817	112,886
			2.15	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.00*
USR Removal Disposal Fee	1,000.00	CY	2,150	258	193	260	34	101	2,996
			12.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*16.72*
USR Removal of Roads 24FT Wide Assumed	6,439.00	LF	77,268	9,272	6,923	9,346	1,234	3,642	107,685
			35.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*48.78*
USR Removal of Utilities	6,439.00	LF	225,365	27,044	20,193	27,260	3,598	10,621	314,081
			2,700.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3,762.87*
USR Herbicide, Hand Application Untouched Areas	32.00	ACR	86,400	10,368	7,741	10,451	1,380	4,072	120,412
			4.25	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*5.92*
USR Filling of Existing Ditches & Channels(from req'd. excavation)	2,023.00	CY	8,598	1,032	770	1,040	137	405	11,982
			2.15	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.00*
USR Environmental Planting	920,040.00	EA	1,978,086	237,370	177,237	239,269	31,584	93,224	2,756,770
(Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 766,700 plants plus 20% replacement = 920,040 plants. Material price fob job site @ $0.78/ea, Fertilizer @0.10/ea, Labor Cost @ $0.90/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.16 / plant. Use $2.15 / plant.)									
USR Miscellaneous Site Items	1.00	LS	85,000	10,200	7,616	10,282	1,357	4,006	118,461

Description	Quantity	UOM	SubBidCost	CostToPrime
Project Direct Costs Report			**9,732,957**	**9,732,957**
01 Bayou Cumbest Area 34, Environmental Restoration	**1.00**	**LS**	**9,732,957**	**9,732,957**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**9,732,957**	**9,732,957**
006 Fish & Wildlife	**1.00**	**LS**	**9,732,957**	**9,732,957**
			88,481.43	*88,481.43*
01 Restore Wetlands	**110.00**	**ACR**	**9,732,957**	**9,732,957**
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	250,000	250,000
			10.00	*10.00*
USR Removal Excavation Existing Area From -0.5 to+2.0 (Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)	693,909.00	CY	6,939,090	6,939,090
			3.00	*3.00*
USR Removal of Structures Avg. 1500SF@18EA	27,000.00	SF	81,000	81,000
			2.15	*2.15*
USR Removal Disposal Fee	1,000.00	CY	2,150	2,150
			12.00	*12.00*
USR Removal of Roads 24FT Wide Assumed	6,439.00	LF	77,268	77,268
			35.00	*35.00*
USR Removal of Utilities	6,439.00	LF	225,365	225,365
			2,700.00	*2,700.00*
USR Herbicide, Hand Application Untouched Areas	32.00	ACR	86,400	86,400
			4.25	*4.25*
USR Filling of Existing Ditches & Channels(from req'd. excavation)	2,023.00	CY	8,598	8,598
			2.15	*2.15*
USR Environmental Planting (Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 766,700 plants plus 20% replacement = 920,040 plants. Material price fob job site @ $0.78/ea, Fertilizer @0.10/ea, Labor Cost @ $0.90/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.16 / plant. Use $2.15 / plant.)	920,040.00	EA	1,978,086	1,978,086
USR Miscellaneous Site Items	1.00	LS	85,000	85,000



The restoration project consists of 110 acres to be restored to tidal marsh and while the remaining 38 acres would remain scrub/shrub wetland habitat. The area was previously filled marsh areas that were developed into a residential community. Fill will be removed and existing exotic plant species will be removed. Existing ditches will be filled. Marsh vegetation will be planted in excavated areas at 1 meter spacing. The design will start in March of 2009, the award will be in Janurary, 2010, and the completion will be Janurary, 2013.



TOTAL PROJECT **** TOTAL PROJECT COST SUMMARY ****

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Franklin Creek -Environmental Restoration, Restore Wetlands DISTRICT: MOBILE

LOCATION: Jackson County, Mississippi P.O.C.: Joseph H. Ellsworth

ACCOUNT NUMI	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages	25,000	6,250	25%	31,250	25,000	6,250	31,250	25,525	6,381	31,906
06---	Fish & Wildlife -Restore Wetlands ***(Franklin Creek)***	1,271,000	317,750	25%	1,588,750	1,271,000	317,750	1,588,750	1,365,054	341,264	1,706,318
30---	PLANNING, ENGINEERING & DESIGN	101,680	25,420	25%	127,100	101,680	25,420	127,100	103,815	25,954	129,769
31---	CONSTRUCTION MANAGEMENT	76,260	19,065	25%	95,325	76,260	19,065	95,325	81,903	20,476	102,379
	TOTAL PROJECT COST =======>	**1,473,940**	**368,485**		**1,842,425**	**1,473,940**	**368,485**	**1,842,425**	**1,576,297**	**394,075**	**1,970,372**

rounded

65% **TOTAL FEDERAL COSTS ============>** **$1,300,000**

35% **TOTAL NON - FEDERAL COSTS ======>** **$700,000**

TOTAL PROJECT COSTS ============> **$2,000,000**

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

****** TOTAL CONTRACT COST SUMMARY ******

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Franklin Creek -Environmental Restoration, Restore Wetlands DISTRICT: MOBILE

LOCATION: Jackson County, Mississippi P.O.C.: Joseph H. Ellsworth

	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08					AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT No.	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages (PCA)	25,000	6,250	25%	31,250	0.0%	25,000	6,250	31,250	Sep 09	2.1%	25,525	6,381	31,906
	Subtotal	25,000	6,250		31,250		25,000	6,250	31,250			25,525	6,381	31,906
06---	Fish & Wildlife -Restore Wetlands	1,271,000	317,750	25%	1,588,750	0.0%	1,271,000	317,750	1,588,750	Jan 12	7.4%	1,365,054	341,264	1,706,318
30---	PLANNING, ENGINEERING & DESIGN, 8%+-	101,680	25,420	25%	127,100	0.0%	101,680	25,420	127,100	Sep 09	2.1%	103,815	25,954	129,769
31---	CONSTRUCTION MANAGEMENT, 6% +-	76,260	19,065	25%	95,325	0.0%	76,260	19,065	95,325	Jan 12	7.4%	81,903	20,476	102,379
	Subtotal	1,448,940	362,235		1,811,175		1,448,940	362,235	1,811,175			1,550,772	387,694	1,938,466

4. Add culverts (Mandatory)

3. Excavate and remove existing roadbeds and any additional fill (Mandatory)

2. Maintain vegetation (Mandatory) by mowing 1st year and Burn 1st year; Burn every 3 years for life of project.

1. Filling in ditches (Mandatory)

The restoration site is an interim buy-out project currently being implemented. The site consists of 149 acres bisected by an elevated railroad atop an earthen berm. The site received severe flood damages during the hurricanes of 2005 and previous storm events. Historically, the site consisted of pine savannah wetlands. It is assumed that removal of utilities, building slabs, and roadways would be completed as part of the ongoing interim project. The following restoration measures were developed:

Franklin Creek

Price Level Aug 08

FEASIBILITY STUDY

Estimated by CESAM-EN-E, Cost Engineering Branch

Designed by CESAM-EN-E, Mobile District, Corps of Engineers

Prepared by Joseph H. Ellsworth

Preparation Date 8/8/2008

Effective Date of Pricing 8/8/2008

Estimated Construction Time Days

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project file: franklin-feasibility-aug08.mlp

report file: feasibilty standard report.mrp

output file: franklin-feasibility-aug08.doc

Date	Author	Note

Joseph H. Ellsworth

BASIS of COST ESTIMATE and RATIONALE

Feasibility Estimate is based on Historical Data, Recent Pricing, and Estimator's Judgment. Estimate is structured and priced as a General Prime contractor supported by major subcontractors. Anticipated bidding conditions and construction duration with reasonable schedules are considered Normal. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Current Contract Cost (price level Aug 08). The Non-structural and Real Estate Cost were prepared by the Savannah & Huntington Districts.

Price Level of Estimate is Aug 08.

Project Life is assumed as 50 years in Cost Estimate.

30 Feature Account, Planning, Engineering & Design was developed and assigned at 8% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Eight percent was used in the Interim MsCIP projects which was reviewed and approved and included in the Chief's Report.

31 Feature Account, Construction Management was developed and assigned at 6% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Six percent was used in the Interim MsCIP projects which was reviewed & approved and included in the Chief's Report.

Contingency was jointly developed and assigned by the Project Delivery Team. The Contingency percentage at 25% reflects the possibility of changes in quantity estimates and unknowns associated with the unit price. The contingency factor used does not vary throughout the cost estimate. It was determined and agreed upon by the Project Delivery Team that a high rate be used primarily due to risk, degree of confidence, and the project not being of the normal design.

Markups for subcontractors are included in the unit prices and include such items as field overheads, home office expenses, profit, bond and insurance.

Mobilization Preparatory Work & Demobilization are derived within the estimate generally at 2.5 % +- of construction cost excluding the Misc Items cost.

Miscellaneous Items represent cost where quantities were not available, such items as signage, construction site/staging restoration, silt fencing, site access, etc. These cost are derived within the estimate at .25 percent (.25%) of construction cost excluding Mob & Demob Cost

Unit Prices, for such items as site work, earthwork, stone protection, concrete, reinforcing, etc., were based on Historical Data, Recent Pricing, Estimator's Judgment, and Cost derivation using MCACES / MII estimating systems.

8/5/2008 Joseph H. Ellsworth

The following Contractor Markups are applied to the Cost to Prime Direct Cost:

Contractor's Field Overhead @ 12%

Contractor's Home Office (G&A) @ 8%

Date	Author	Note

Profit @ 10%

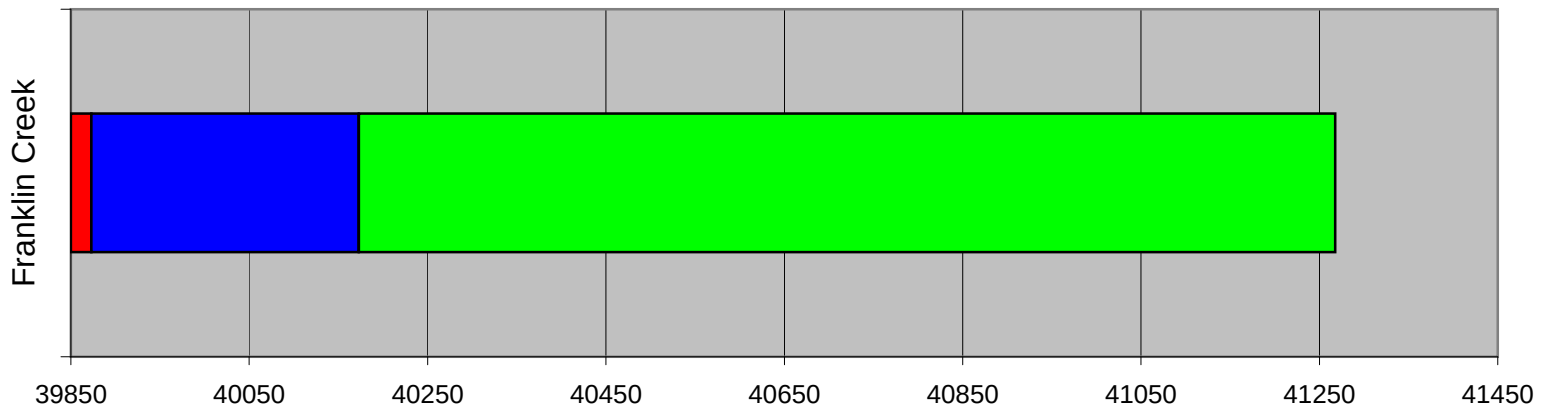
Bond @ 1.2%

Miss. Gross Receipts Tax @ 3.5%

Listed are all Cost Engineering Personnel that worked on the Feasibility Cost Estimate.
Joseph H. Ellsworth, Lead Cost Engineer
Gary Payton, Cost Engineer
George F. Rush, Civil Engineer, Dredging
Michael A. McKown, Geo Tech Engineer
Lloyd Oliver, Structural Engineer
Richard W. Harvey, Mechanical Engineer
John R. Thomas, Real Estate Specialist
Donald A. Whitmore, Civil Engineer- Non-Structural Estimates
Jennifer L. Jacobson, Environmentalist

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
Contract Cost Summary Report			**912,045**	**109,445**	**81,719**	**110,321**	**14,562**	**42,983**	**1,271,076**
01 Franklin Creek, Jackson County - Environmental Restoration	**1.00**	**LS**	**912,045**	**109,445**	**81,719**	**110,321**	**14,562**	**42,983**	**1,271,076**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**912,045**	**109,445**	**81,719**	**110,321**	**14,562**	**42,983**	**1,271,076**
006 Fish & Wildlife	**1.00**	**LS**	**912,045**	**109,445**	**81,719**	**110,321**	**14,562**	**42,983**	**1,271,076**
01 Restore Wetlands	**1.00**	**LS**	**912,045**	**109,445**	**81,719**	**110,321**	**14,562**	**42,983**	**1,271,076**
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)									
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	40,000	4,800	3,584	4,838	639	1,885	55,746
			100.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*139.37*
USR 24" RCP culverts, (15@100' long ea)	1,500.00	LF	150,000	18,000	13,440	18,144	2,395	7,069	209,048
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)									
			9.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*13.59*
USR Fill in ditches(from off-site borrow)	26,000.00	CY	253,500	30,420	22,714	30,663	4,048	11,947	353,292
			130.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*181.18*
USR Burn vegetation	149.00	ACR	19,370	2,324	1,736	2,343	309	913	26,995
			75.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*104.52*
USR Mow vegetation(annually)	149.00	ACR	11,175	1,341	1,001	1,352	178	527	15,574
			12.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*16.72*
USR Remove roads(assume 24' wide)	9,000.00	LF	108,000	12,960	9,677	13,064	1,724	5,090	150,515
			35.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*48.78*
USR Remove utilties	9,000.00	LF	315,000	37,800	28,224	38,102	5,030	14,845	439,001
USR Misc site items	1.00	LS	15,000	1,800	1,344	1,814	240	707	20,905

Description	Quantity	UOM	SubBidCost	CostToPrime
Project Direct Costs Report			**912,045**	**912,045**
01 Franklin Creek, Jackson County - Environmental Restoration	**1.00**	**LS**	**912,045**	**912,045**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**912,045**	**912,045**
006 Fish & Wildlife	**1.00**	**LS**	**912,045**	**912,045**
01 Restore Wetlands	**1.00**	**LS**	**912,045**	**912,045**
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)				
USR Mobilization, Preparatory Work, & Demobilization	1.00	LS	40,000	40,000
			100.00	*100.00*
USR 24" RCP culverts, (15@100' long ea)	1,500.00	LF	150,000	150,000
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)				
			9.75	*9.75*
USR Fill in ditches(from off-site borrow)	26,000.00	CY	253,500	253,500
			130.00	*130.00*
USR Burn vegetation	149.00	ACR	19,370	19,370
			75.00	*75.00*
USR Mow vegetation(annually)	149.00	ACR	11,175	11,175
			12.00	*12.00*
USR Remove roads(assume 24' wide)	9,000.00	LF	108,000	108,000
			35.00	*35.00*
USR Remove utilties	9,000.00	LF	315,000	315,000
USR Misc site items	1.00	LS	15,000	15,000



The restoration site is an interim buy-out project currently being implemented. The site consists of 149 acres bisected by an elevated railroad atop an earthen berm. Historically, the site consisted of pine savannah wetlands. It is assumed that removal of utilities, building slabs, and roadways would be completed as part of the ongoing interim project. Additional restoration measures consist of filling in ditches, removing existing roadbeds and any additional fill, mowing and burning to control exotic plant species and adding culverts to improve hydrology. The design will start in March of 2009, the award will be in Janurary, 2010, and the completion will be Janurary, 2013.

Design

Period of Performance

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Deer Island Ecosystem Restoration DISTRICT: MOBILE

LOCATION: Mississippi P.O.C.: Joseph H. Ellsworth

ACCOUNT NUMI	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages	25,000	6,250	25%	31,250	25,000	6,250	31,250	25,400	6,350	31,750
06---	Fish & Wildlife -Restore Wetlands ***(Deer Island Ecosystem Restoration)***	14,964,000	3,741,000	25%	18,705,000	14,964,000	3,741,000	18,705,000	16,071,336	4,017,834	20,089,170
30---	PLANNING, ENGINEERING & DESIGN	1,197,120	299,280	25%	1,496,400	1,197,120	299,280	1,496,400	1,237,822	309,456	1,547,278
31---	CONSTRUCTION MANAGEMENT	897,840	224,460	25%	1,122,300	897,840	224,460	1,122,300	964,280	241,070	1,205,350
	TOTAL PROJECT COST =======>	**17,083,960**	**4,270,990**		**21,354,950**	**17,083,960**	**4,270,990**	**21,354,950**	**18,298,838**	**4,574,710**	**22,873,548**

rounded

65%	**TOTAL FEDERAL COSTS ==========>**	**$14,885,000**
35%	**TOTAL NON - FEDERAL COSTS ======>**	**$8,015,000**
	TOTAL PROJECT COSTS ==========>	**$22,900,000**

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

****** TOTAL CONTRACT COST SUMMARY ******

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Deer Island Ecosystem Restoration

DISTRICT: MOBILE

LOCATION: Mississippi

P.O.C.: Joseph H. Ellsworth

	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08					AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT No.	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages (PCA)	25,000	6,250	25%	31,250	0.0%	25,000	6,250	31,250	Jun 09	1.6%	25,400	6,350	31,750
	Subtotal	25,000	6,250		31,250		25,000	6,250	31,250			25,400	6,350	31,750
06---	Fish & Wildlife -Restore Wetlands	14,964,000	3,741,000	25%	18,705,000	0.0%	14,964,000	3,741,000	18,705,000	Jan 12	7.4%	16,071,336	4,017,834	20,089,170
30---	PLANNING, ENGINEERING & DESIGN, 8%+-	1,197,120	299,280	25%	1,496,400	0.0%	1,197,120	299,280	1,496,400	Jun 09	3.4%	1,237,822	309,456	1,547,278
31---	CONSTRUCTION MANAGEMENT, 6% +-	897,840	224,460	25%	1,122,300	0.0%	897,840	224,460	1,122,300	Jan 12	7.4%	964,280	241,070	1,205,350
	Subtotal	17,058,960	4,264,740		21,323,700		17,058,960	4,264,740	21,323,700			18,273,438	4,568,360	22,841,798

Create additional marsh habitat area adjacent to the existing created marsh area.

Lengthen stone containment dikes on northern and southern ends as a result of Section 204; and

Analyze new stone training dikes on the northern and southern ends of the islands as a result of Section 204;

Add/Replace material in the Section 204 containment dike;

Repair/Replace the Section 204 containment dike;

Deer Island restoration consists of a combination of the following alternatives to form the recommended plan:

Deer Island also includes the following aspects in the MsCIP effort.

The proposed project for Deer Island will provide for ecosystem restoration as well as preservation of critical coastal wetlands by restoring portions of the island and its shoreline lost during storm events. The island also provides storm protection from surge, wave action and wind for the adjacent coastal portion of the City of Biloxi, Mississippi. The proposed project will consist of three components: shoreline restoration in the Grand Bayou area of Deer Island with beach, dune, marsh and maritime forest reestablishment; restoration of the west end breach area with reestablishment of maritime forest area; and, restoration of the remaining shoreline areas along the seaward shoreline with beach, dune, marsh and maritime forest reestablishment. Fill material will be obtained from an offshore borrow area located approximately 500 feet off the southern shoreline of Deer Island. The offshore borrow area adjacent to the island would be approximately 1,000 feet wide, 6 feet deep, with a distance equal to the length of the project area. The borrow site is far enough from and is of sufficiently shallow depth to not affect shoreline stability. The wind and wave attack at Deer Island is generally southwest to northeast which is expected to push material along the shoreline. Material from the borrow area will be cast on the existing shoreline for beach nourishment via a hydraulic dredge. After filling, environmental plantings will be made to establish the maritime forest and aquatic marsh in the restored area.

Price Level	Aug 08
Estimated by	CESAM-EN-E, Cost Engineering Branch
Designed by	CESAM-EN-E, Mobile District, Corps of Engineers
Prepared by	Joseph Ellsworth
Preparation Date	8/14/2008
Effective Date of Pricing	8/14/2008
Estimated Construction Time	Days

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project file: mscip-deer island-feasibility-14aug08.mlp

report file: MSCIP-feasibilty standard report selection.mrp

output file: mscip-deer islands-feasibility-14aug08.doc

Estimated by	CESAM-EN-E, Cost Engineering Branch
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Date	Author	Note
	Joseph H. Ellsworth	BASIS of COST ESTIMATE and RATIONALE Feasibility Estimate is based on Historical Data, Recent Pricing, and Estimator's Judgment. Estimate is structured and priced as a General Prime contractor supported by major subcontractors. Anticipated bidding conditions and construction duration with reasonable schedules are considered Normal. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Current Contract Cost (price level Aug 08). The Non-structural and Real Estate Cost were prepared by the Savannah & Huntington Districts. Price Level of Estimate is Aug 08. Project Life is assumed as 50 years in Cost Estimate. 30 Feature Account, Planning, Engineering & Design was developed and assigned at 8% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Eight percent was used in the Interim MsCIP projects which was reviewed and approved and included in the Chief's Report. 31 Feature Account, Construction Management was developed and assigned at 6% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Six percent was used in the Interim MsCIP projects which was reviewed & approved and included in the Chief's Report. Contingency was jointly developed and assigned by the Project Delivery Team. The Contingency percentage at 25% reflects the possibility of changes in quantity estimates and unknowns associated with the unit price. The contingency factor used does not vary throughout the cost estimate. It was determined and agreed upon by the Project Delivery Team that a high rate be used primarily due to risk, degree of confidence, and the project not being of the normal design. Markups for subcontractors are included in the unit prices and include such items as field overheads, home office expenses, profit, bond and insurance. Mobilization Preparatory Work & Demobilization are derived within the CEDEP estimate for the Dredging work and the land based equipment is based on recent on-going project at the proposed site. Miscellaneous Items represent cost where quantities were not available, such items as signage, construction site/staging restoration, silt fencing, site access, etc. These cost are derived within the estimate at .25 percent (.25%) of construction cost excluding Mob & Demob Cost Unit Prices, for such items as site work, earthwork, planting, etc., were based on Historical Data, Recent Pricing, Estimator's Judgment, and Cost derivation using MCACES / MII estimating systems.
8/5/2008	Joseph H. Ellsworth	The following Contractor Markups are applied to the Cost to Prime Direct Cost: Contractor's Field Overhead @ 12%

Date	Author	Note

Contractor's Home Office (G&A) @ 8%

Profit @ 10%

Bond @ 1.2%

Miss. Gross Receipts Tax @ 3.5%

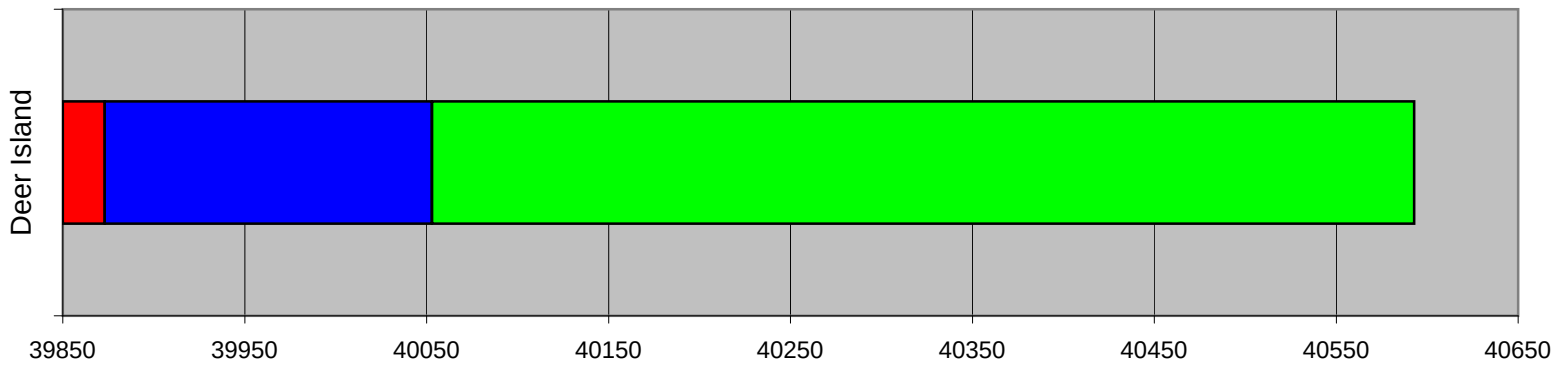
Listed are all Cost Engineering Personnel that worked on the Feasibility Cost Estimate.
Joseph H. Ellsworth, Lead Cost Engineer
Gary Payton, Cost Engineer
George F. Rush, Civil Engineer, Dredging
Michael A. McKown, Geo Tech Engineer
Lloyd Oliver, Structural Engineer
Richard W. Harvey, Mechanical Engineer
John R. Thomas, Real Estate Specialist
Donald A. Whitmore, Civil Engineer- Non-Structural Estimates
Jennifer L. Jacobson, Environmentalist

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
Contract Cost Summary Report			**10,737,186**	**1,288,462**	**962,052**	**1,298,770**	**171,438**	**506,027**	**14,963,934**
01 Deer Island-Aquatic Ecosystem Restoration	**1.00**	**LS**	**10,737,186**	**1,288,462**	**962,052**	**1,298,770**	**171,438**	**506,027**	**14,963,934**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**10,737,186**	**1,288,462**	**962,052**	**1,298,770**	**171,438**	**506,027**	**14,963,934**
006 Fish & Wildlife	**1.00**	**LS**	**10,737,186**	**1,288,462**	**962,052**	**1,298,770**	**171,438**	**506,027**	**14,963,934**
01 Ecosystem Restoration	**1.00**	**LS**	**10,737,186**	**1,288,462**	**962,052**	**1,298,770**	**171,438**	**506,027**	**14,963,934**
Mobilization, Preparatory Work, & Demobilization	**1.00**	**LS**	**1,200,000**	**144,000**	**107,520**	**145,152**	**19,160**	**56,554**	**1,672,386**
USR Mobilization, Preparatory Work, Demobilizaiton(Dredge Plant, 27")	1.00	LS	950,000	114,000	85,120	114,912	15,168	44,772	1,323,972
USR Mobilization, Preparatory Work, Demobilization(Land Base Equipment)	1.00	LS	250,000	30,000	22,400	30,240	3,992	11,782	348,414
Seaward Shoreline	**1.00**	**LS**	**4,798,722**	**575,847**	**429,965**	**580,453**	**76,620**	**226,156**	**6,687,763**
			5.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*6.97*
USR Beach Fill, in-place, 27" Dredge	400,000.00	CY	2,000,000	240,000	179,200	241,920	31,933	94,257	2,787,310
(Note: Unit Cost based a recent on-going project at existing project proforming similar work. Work is being performed by a 27" pipeline dredge.)									
			3,400.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*4,738.43*
USR Grade/Shape Berm, small Dozer-Trackhoe Work	120.00	DAY	408,000	48,960	36,557	49,352	6,514	19,228	568,611
			2.80	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.90*
USR Environmental Planting (Marsh Grass)	652,392.00	EA	1,826,698	219,204	163,672	220,957	29,166	86,089	2,545,787
(Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 543,660 plants plus 20% replacement = 652,392 plants. Material price fob job site @ $0.95/ea, Fertilizer @ $0.10/ea, Labor Cost @ $1.25/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.78/plant. Use $2.80 / plant.)									
			2.20	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.07*
USR Environmental Planting (SeaOats)	250,920.00	EA	552,024	66,243	49,461	66,773	8,814	26,016	769,331
(Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 209,100 plants plus 20% replacement = 250,920 plants. Material price fob job site @ $0.46/ea, Fertilizer @0.10/ea, Labor Cost @ $1.25/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.19/plant. Use $2.20 / plant.)									
USR Misc. Site Items	1.00	LS	12,000	1,440	1,075	1,452	192	566	16,724
Repair/Replace Containment Dike	**1.00**	**LS**	**430,000**	**51,600**	**38,528**	**52,013**	**6,866**	**20,265**	**599,272**
			5.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*6.97*
USR Fill, in-place, 27" Dia. Dredge	4,200.00	CY	21,000	2,520	1,882	2,540	335	990	29,267
			3,400.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*4,738.43*
USR Grade/Shape Berm, small Dozer-Trackhoe Work	120.00	DAY	408,000	48,960	36,557	49,352	6,514	19,228	568,611
USR Misc. Site Items	1.00	LS	1,000	120	90	121	16	47	1,394
Add Material to Containment Area	**1.00**	**LS**	**1,243,030**	**149,164**	**111,375**	**150,357**	**19,847**	**58,582**	**1,732,355**
			5.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*6.97*
USR Fill, in-place, 27" Dia. Dredge	100,000.00	CY	500,000	60,000	44,800	60,480	7,983	23,564	696,828
			3,400.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*4,738.43*
USR Grade/Shape Berm, small Dozer-Trackhoe Work	15.00	DAY	51,000	6,120	4,570	6,169	814	2,404	71,076
			2.75	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.83*
USR Environmental Planting(Marsh Plants	250,920.00	EA	690,030	82,804	61,827	83,466	11,018	32,520	961,664
(Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 209,100 plants plus 20% replacement = 250,920 plants. Material price fob job site @ $0.93/ea, Fertilizer @ $0.10/ea, Labor Cost @ $1.25/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.76/plant. Use $2.75 / plant.)									
USR Misc. Site Items	1.00	LS	2,000	240	179	242	32	94	2,787

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
Lengthen Stone Breakwater	**1.00**	**LS**	**888,050**	**106,566**	**79,569**	**107,419**	**14,179**	**41,852**	**1,237,635**
USR Analyze Stone Breakwater	1.00	LS	45,000	5,400	4,032	5,443	719	2,121	62,714
			5.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*6.97*
USR Fill, in-place, 27" Dia. Dredge	91,000.00	CY	455,000	54,600	40,768	55,037	7,265	21,443	634,113
			3,400.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*4,738.43*
USR Grade/Shape Berm, small Dozer-Trackhoe Work	30.00	DAY	102,000	12,240	9,139	12,338	1,629	4,807	142,153
			2.50	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.48*
USR Filter Fabric	1,500.00	SY	3,750	450	336	454	60	177	5,226
			93.50	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*130.31*
USR Riprap	3,000.00	CY	280,500	33,660	25,133	33,929	4,479	13,220	390,920
USR Misc. Site Items	1.00	LS	1,800	216	161	218	29	85	2,509
Create Additional Marsh Area	**1.00**	**LS**	**2,177,384**	**261,286**	**195,094**	**263,376**	**34,766**	**102,617**	**3,034,522**
			5.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*6.97*
USR Beach Fill, in-place, 27" Dia. Dredge	300,000.00	CY	1,500,000	180,000	134,400	181,440	23,950	70,693	2,090,483
			3,400.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*4,738.43*
USR Grade/Shape Berm, small Dozer-Trackhoe Work	60.00	DAY	204,000	24,480	18,278	24,676	3,257	9,614	284,306
			2.80	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*3.90*
USR Environmental Planting(Marsh Grass)	167,280.00	EA	468,384	56,206	41,967	56,656	7,479	22,074	652,766
(Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 139,400 plants plus 20% replacement = 167280 plants. Material price fob job site @ $0.96/ea, Fertilizer @ $0.10/ea, Labor Cost @ $1.25/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.80/plant. Use $2.80 / plant.)										
USR Misc. Site Items	1.00	LS	5,000	600	448	605	80	236	6,968

Description	Quantity	UOM	SubBidCost	CostToPrime
Project Direct Costs Report			**10,737,186**	**10,737,186**
01 Deer Island-Aquatic Ecosystem Restoration	**1.00**	**LS**	**10,737,186**	**10,737,186**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**10,737,186**	**10,737,186**
006 Fish & Wildlife	**1.00**	**LS**	**10,737,186**	**10,737,186**
01 Ecosystem Restoration	**1.00**	**LS**	**10,737,186**	**10,737,186**
Mobilization, Preparatory Work, & Demobilization	**1.00**	**LS**	**1,200,000**	**1,200,000**
USR Mobilization, Preparatory Work, Demobilizaiton(Dredge Plant, 27")	1.00	LS	950,000	950,000
USR Mobilization, Preparatory Work, Demobilization(Land Base Equipment)	1.00	LS	250,000	250,000
Seaward Shoreline	**1.00**	**LS**	**4,798,722**	**4,798,722**
			5.00	*5.00*
USR Beach Fill, in-place, 27" Dredge	400,000.00	CY	2,000,000	2,000,000
(Note: Unit Cost based a recent on-going project at existing project proforming similar work. Work is being performed by a 27" pipeline dredge.)				
			3,400.00	*3,400.00*
USR Grade/Shape Berm, small Dozer-Trackhoe Work	120.00	DAY	408,000	408,000
			2.80	*2.80*
USR Environmental Planting (Marsh Grass)	652,392.00	EA	1,826,698	1,826,698
(Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 543,660 plants plus 20% replacement = 652,392 plants. Material price fob job site @ $0.95/ea, Fertilizer @ $0.10/ea, Labor Cost @ $1.25/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.78/plant. Use $2.80 / plant.)					
			2.20	*2.20*
USR Environmental Planting (SeaOats)	250,920.00	EA	552,024	552,024
(Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 209,100 plants plus 20% replacement = 250,920 plants. Material price fob job site @ $0.46/ea, Fertilizer @0.10/ea, Labor Cost @ $1.25/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.19/plant. Use $2.20 / plant.)					
USR Misc. Site Items	1.00	LS	12,000	12,000
Repair/Replace Containment Dike	**1.00**	**LS**	**430,000**	**430,000**
			5.00	*5.00*
USR Fill, in-place, 27" Dia. Dredge	4,200.00	CY	21,000	21,000
			3,400.00	*3,400.00*
USR Grade/Shape Berm, small Dozer-Trackhoe Work	120.00	DAY	408,000	408,000
USR Misc. Site Items	1.00	LS	1,000	1,000
Add Material to Containment Area	**1.00**	**LS**	**1,243,030**	**1,243,030**
			5.00	*5.00*
USR Fill, in-place, 27" Dia. Dredge	100,000.00	CY	500,000	500,000
			3,400.00	*3,400.00*
USR Grade/Shape Berm, small Dozer-Trackhoe Work	15.00	DAY	51,000	51,000
			2.75	*2.75*
USR Environmental Planting(Marsh Plants	250,920.00	EA	690,030	690,030
(Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 209,100 plants plus 20% replacement = 250,920 plants. Material price fob job site @ $0.93/ea, Fertilizer @ $0.10/ea, Labor Cost @ $1.25/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.76/plant. Use $2.75 / plant.)					
USR Misc. Site Items	1.00	LS	2,000	2,000

Description	Quantity	UOM	SubBidCost	CostToPrime
Lengthen Stone Containment Dikes	**1.00**	**LS**	**888,050**	**888,050**
USR Analyze Stone Containment Dikes	1.00	LS	45,000	45,000
			5.00	*5.00*
USR Fill, in-place, 27" Dia. Dredge	91,000.00	CY	455,000	455,000
			3,400.00	*3,400.00*
USR Grade/Shape Berm, small Dozer-Trackhoe Work	30.00	DAY	102,000	102,000
			2.50	*2.50*
USR Filter Fabric	1,500.00	SY	3,750	3,750
			93.50	*93.50*
USR Riprap	3,000.00	CY	280,500	280,500
USR Misc. Site Items	1.00	LS	1,800	1,800
Create Additional Marsh Area	**1.00**	**LS**	**2,177,384**	**2,177,384**
			5.00	*5.00*
USR Beach Fill, in-place, 27" Dia. Dredge	300,000.00	CY	1,500,000	1,500,000
			3,400.00	*3,400.00*
USR Grade/Shape Berm, small Dozer-Trackhoe Work	60.00	DAY	204,000	204,000
			2.80	*2.80*
USR Environmental Planting(Marsh Grass)	167,280.00	EA	468,384	468,384
(Note: Plants are planted at 30 in centers. Contractor shall be required to guarantee that 80% of the planted vegetation is in good condition one (1) year after initial planting. Planting shall be accomplished by hand. Fertilizer shall be placed in the bottom of hole at required rate. Required plants 139,400 plants plus 20% replacement = 167280 plants. Material price fob job site @ $0.96/ea, Fertilizer @ $0.10/ea, Labor Cost @ $1.25/ea, Plus Subcontract Markups @ 21% Total Cost to Prime = $2.80/plant. Use $2.80 / plant.)				
USR Misc. Site Items	1.00	LS	5,000	5,000



The proposed project will provide for ecosystem restoration and preservation of critical coastal wetlands. The island also provides storm protection from surge, wave action and wind for the adjacent coastal portion of the City of Biloxi, Mississippi. The proposed project will consist of three components: shoreline restoration in the Grand Bayou area of Deer Island with beach, dune, marsh and maritime forest reestablishment; restoration of the west end breach area with reestablishment of maritime forest area; and, restoration of the remaining shoreline areas along the seaward shoreline with beach, dune, marsh and maritime forest reestablishment. Fill material will be obtained from an offshore borrow area located approximately 500 feet off the southern shoreline of Deer Island. Material from the borrow area will be cast on the existing shoreline for beach nourishment via a hydraulic dredge. After filling, environmental plantings will be made to establish the maritime forest and aquatic marsh in the restored area. The design will start in March of 2009, the award will be in September, 2009, and the completion will be March, 2011.

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Bayou Cumbest SAV Pilot -Environmental Restoration, Restore Wet DISTRICT: MOBILE

LOCATION: Jackson County, Mississippi P.O.C.: Joseph H. Ellsworth

ACCOUNT NUMI	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages	25,000	6,250	25%	31,250	25,000	6,250	31,250	25,400	6,350	31,750
06---	Fish & Wildlife -Restore Wetlands ***(Bayou Cumbest SAV Pilot Project)***	604,000	151,000	25%	755,000	604,000	151,000	755,000	648,696	162,174	810,870
30---	PLANNING, ENGINEERING & DESIGN	48,320	12,080	25%	60,400	48,320	12,080	60,400	49,093	12,273	61,366
31---	CONSTRUCTION MANAGEMENT	36,240	9,060	25%	45,300	36,240	9,060	45,300	38,922	9,730	48,652
	TOTAL PROJECT COST =======>	**713,560**	**178,390**		**891,950**	**713,560**	**178,390**	**891,950**	**762,111**	**190,527**	**952,638**

rounded

65%	**TOTAL FEDERAL COSTS ==========>**	**$650,000**
35%	**TOTAL NON - FEDERAL COSTS ======>**	**$350,000**
	TOTAL PROJECT COSTS ==========>	**$1,000,000**

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Bayou Cumbest SAV Pilot -Environmental Restoration, Restore Wet DISTRICT: MOBILE

LOCATION: Jackson County, Mississippi P.O.C.: Joseph H. Ellsworth

ACCOUNT No.	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
01---	Lands & Damages (PCA)	25,000	6,250	25%	31,250	0.0%	25,000	6,250	31,250	Jun 09	1.6%	25,400	6,350	31,750
	Subtotal	25,000	6,250		31,250		25,000	6,250	31,250			25,400	6,350	31,750
06---	Fish & Wildlife -Restore Wetlands	604,000	151,000	25%	755,000	0.0%	604,000	151,000	755,000	Mar 12	7.4%	648,696	162,174	810,870
30---	PLANNING, ENGINEERING & DESIGN, 8%+-	48,320	12,080	25%	60,400	0.0%	48,320	12,080	60,400	Jun 09	1.6%	49,093	12,273	61,366
31---	CONSTRUCTION MANAGEMENT, 6% +-	36,240	9,060	25%	45,300	0.0%	36,240	9,060	45,300	Mar 12	7.4%	38,922	9,730	48,652
	Subtotal	688,560	172,140		860,700		688,560	172,140	860,700			736,711	184,177	920,888

The MsCIP environmental effort will: (1) restore SAV beds in Bayou Cumbest adjacent to the Grand Bay NERR that have been lost since the 2005 hurricanes through transplanting involving participation by the local community groups and students of the local universities and (2) determine the effectiveness of three transplanting methods (i.e. (1) a donor site, (2) harvesting plant sprigs with one or more meristems (growth regions), or (3) spreading seeds or mature flowering shoots over the restoration site) for restoring R. maritima in bayous, streams, and brackish marshes by quarterly monitoring using volunteers. After transplanting, quarterly monitoring for two years will be conducted to determine plant establishment, photosynthesis, growth, and expansion.
The first goal of the proposed community-based restoration project in the Grand Bay NERR will result in restoration of up to 5 acres of R. maritima resulting in the recovery of an equal amount of SAV habitat to that lost during the 2005 hurricane season (Figure 5.5.1-1). Secondly, the Corps, Mobile District proposed to evaluate 3 restoration techniques to demonstrate their feasibility for larger restoration projects. Finally, the volunteer involvement and educational outreach will increase awareness of the importance of SAV habitat in Mississippi Sound and provide coastal managers and restoration practitioners with the knowledge of techniques to maximize their return on dollars spent.
SAVs Write Up

Price Level Aug 08
FEASIBILITY STUDY

Estimated by	CESAM-EN-E, Cost Engineering Branch
Designed by	CESAM-EN-E, Mobile District, Corps of Engineers
Prepared by	Russell Haynes
Preparation Date	8/8/2008
Effective Date of Pricing	8/8/2008
Estimated Construction Time	Days

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project file:sav-pilot-feasibility-aug08.mlp

report file: feasibilty standard report.mrp

output file: sav-pilot-feasibility-aug08.doc

Date	Author	Note

Joseph H. Ellsworth

BASIS of COST ESTIMATE and RATIONALE

Feasibility Estimate is based on Historical Data, Recent Pricing, and Estimator's Judgment. Estimate is structured and priced as a General Prime contractor supported by major subcontractors. Anticipated bidding conditions and construction duration with reasonable schedules are considered Normal. Unit cost as shown in estimate, are fair and reasonable rates based on fair market value. Estimates represent Current Contract Cost (price level Aug 08). The Non-structural and Real Estate Cost were prepared by the Savannah & Huntington Districts.

Price Level of Estimate is Aug 08.

Project Life is assumed as 50 years in Cost Estimate.

30 Feature Account, Planning, Engineering & Design was developed and assigned at 8% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Eight percent was used in the Interim MsCIP projects which was reviewed and approved and included in the Chief's Report.

31 Feature Account, Construction Management was developed and assigned at 6% by the PDT. This is the percentage that has historically been used for these types of civil works projects. Six percent was used in the Interim MsCIP projects which was reviewed & approved and included in the Chief's Report.

Contingency was jointly developed and assigned by the Project Delivery Team. The Contingency percentage at 25% reflects the possibility of changes in quantity estimates and unknowns associated with the unit price. The contingency factor used does not vary throughout the cost estimate. It was determined and agreed upon by the Project Delivery Team that a high rate be used primarily due to risk, degree of confidence, and the project not being of the normal design.

Markups for subcontractors are included in the unit prices and include such items as field overheads, home office expenses, profit, bond and insurance.

Miscellaneous Items represent cost where quantities were not available, such items as signage, construction site/staging restoration, silt fencing, site access, etc. These cost are derived within the estimate at .25 percent (.25%) of construction cost excluding Mob & Demob Cost

Unit Prices, for such items as site work, earthwork, stone protection, concrete, reinforcing, etc., were based on Historical Data, Recent Pricing, Estimator's Judgment, and Cost derivation using MCACES / MII estimating systems.

8/5/2008 Joseph H. Ellsworth

The following Contractor Markups are applied to the Cost to Prime Direct Cost:

Contractor's Field Overhead @ 12%

Contractor's Home Office (G&A) @ 8%

Profit @ 10%

Date	Author	Note

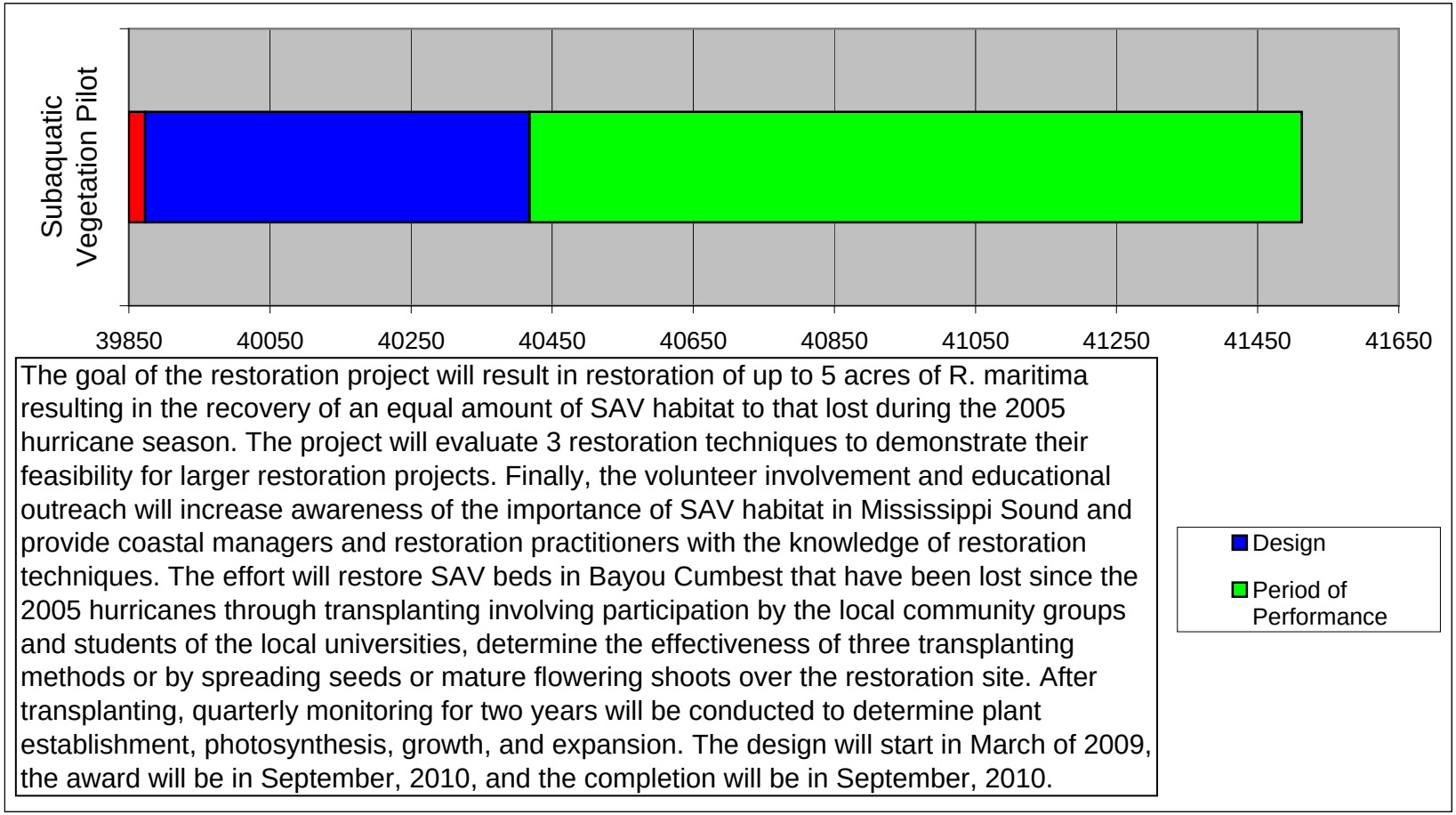
Bond @ 1.2%

Miss. Gross Receipts Tax @ 3.5%

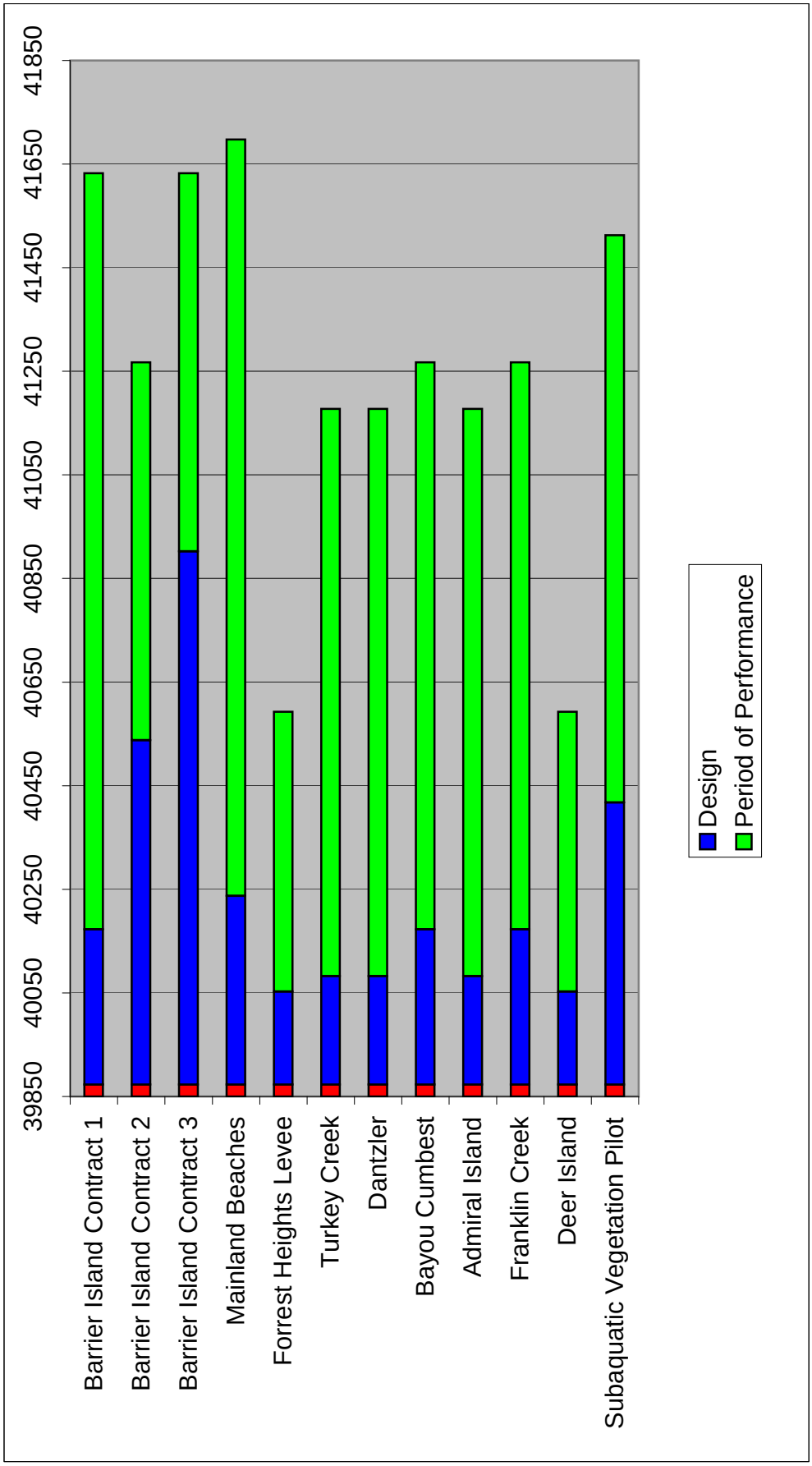
Listed are all Cost Engineering Personnel that worked on the Feasibility Cost Estimate.
Joseph H. Ellsworth, Lead Cost Engineer
Gary Payton, Cost Engineer
George F. Rush, Civil Engineer, Dredging
Michael A. McKown, Geo Tech Engineer
Lloyd Oliver, Structural Engineer
Richard W. Harvey, Mechanical Engineer
John R. Thomas, Real Estate Specialist
Donald A. Whitmore, Civil Engineer- Non-Structural Estimates
Jennifer L. Jacobson, Environmentalist

Description	Quantity	UOM	CostToPrime	JOOH	HOOH	Profit	Bond	Excise	ContractCost
Contract Cost Summary Report			**433,500**	**52,020**	**38,842**	**52,436**	**6,922**	**20,430**	**604,150**
01 Jackson County SAV Pilot Project- Environmental Restoration	**1.00**	**LS**	**433,500**	**52,020**	**38,842**	**52,436**	**6,922**	**20,430**	**604,150**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**433,500**	**52,020**	**38,842**	**52,436**	**6,922**	**20,430**	**604,150**
006 Fish & Wildlife	**1.00**	**LS**	**433,500**	**52,020**	**38,842**	**52,436**	**6,922**	**20,430**	**604,150**
01 Bayou Cumbest SAV Pilot Project	**1.00**	**LS**	**433,500**	**52,020**	**38,842**	**52,436**	**6,922**	**20,430**	**604,150**
(Note: 5 acres SAVcreation 3 planting sessions; 4 monitoring sessions)									
			30.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*41.81*
USR Planting sessions, 3@1500 mh per session	4,500.00	HR	135,000	16,200	12,096	16,330	2,156	6,362	188,143
			30.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*41.81*
USR Monitoring sessions, 4@1500 mh per session	6,000.00	HR	180,000	21,600	16,128	21,773	2,874	8,483	250,858
			7,000.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*9,755.59*
USR Professional oversight: Patrick Biber	8.00	MO	56,000	6,720	5,018	6,774	894	2,639	78,045
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)									
			2,000.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*2,787.31*
USR Grad Asst	9.00	MO	18,000	2,160	1,613	2,177	287	848	25,086
			50.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*69.68*
USR Vehicles, 2 x 25 days x7trips	350.00	DAY	17,500	2,100	1,568	2,117	279	825	24,389
			40.00	*12.00%*	*8.00%*	*10.00%*	*1.20%*	*3.50%*	*55.75*
USR Boat usage, 21', 25 trips	175.00	DAY	7,000	840	627	847	112	330	9,756
USR Misc supplies	1.00	LS	20,000	2,400	1,792	2,419	319	943	27,873

Description	Quantity	UOM	SubBidCost	CostToPrime
Project Direct Costs Report			**433,500**	**433,500**
01 Jackson County SAV Pilot Project- Environmental Restoration	**1.00**	**LS**	**433,500**	**433,500**
06 Federal & Non-Federal Costs	**1.00**	**LS**	**433,500**	**433,500**
006 Fish & Wildlife	**1.00**	**LS**	**433,500**	**433,500**
01 Bayou Cumbest SAV Pilot Project	**1.00**	**LS**	**433,500**	**433,500**
(Note: 5 acres SAVcreation 3 planting sessions; 4 monitoring sessions)				
			30.00	*30.00*
USR Planting sessions, 3@1500 mh per session	4,500.00	HR	135,000	135,000
			30.00	*30.00*
USR Monitoring sessions, 4@1500 mh per session	6,000.00	HR	180,000	180,000
			7,000.00	*7,000.00*
USR Professional oversight: Patrick Biber	8.00	MO	56,000	56,000
(Note: Unit price based on current on going Coastal Mississippi construction projects for similar work.)				
			2,000.00	*2,000.00*
USR Grad Asst	9.00	MO	18,000	18,000
			50.00	*50.00*
USR Vehicles, 2 x 25 days x7trips	350.00	DAY	17,500	17,500
			40.00	*40.00*
USR Boat usage, 21', 25 trips	175.00	DAY	7,000	7,000
USR Misc supplies	1.00	LS	20,000	20,000



The goal of the restoration project will result in restoration of up to 5 acres of R. maritima resulting in the recovery of an equal amount of SAV habitat to that lost during the 2005 hurricane season. The project will evaluate 3 restoration techniques to demonstrate their feasibility for larger restoration projects. Finally, the volunteer involvement and educational outreach will increase awareness of the importance of SAV habitat in Mississippi Sound and provide coastal managers and restoration practitioners with the knowledge of restoration techniques. The effort will restore SAV beds in Bayou Cumbest that have been lost since the 2005 hurricanes through transplanting involving participation by the local community groups and students of the local universities, determine the effectiveness of three transplanting methods or by spreading seeds or mature flowering shoots over the restoration site. After transplanting, quarterly monitoring for two years will be conducted to determine plant establishment, photosynthesis, growth, and expansion. The design will start in March of 2009, the award will be in September, 2010, and the completion will be in September, 2010.


39850
40050
40250
40450
40650
40850
41050
41250
41450
41650
41850
Barrier Island Contract 1
Barrier Island Contract 2
Barrier Island Contract 3
Mainland Beaches
Forrest Heights Levee
Turkey Creek
Dantzler
Bayou Cumbest
Admiral Island
Franklin Creek
Deer Island
Subaquatic Vegetation Pilot
Design
Period of Performance

FEASIBILITY COST ESTIMATE
Mississippi Coastal Improvements Program "MsCIP" Projects

Escalation Derivations

5-Aug-08

Joseph H. Ellsworth

	Project Feature Account Number	*Price Level*	*(Cal mo.) Contruction Duration*	*Contr. Start*	*Price Level Index*	*Feature Midpoint*	*Midpoint Index*	*Escalation %*	USE
Barrier Islands - Contract 1									
	01 Account - Real Estate								
	17 & 31 Account- Construction	Aug 08	36 mo	Apr 10	710.58	Apr 12	766.42	7.86%	7.9%
	30 Account- PED	Aug 08			710.58	Apr 09	721.51	1.54%	1.6%
Barrier Islands - Contract 2	01 Account - Real Estate								
	17 & 31 Account- Construction	Aug 08	36 mo	Apr 11	710.58	Apr 12	766.42	7.86%	7.9%
	30 Account- PED	Aug 08			710.58	Oct 10	743.91	4.69%	4.7%
Barrier Islands - Contract 3	01 Account - Real Estate								
	17 & 31 Account- Construction	Aug 08	36 mo	Apr 12	710.58	Apr 13	781.75	10.02%	10.1%
	30 Account- PED	Aug 08			710.58	Oct 11	758.78	6.78%	6.8%
Turkey Creek	01 Account - Real Estate	Oct 07			676.14	Apr 09	698.89	3.36%	3.4%
	06 & 31 Account- Construction	Aug 08	36 mo	Oct 09	688.31	Apr 11	727.84	5.74%	5.8%
	30 Account- PED	Aug 08			688.31	Apr 09	698.89	1.54%	1.6%
Dantzler	01 Account - Real Estate	Aug 08			688.31	Jun 09	698.89	1.54%	1.6%
	06 & 31 Account- Construction	Aug 08	36 mo	Oct 09	688.31	Jan 12	738.69	7.32%	7.4%
	30 Account- PED	Aug 08			688.31	Jun 09	698.89	1.54%	1.6%
Franklin Creek	01 Account - Real Estate	Aug 08			688.31	Sep 09	702.73	2.09%	2.1%
	06 & 31 Account- Construction	Aug 08	36 mo	Jan 10	688.31	Jan 12	738.69	7.32%	7.4%
	30 Account- PED	Aug 08			688.31	Sep 09	702.73	2.09%	2.1%
Admiral Island	01 Account - Real Estate	Aug 08			688.31	Jun 09	698.89	1.54%	1.6%
	06 & 31 Account- Construction	Aug 08	36 mo	Oct 09	688.31	Jan 12	738.69	7.32%	7.4%
	30 Account- PED	Aug 08			688.31	Jun 09	698.89	1.54%	1.6%
Bayou Cumbest	01 Account - Real Estate	Oct 07			676.14	Sep 09	702.73	3.93%	4.0%
	06 & 31 Account- Construction	Aug 08	36 mo	Jan 10	688.31	Jan 12	738.69	7.32%	7.4%
	30 Account- PED	Aug 08			688.31	Sep 09	702.73	2.09%	2.1%
Forest Heights Levee	01 Account - Real Estate	Oct 07			696.01	Jun 09	723.38	3.93%	4.0%
	11 & 31 Account- Construction	Aug 08	18 mo	Sep 09	708.54	Jun 10	734.63	3.68%	3.7%
	30 Account- PED	Aug 08			688.31	Jun 09	723.38	5.10%	5.1%
Subaquatic Vegetation PioIt	01 Account - Real Estate	Aug 08			688.31	Jun 09	698.89	1.54%	1.6%
	06 & 31 Account- Construction	Aug 08	36 mo	Sep 10	688.31	Mar 12	738.69	7.32%	7.4%
	30 Account- PED	Aug 08			688.31	Jun 09	698.89	1.54%	1.6%
Mainland Beach and Dunes	01 Account - Real Estate	Aug 08			710.58	Oct 09	729.04	2.60%	2.6%
	17 & 31 Account- Construction	Aug 08	48 mo	Mar 10	710.58	Jan 12	762.6	7.32%	7.4%
	30 Account- PED	Aug 08			710.58	Oct 09	729.04	2.60%	2.6%
Deer Island	01 Account - Real Estate	Aug 08			710.58	Oct 09	729.04	2.60%	2.6%
	17 & 31 Account- Construction	Aug 08	48 mo	Mar 10	710.58	Jan 12	762.6	7.32%	7.4%
	30 Account- PED	Aug 08			710.58	Oct 09	729.04	2.60%	2.6%

Preliminary Estimate of Project Cost

for the

Floodproofing of Residential Structures

associated with the

Mississippi Coastal Improvement Program Comprehensive Study

at a Price Level equivalent to

1 October 2007

List of Tables

Table 1 - Cost and Structure Summary by Project Reach

Table 2 - Cost Summary by Project Reach and Feature Account

Table 3 - Cost Summary by Project Reach and Cost Model Used

Table 4 - Structure Summary by Project Reach and Cost Model Used

Table 5 - Cost Summary by County

Table 6 - Cost Summary by County and Cost Model Used

Table 7 - Structure Summary by Cost Model Used and County

Table 8 - Structure Summary by Project Reach and County

Table 9 - Cost and Structure Summary by Cost Model Used

Attached

Model Estimates - Spreadsheet Summaries

Model Estimates - MII Estimates

Preliminary Estimate of Project Cost
for the
Floodproofing of Residential Structures
associated with the
Mississippi Coastal Improvement Program
Comprehensive Study
at a Price Level equivalent to
1 October 2007

Table 1 - Cost and Structure Summary by Project Reach*

COUNTY	(All)
CAT_NAME	RES
FP	Y
COST_MODEL	(Multiple Items)

REACH	STRUCTURE COUNT	CONSTRUCTION	ADMIN	FP PROJECT COST	AVERAGE COST
1	369	58,129,150	9,225,000	**67,354,150**	182,532
2	2,741	509,470,389	68,525,000	**577,995,389**	210,870
3	293	70,275,578	7,325,000	**77,600,578**	264,848
4	7	1,742,670	175,000	**1,917,670**	273,953
5	99	20,080,584	2,475,000	**22,555,584**	227,834
6	549	142,864,220	13,725,000	**156,589,220**	285,226
7	180	27,636,910	4,500,000	**32,136,910**	178,538
8	1,680	417,349,546	42,000,000	**459,349,546**	273,422
9	12	2,961,448	300,000	**3,261,448**	271,787
10	61	15,978,706	1,525,000	**17,503,706**	286,946
11	8	1,527,008	200,000	**1,727,008**	215,876
12	1,010	228,675,524	25,250,000	**253,925,524**	251,411
13	-	-	-	**-**	-
14	-	-	-	**-**	-
15	-	-	-	**-**	-
16	121	28,690,348	3,025,000	**31,715,348**	262,110
17	-	-	-	**-**	-
18	4	763,504	100,000	**863,504**	215,876
19	-	-	-	**-**	-
20	1,768	406,122,655	44,200,000	**450,322,655**	254,707
21	380	73,753,926	9,500,000	**83,253,926**	219,089
22	85	19,037,106	2,125,000	**21,162,106**	248,966
23	39	6,386,176	975,000	**7,361,176**	188,748
24	172	32,714,846	4,300,000	**37,014,846**	215,203
25	-	-	-	**-**	-
26	937	214,641,981	23,425,000	**238,066,981**	254,074
27	1,020	188,257,732	25,500,000	**213,757,732**	209,566
28	110	17,189,150	2,750,000	**19,939,150**	181,265
29	154	23,446,802	3,850,000	**27,296,802**	177,252
30	430	95,294,119	10,750,000	**106,044,119**	246,614
31	399	62,565,104	9,975,000	**72,540,104**	181,805
32	198	30,510,800	4,950,000	**35,460,800**	179,095
33	-	-	-	**-**	-
34	-	-	-	**-**	-
35	1,273	190,166,536	31,825,000	**221,991,536**	174,385
36	-	-	-	**-**	-
37	-	-	-	**-**	-
38	65	9,533,024	1,625,000	**11,158,024**	171,662
39	6	841,302	150,000	**991,302**	165,217
40	-	-	-	**-**	-
41	-	-	-	**-**	-

*Price includes a net contingency of 24.9%

Table 1 - Cost and Structure Summary by Project Reach*

COUNTY	(All)
CAT_NAME	RES
FP	Y
COST_MODEL	(Multiple Items)

REACH	STRUCTURE COUNT	CONSTRUCTION	ADMIN	FP PROJECT COST	AVERAGE COST
42	-	-	-	**-**	-
43	1	145,304	25,000	**170,304**	170,304
44	-	-	-	**-**	-
45	-	-	-	**-**	-
46	-	-	-	**-**	-
47	-	-	-	**-**	-
48	2	316,298	50,000	**366,298**	183,149
49	-	-	-	**-**	-
50	821	160,688,629	20,525,000	**181,213,629**	220,723
51	691	114,306,392	17,275,000	**131,581,392**	190,422
52	6,025	1,199,525,170	150,625,000	**1,350,150,170**	224,091
53	277	46,582,670	6,925,000	**53,507,670**	193,168
54	682	106,347,144	17,050,000	**123,397,144**	180,934
Grand Total	**22,669**	**4,524,518,451**	**566,725,000**	**5,091,243,451**	**224,591**

*Price includes a net contingency of 24.9%

Preliminary Estimate of Project Cost
for the
Floodproofing of Residential Structures
associated with the
Mississippi Coastal Improvement Program
Comprehensive Study
at a Price Level equivalent to
1 October 2007

Table 2 - Cost Summary by Project Reach and Feature Account*

COUNTY	(All)
CAT_NAME	RES
FP	Y
COST MODEL	(Multiple Items)

REACH	01 - LANDS & DAMAGES	11 - FLOODPROOFING	30 - E & D	31 - S & A	FP PROJECT COST
1	1,845,000	58,129,150	4,797,000	2,583,000	67,354,150
2	13,705,000	509,470,389	35,633,000	19,187,000	577,995,389
3	1,465,000	70,275,578	3,809,000	2,051,000	77,600,578
4	35,000	1,742,670	91,000	49,000	1,917,670
5	495,000	20,080,584	1,287,000	693,000	22,555,584
6	2,745,000	142,864,220	7,137,000	3,843,000	156,589,220
7	900,000	27,636,910	2,340,000	1,260,000	32,136,910
8	8,400,000	417,349,546	21,840,000	11,760,000	459,349,546
9	60,000	2,961,448	156,000	84,000	3,261,448
10	305,000	15,978,706	793,000	427,000	17,503,706
11	40,000	1,527,008	104,000	56,000	1,727,008
12	5,050,000	228,675,524	13,130,000	7,070,000	253,925,524
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	-	-
16	605,000	28,690,348	1,573,000	847,000	31,715,348
17	-	-	-	-	-
18	20,000	763,504	52,000	28,000	863,504
19	-	-	-	-	-
20	8,840,000	406,122,655	22,984,000	12,376,000	450,322,655
21	1,900,000	73,753,926	4,940,000	2,660,000	83,253,926
22	425,000	19,037,106	1,105,000	595,000	21,162,106
23	195,000	6,386,176	507,000	273,000	7,361,176
24	860,000	32,714,846	2,236,000	1,204,000	37,014,846
25	-	-	-	-	-
26	4,685,000	214,641,981	12,181,000	6,559,000	238,066,981
27	5,100,000	188,257,732	13,260,000	7,140,000	213,757,732
28	550,000	17,189,150	1,430,000	770,000	19,939,150
29	770,000	23,446,802	2,002,000	1,078,000	27,296,802
30	2,150,000	95,294,119	5,590,000	3,010,000	106,044,119
31	1,995,000	62,565,104	5,187,000	2,793,000	72,540,104
32	990,000	30,510,800	2,574,000	1,386,000	35,460,800
33	-	-	-	-	-
34	-	-	-	-	-
35	6,365,000	190,166,536	16,549,000	8,911,000	221,991,536
36	-	-	-	-	-
37	-	-	-	-	-
38	325,000	9,533,024	845,000	455,000	11,158,024
39	30,000	841,302	78,000	42,000	991,302
40	-	-	-	-	-
41	-	-	-	-	-
42	-	-	-	-	-
43	5,000	145,304	13,000	7,000	170,304

*Price includes a net contingency of 24.9%

Table 2 - Cost Summary by Project Reach and Feature Account*

COUNTY	(All)
CAT_NAME	RES
FP	Y
COST MODEL	(Multiple Items)

REACH	01 - LANDS & DAMAGES	11 - FLOODPROOFING	30 - E & D	31 - S & A	FP PROJECT COST
44	-	-	-	-	-
45	-	-	-	-	-
46	-	-	-	-	-
47	-	-	-	-	-
48	10,000	316,298	26,000	14,000	366,298
49	-	-	-	-	-
50	4,105,000	160,688,629	10,673,000	5,747,000	181,213,629
51	3,455,000	114,306,392	8,983,000	4,837,000	131,581,392
52	30,125,000	1,199,525,170	78,325,000	42,175,000	1,350,150,170
53	1,385,000	46,582,670	3,601,000	1,939,000	53,507,670
54	3,410,000	106,347,144	8,866,000	4,774,000	123,397,144
Grand Total	**113,345,000**	**4,524,518,451**	**294,697,000**	**158,683,000**	**5,091,243,451**

*Price includes a net contingency of 24.9%

Preliminary Estimate of Project Cost
for the
Floodproofing of Residential Structures
associated with the
Mississippi Coastal Improvement Program
Comprehensive Study
at a Price Level equivalent to
1 October 2007

Table 3 - Cost Summary by Project Reach and Cost Model Used*

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
1	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	11	286,946	3,156,406
	Slab, 6' Raise	204	170,304	34,742,016
	Slab, 15' Raise	143	195,994	28,027,142
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	2	192,148	384,296
	Trailer, 6' Raise	8	114,092	912,736
	Trailer, 15' Raise	1	131,554	131,554
1 Total		**369**	182,532	**67,354,150**
2	Slab, 6' Replacement	33	261,448	8,627,784
	Slab, 15' Replacement	812	286,946	233,000,152
	Slab, 6' Raise	947	170,304	161,277,888
	Slab, 15' Raise	775	195,994	151,895,350
	Trailer, 6' Replacement	5	177,157	885,785
	Trailer, 15' Replacement	22	192,148	4,227,256
	Trailer, 6' Raise	72	114,092	8,214,624
	Trailer, 15' Raise	75	131,554	9,866,550
2 Total		**2,741**	210,870	**577,995,389**
3	Slab, 6' Replacement	71	261,448	18,562,808
	Slab, 15' Replacement	171	286,946	49,067,766
	Slab, 6' Raise	1	170,304	170,304
	Slab, 15' Raise	50	195,994	9,799,700
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
3 Total		**293**	264,848	**77,600,578**
4	Slab, 6' Replacement	-	-	-

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
	Slab, 15' Replacement	6	286,946	1,721,676
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	1	195,994	195,994
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
4 Total		**7**	273,953	**1,917,670**
5	Slab, 6' Replacement	1	261,448	261,448
	Slab, 15' Replacement	42	286,946	12,051,732
	Slab, 6' Raise	17	170,304	2,895,168
	Slab, 15' Raise	34	195,994	6,663,796
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	1	192,148	192,148
	Trailer, 6' Raise	2	114,092	228,184
	Trailer, 15' Raise	2	131,554	263,108
5 Total		**99**	227,834	**22,555,584**
6	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	539	286,946	154,663,894
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	1	195,994	195,994
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	9	192,148	1,729,332
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
6 Total		**549**	285,226	**156,589,220**
7	Slab, 6' Replacement	1	261,448	261,448
	Slab, 15' Replacement	1	286,946	286,946
	Slab, 6' Raise	35	170,304	5,960,640
	Slab, 15' Raise	112	195,994	21,951,328
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	23	114,092	2,624,116
	Trailer, 15' Raise	8	131,554	1,052,432
7 Total		**180**	178,538	**32,136,910**
8	Slab, 6' Replacement	235	261,448	61,440,280
	Slab, 15' Replacement	1,282	286,946	367,864,772
	Slab, 6' Raise	28	170,304	4,768,512
	Slab, 15' Raise	93	195,994	18,227,442

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
	Trailer, 6' Replacement	8	177,157	1,417,256
	Trailer, 15' Replacement	22	192,148	4,227,256
	Trailer, 6' Raise	10	114,092	1,140,920
	Trailer, 15' Raise	2	131,554	263,108
8 Total		**1,680**	273,422	**459,349,546**
9	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	10	286,946	2,869,460
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	2	195,994	391,988
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
9 Total		**12**	271,787	**3,261,448**
10	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	61	286,946	17,503,706
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
10 Total		**61**	286,946	**17,503,706**
11	Slab, 6' Replacement	4	261,448	1,045,792
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	4	170,304	681,216
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
11 Total		**8**	215,876	**1,727,008**
12	Slab, 6' Replacement	489	261,448	127,848,072
	Slab, 15' Replacement	312	286,946	89,527,152
	Slab, 6' Raise	140	170,304	23,842,560
	Slab, 15' Raise	54	195,994	10,583,676
	Trailer, 6' Replacement	2	177,157	354,314
	Trailer, 15' Replacement	3	192,148	576,444
	Trailer, 6' Raise	7	114,092	798,644

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
	Trailer, 15' Raise	3	131,554	394,662
12 Total		**1,010**	251,411	**253,925,524**
13	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
13 Total		**-**	-	**-**
14	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
14 Total		**-**	-	**-**
15	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
15 Total		**-**	-	**-**
16	Slab, 6' Replacement	68	261,448	17,778,464
	Slab, 15' Replacement	41	286,946	11,764,786
	Slab, 6' Raise	7	170,304	1,192,128
	Slab, 15' Raise	5	195,994	979,970
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
16 Total		**121**	262,110	**31,715,348**

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
17	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
17 Total		**-**	-	**-**
18	Slab, 6' Replacement	2	261,448	522,896
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	2	170,304	340,608
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
18 Total		**4**	215,876	**863,504**
19	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
19 Total		**-**	-	**-**
20	Slab, 6' Replacement	1,398	261,448	365,504,304
	Slab, 15' Replacement	181	286,946	51,937,226
	Slab, 6' Raise	130	170,304	22,139,520
	Slab, 15' Raise	38	195,994	7,447,772
	Trailer, 6' Replacement	13	177,157	2,303,041
	Trailer, 15' Replacement	1	192,148	192,148
	Trailer, 6' Raise	7	114,092	798,644
	Trailer, 15' Raise	-	-	-
20 Total		**1,768**	254,707	**450,322,655**
21	Slab, 6' Replacement	92	261,448	24,053,216
	Slab, 15' Replacement	75	286,946	21,520,950
	Slab, 6' Raise	149	170,304	25,375,296

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
	Slab, 15' Raise	58	195,994	11,367,652
	Trailer, 6' Replacement	4	177,157	708,628
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	2	114,092	228,184
	Trailer, 15' Raise	-	-	-
21 Total		**380**	219,089	**83,253,926**
22	Slab, 6' Replacement	30	261,448	7,843,440
	Slab, 15' Replacement	33	286,946	9,469,218
	Slab, 6' Raise	18	170,304	3,065,472
	Slab, 15' Raise	4	195,994	783,976
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
22 Total		**85**	248,966	**21,162,106**
23	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	11	170,304	1,873,344
	Slab, 15' Raise	28	195,994	5,487,832
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
23 Total		**39**	188,748	**7,361,176**
24	Slab, 6' Replacement	23	261,448	6,013,304
	Slab, 15' Replacement	41	286,946	11,764,786
	Slab, 6' Raise	75	170,304	12,772,800
	Slab, 15' Raise	32	195,994	6,271,808
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	1	192,148	192,148
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
24 Total		**172**	215,203	**37,014,846**
25	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
25 Total		**-**	-	**-**
26	Slab, 6' Replacement	210	261,448	54,904,080
	Slab, 15' Replacement	522	286,946	149,785,812
	Slab, 6' Raise	120	170,304	20,436,480
	Slab, 15' Raise	8	195,994	1,567,952
	Trailer, 6' Replacement	1	177,157	177,157
	Trailer, 15' Replacement	31	192,148	5,956,588
	Trailer, 6' Raise	39	114,092	4,449,588
	Trailer, 15' Raise	6	131,554	789,324
26 Total		**937**	254,074	**238,066,981**
27	Slab, 6' Replacement	217	261,448	56,734,216
	Slab, 15' Replacement	175	286,946	50,215,550
	Slab, 6' Raise	624	170,304	106,269,696
	Slab, 15' Raise	1	195,994	195,994
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	3	114,092	342,276
	Trailer, 15' Raise	-	-	-
27 Total		**1,020**	209,566	**213,757,732**
28	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	43	170,304	7,323,072
	Slab, 15' Raise	59	195,994	11,563,646
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	8	131,554	1,052,432
28 Total		**110**	181,265	**19,939,150**
29	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	80	170,304	13,624,320
	Slab, 15' Raise	63	195,994	12,347,622
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	7	114,092	798,644
	Trailer, 15' Raise	4	131,554	526,216
29 Total		**154**	177,252	**27,296,802**

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
30	Slab, 6' Replacement	127	261,448	33,203,896
	Slab, 15' Replacement	180	286,946	51,650,280
	Slab, 6' Raise	106	170,304	18,052,224
	Slab, 15' Raise	11	195,994	2,155,934
	Trailer, 6' Replacement	1	177,157	177,157
	Trailer, 15' Replacement	3	192,148	576,444
	Trailer, 6' Raise	2	114,092	228,184
	Trailer, 15' Raise	-	-	-
30 Total		**430**	246,614	**106,044,119**
31	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	1	286,946	286,946
	Slab, 6' Raise	205	170,304	34,912,320
	Slab, 15' Raise	186	195,994	36,454,884
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	2	114,092	228,184
	Trailer, 15' Raise	5	131,554	657,770
31 Total		**399**	181,805	**72,540,104**
32	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	76	170,304	12,943,104
	Slab, 15' Raise	102	195,994	19,991,388
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	6	114,092	684,552
	Trailer, 15' Raise	14	131,554	1,841,756
32 Total		**198**	179,095	**35,460,800**
33	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
33 Total		**-**	-	**-**
34	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
34 Total		**-**	-	**-**
35	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	938	170,304	159,745,152
	Slab, 15' Raise	291	195,994	57,034,254
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	33	114,092	3,765,036
	Trailer, 15' Raise	11	131,554	1,447,094
35 Total		**1,273**	174,385	**221,991,536**
36	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
36 Total		**-**	-	**-**
37	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
37 Total		**-**	-	**-**
38	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	52	170,304	8,855,808
	Slab, 15' Raise	10	195,994	1,959,940
	Trailer, 6' Replacement	-	-	-

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	3	114,092	342,276
	Trailer, 15' Raise	-	-	-
38 Total		**65**	171,662	**11,158,024**
39	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	4	170,304	681,216
	Slab, 15' Raise	1	195,994	195,994
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	1	114,092	114,092
	Trailer, 15' Raise	-	-	-
39 Total		**6**	165,217	**991,302**
40	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
40 Total		**-**	-	**-**
41	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
41 Total		**-**	-	**-**
42	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
42 Total		**-**	-	**-**
43	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	1	170,304	170,304
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
43 Total		**1**	170,304	**170,304**
44	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
44 Total		**-**	-	**-**
45	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
45 Total		**-**	-	**-**
46	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
46 Total		**-**	-	**-**
47	Slab, 6' Replacement	-	-	-

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
47 Total		**-**	-	**-**
48	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	1	170,304	170,304
	Slab, 15' Raise	1	195,994	195,994
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
48 Total		**2**	183,149	**366,298**
49	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	-	-	-
	Slab, 6' Raise	-	-	-
	Slab, 15' Raise	-	-	-
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	-	-	-
	Trailer, 15' Raise	-	-	-
49 Total		**-**	-	**-**
50	Slab, 6' Replacement	305	261,448	79,741,640
	Slab, 15' Replacement	97	286,946	27,833,762
	Slab, 6' Raise	220	170,304	37,466,880
	Slab, 15' Raise	161	195,994	31,555,034
	Trailer, 6' Replacement	1	177,157	177,157
	Trailer, 15' Replacement	1	192,148	192,148
	Trailer, 6' Raise	28	114,092	3,194,576
	Trailer, 15' Raise	8	131,554	1,052,432
50 Total		**821**	220,723	**181,213,629**
51	Slab, 6' Replacement	7	261,448	1,830,136
	Slab, 15' Replacement	86	286,946	24,677,356
	Slab, 6' Raise	469	170,304	79,872,576
	Slab, 15' Raise	128	195,994	25,087,232

*Price includes a net contingency of 24.9%

*Table 3 - Cost Summary by Project Reach and Cost Model Used**

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	1	114,092	114,092
	Trailer, 15' Raise	-	-	-
51 Total		**691**	190,422	**131,581,392**
52	Slab, 6' Replacement	2,453	261,448	641,331,944
	Slab, 15' Replacement	837	286,946	240,173,802
	Slab, 6' Raise	2,585	170,304	440,235,840
	Slab, 15' Raise	136	195,994	26,655,184
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	2	192,148	384,296
	Trailer, 6' Raise	12	114,092	1,369,104
	Trailer, 15' Raise	-	-	-
52 Total		**6,025**	224,091	**1,350,150,170**
53	Slab, 6' Replacement	1	261,448	261,448
	Slab, 15' Replacement	25	286,946	7,173,650
	Slab, 6' Raise	18	170,304	3,065,472
	Slab, 15' Raise	192	195,994	37,630,848
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	1	114,092	114,092
	Trailer, 15' Raise	40	131,554	5,262,160
53 Total		**277**	193,168	**53,507,670**
54	Slab, 6' Replacement	-	-	-
	Slab, 15' Replacement	2	286,946	573,892
	Slab, 6' Raise	323	170,304	55,008,192
	Slab, 15' Raise	326	195,994	63,894,044
	Trailer, 6' Replacement	-	-	-
	Trailer, 15' Replacement	-	-	-
	Trailer, 6' Raise	9	114,092	1,026,828
	Trailer, 15' Raise	22	131,554	2,894,188
54 Total		**682**	180,934	**123,397,144**
Grand Total		**22,669**	224,591	**5,091,243,451**

*Price includes a net contingency of 24.9%

Preliminary Estimate of Project Cost
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at a Price Level equivalent to
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Table 4 - Structure Summary by Project Reach and Cost Model Used

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	Slab, 6' Replacement	Slab, 15' Replacement	Slab, 6' Raise	Slab, 15' Raise	Trailer, 6' Replacement	Trailer, 15' Replacement	Trailer, 6' Raise	Trailer, 15' Raise	Grand Total
1	-	11	204	143	-	2	8	1	369
2	33	812	947	775	5	22	72	75	2,741
3	71	171	1	50	-	-	-	-	293
4	-	6	-	1	-	-	-	-	7
5	1	42	17	34	-	1	2	2	99
6	-	539	-	1	-	9	-	-	549
7	1	1	35	112	-	-	23	8	180
8	235	1,282	28	93	8	22	10	2	1,680
9	-	10	-	2	-	-	-	-	12
10	-	61	-	-	-	-	-	-	61
11	4	-	4	-	-	-	-	-	8
12	489	312	140	54	2	3	7	3	1,010
13	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-
16	68	41	7	5	-	-	-	-	121
17	-	-	-	-	-	-	-	-	-
18	2	-	2	-	-	-	-	-	4
19	-	-	-	-	-	-	-	-	-
20	1,398	181	130	38	13	1	7	-	1,768
21	92	75	149	58	4	-	2	-	380
22	30	33	18	4	-	-	-	-	85
23	-	-	11	28	-	-	-	-	39
24	23	41	75	32	-	1	-	-	172
25	-	-	-	-	-	-	-	-	-
26	210	522	120	8	1	31	39	6	937
27	217	175	624	1	-	-	3	-	1,020
28	-	-	43	59	-	-	-	8	110
29	-	-	80	63	-	-	7	4	154
30	127	180	106	11	1	3	2	-	430
31	-	1	205	186	-	-	2	5	399
32	-	-	76	102	-	-	6	14	198

Table 4 - Structure Summary by Project Reach and Cost Model Used

COUNTY	(All)
CAT_NAME	RES
FP	Y

REACH	Slab, 6' Replacement	Slab, 15' Replacement	Slab, 6' Raise	Slab, 15' Raise	Trailer, 6' Replacement	Trailer, 15' Replacement	Trailer, 6' Raise	Trailer, 15' Raise	Grand Total
33	-	-	-	-	-	-	-	-	-
34	-	-	-	-	-	-	-	-	-
35	-	-	938	291	-	-	33	11	1,273
36	-	-	-	-	-	-	-	-	-
37	-	-	-	-	-	-	-	-	-
38	-	-	52	10	-	-	3	-	65
39	-	-	4	1	-	-	1	-	6
40	-	-	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-	-	-
42	-	-	-	-	-	-	-	-	-
43	-	-	1	-	-	-	-	-	1
44	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-
46	-	-	-	-	-	-	-	-	-
47	-	-	-	-	-	-	-	-	-
48	-	-	1	1	-	-	-	-	2
49	-	-	-	-	-	-	-	-	-
50	305	97	220	161	1	1	28	8	821
51	7	86	469	128	-	-	1	-	691
52	2,453	837	2,585	136	-	2	12	-	6,025
53	1	25	18	192	-	-	1	40	277
54	-	2	323	326	-	-	9	22	682
Grand Total	**5,767**	**5,543**	**7,633**	**3,106**	**35**	**98**	**278**	**209**	**22,669**

Preliminary Estimate of Project Cost
for the
Floodproofing of Residential Structures
associated with the
Mississippi Coastal Improvement Program Comprehensive Study
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1 October 2007

Table 5 - Cost Summary by County*

CAT_NAME	RES
FP	Y
REACH	(All)
COST_MODEL	(Multiple Items)

COUNTY	STRUCTURE COUNT	AVERAGE COST	FP PROJECT COST
Hancock	4,303	220,150	947,307,525
Harrison	5,493	255,096	1,401,239,968
Jackson	12,873	213,058	2,742,695,958
Grand Total	**22,669**	**224,591**	**5,091,243,451**

*Price includes a net contingency of 24.9%

Prepared by: Don Whitmore
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Preliminary Estimate of Project Cost
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Mississippi Coastal Improvement Program Comprehensive Study
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Table 6 - Cost Summary by County and Cost Model Used*

CAT_NAME	RES
FP	Y
REACH	(All)

COUNTY	COST MODEL	STRUCTURE COUNT	UNIT PRICE	FP PROJECT COST
Hancock	Slab, 6' Replacement	106	261,448	27,713,488
	Slab, 15' Replacement	1,582	286,946	453,948,572
	Slab, 6' Raise	1,256	170,304	213,901,824
	Slab, 15' Raise	1,126	195,994	220,689,244
	Trailer, 6' Replacement	5	177,157	885,785
	Trailer, 15' Replacement	34	192,148	6,533,032
	Trailer, 6' Raise	108	114,092	12,321,936
	Trailer, 15' Raise	86	131,554	11,313,644
Hancock Total		**4,303**	220,150	**947,307,525**
Harrison	Slab, 6' Replacement	2,501	261,448	653,881,448
	Slab, 15' Replacement	1,984	286,946	569,300,864
	Slab, 6' Raise	536	170,304	91,282,944
	Slab, 15' Raise	355	195,994	69,577,870
	Trailer, 6' Replacement	24	177,157	4,251,768
	Trailer, 15' Replacement	27	192,148	5,187,996
	Trailer, 6' Raise	53	114,092	6,046,876
	Trailer, 15' Raise	13	131,554	1,710,202
Harrison Total		**5,493**	255,096	**1,401,239,968**
Jackson	Slab, 6' Replacement	3,160	261,448	826,175,680
	Slab, 15' Replacement	1,977	286,946	567,292,242
	Slab, 6' Raise	5,841	170,304	994,745,664
	Slab, 15' Raise	1,625	195,994	318,490,250
	Trailer, 6' Replacement	6	177,157	1,062,942
	Trailer, 15' Replacement	37	192,148	7,109,476
	Trailer, 6' Raise	117	114,092	13,348,764
	Trailer, 15' Raise	110	131,554	14,470,940
Jackson Total		**12,873**	213,058	**2,742,695,958**
Grand Total		**22,669**	224,591	**5,091,243,451**

*Price includes a net contingency of 24.9%

Preliminary Estimate of Project Cost
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1 October 2007

Table 7 - Structure Summary by Cost Model Used and County

CAT_NAME	RES
FP	Y
ECO_REA	(All)

STRUCTURE COUNT COST MODEL	COUNTY Hancock	Harrison	Jackson	Grand Total
Slab, 6' Replacement	106	2,501	3,160	5,767
Slab, 15' Replacement	1,582	1,984	1,977	5,543
Slab, 6' Raise	1,256	536	5,841	7,633
Slab, 15' Raise	1,126	355	1,625	3,106
Trailer, 6' Replacement	5	24	6	35
Trailer, 15' Replacement	34	27	37	98
Trailer, 6' Raise	108	53	117	278
Trailer, 15' Raise	86	13	110	209
Grand Total	**4,303**	**5,493**	**12,873**	**22,669**

Preliminary Estimate of Project Cost
for the
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associated with the
Mississippi Coastal Improvement Program Comprehensive Study
at a Price Level equivalent to
1 October 2007

Table 8 - Structure Summary by Project Reach and County

COST_MODEL	(Multiple Items)
FP	Y
CAT_NAME	RES

STRUCTURE COUNT	COUNTY			
REACH	Hancock	Harrison	Jackson	Grand Total
1	369	-	-	369
2	2,741	-	-	2,741
3	293	-	-	293
4	7	-	-	7
5	99	-	-	99
6	549	-	-	549
7	180	-	-	180
8	-	1,680	-	1,680
9	-	12	-	12
10	-	61	-	61
11	-	8	-	8
12	-	1,010	-	1,010
13	-	-	-	-
14	-	-	-	-
15	-	-	-	-
16	-	121	-	121
17	-	-	-	-
18	-	4	-	4
19	-	-	-	-
20	-	1,768	-	1,768
21	-	-	380	380
22	-	-	85	85
23	-	-	39	39
24	-	-	172	172
25	-	-	-	-
26	-	-	937	937
27	-	-	1,020	1,020

Table 8 - Structure Summary by Project Reach and County

COST_MODEL	(Multiple Items)
FP	Y
CAT_NAME	RES

STRUCTURE COUNT	COUNTY			
REACH	Hancock	Harrison	Jackson	Grand Total
28	-	-	110	110
29	-	-	154	154
30	-	-	430	430
31	-	-	399	399
32	-	-	198	198
33	-	-	-	-
34	-	-	-	-
35	-	-	1,273	1,273
36	-	-	-	-
37	-	-	-	-
38	65	-	-	65
39	-	6	-	6
40	-	-	-	-
41	-	-	-	-
42	-	-	-	-
43	-	-	1	1
44	-	-	-	-
45	-	-	-	-
46	-	-	-	-
47	-	-	-	-
48	-	2	-	2
49	-	-	-	-
50	-	821	-	821
51	-	-	691	691
52	-	-	6,025	6,025
53	-	-	277	277
54	-	-	682	682
Grand Total	**4,303**	**5,493**	**12,873**	**22,669**

Preliminary Estimate of Project Cost
for the
Floodproofing of Residential Structures
associated with the
Mississippi Coastal Improvement Program
Comprehensive Study
at a Price Level equivalent to
1 October 2007

Table 9 - Cost and Structure Summary by Cost Model Used*

CAT_NAME	RES
FP	Y
ECO_REA	(All)
COUNTY	(All)

COST MODEL	STRUCTURE COUNT	CONSTRUCTION	ADMIN	FP PROJECT COST	UNIT PRICE
Slab, 6' Replacement	5,767	1,363,595,616	144,175,000	1,507,770,616	261,448
Slab, 15' Replacement	5,543	1,451,966,678	138,575,000	1,590,541,678	286,946
Slab, 6' Raise	7,633	1,109,105,432	190,825,000	1,299,930,432	170,304
Slab, 15' Raise	3,106	531,107,364	77,650,000	608,757,364	195,994
Trailer, 6' Replacement	35	5,325,495	875,000	6,200,495	177,157
Trailer, 15' Replacement	98	16,380,504	2,450,000	18,830,504	192,148
Trailer, 6' Raise	278	24,767,576	6,950,000	31,717,576	114,092
Trailer, 15' Raise	209	22,269,786	5,225,000	27,494,786	131,554
Grand Total	**22,669**	**4,524,518,451**	**566,725,000**	**5,091,243,451**	224,591

*Price includes a net contingency of 24.9%

Prepared by: Don Whitmore
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Preliminary Estimate of Project Cost

for the

Floodproofing of Residential Structures

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at a Price Level equivalent to

1 October 2007

Model Cost Estimates

Spreadsheet Summaries

PROGRAMMING & PLANNING COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. -- DATE 22-Sep-07
LOCATION: **Mississippi** SHEET NO. OF
PREPARED: Don Whitmore CHECKED:
WORK ITEM: ***New Site Built Structure, 6' off low ground*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME:

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Timber Piles*	60	ea	815.66	$48,940
4x4 Cross Bracing*	990	lf	4.36	$4,317
Treated Lumber, 2x10*	640	lf	2.64	$1,691
Structure Above Sill Plate**	1,600	sf	70.28	$112,451
Misc.- Other***	1	job	12,425.27	$12,425
Misc.- Utility hookups	1	job	5,091.63	$5,092
Aerator System - Assume to be installed on 10% on the structures	0.1	job	8,486.04	$849
Asbestos Abatement	1	job	1,697.21	$1,697
Temporary Housing Allowance	2	mo	848.60	$1,697
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0

Note: See MII reports for unit price backup and justification.

*Assume a 6' grid for a house that is 25' x 64' (i.e., a 1600 SF house).

**Cost estimated by Marshall-Swift for an average quality 1600 SF structure in the Gulfport, MS area. Price is assumed to include all setup and prep work such as mob/de-mob. Foundation costs have been subtracted from the Marshall-Swift estimate.

***This price has been taken from LRH's floodproofing model in MCACES 5.31 and includes items such as site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanup.

		Current Contract Cost, FY 07		$189,159
	CONTINGENCY	@	**25.0%**	47,290
	01 Account, Lands & Damage	Real Estate	**LS**	5,000
	02 Account, Relocations	Relocations	**LS**	0
	xx Account, Environmental Mitigation		**LS**	0
	30 Account, Plan, Engr.& Design	@	**6.9%**	13,000
	31 Account, Constr. Management	@	**3.7%**	7,000
	ESCALATION, FY-06	@	**0.0%**	0
				$261,448
				rounded
	TOTAL PROJECT COST, FY-2007			**$261,000**

Notes.

Estimate Excludes:

Operational & Maintenance Cost
Permanent Intrastructure
Relocations (pipelines, etc.)
Equipment (by Other Appropriations)

PROGRAMMING & PLANNING COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. -- DATE 22-Sep-07
LOCATION: **Mississippi** SHEET NO. OF
PREPARED: Don Whitmore CHECKED:
WORK ITEM: ***New Site Built Structure, 15' off low ground*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME:

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Timber Piles*	60	ea	978.79	$58,728
4x4 Cross Bracing*	1,980	lf	4.36	$8,634
Treated Lumber, 2x10*	640	lf	2.64	$1,691
Structure Above Sill Plate**	1,600	sf	70.28	$112,451
Misc.- Storage Area	300	sf	15.17	$4,552
Misc.- Other***	1	job	14,166.60	$14,167
Misc.- Utility hookups	1	job	5,091.63	$5,092
Aerator System - Assume to be installed on 10% on the structures	0.1	job	8,486.04	$849
Asbestos Abatement	1	job	1,697.21	$1,697
Temporary Housing Allowance	2	mo	848.60	$1,697
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0

Note: See MII reports for unit price backup and justification.

*Assume a 6' grid for a house that is 25' x 64' (i.e., a 1600 SF house).

**Cost estimated by Marshall-Swift for an average quality 1600 SF structure in the Gulfport, MS area. Price is assumed to include all setup and prep work such as mob/de-mob. Foundation costs have been subtracted from the Marshall-Swift estimate.

***This price has been taken from LRH's floodproofing model in MCACES 5.31 and includes items such as site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanup.

	Current Contract Cost, FY 07			$209,557
	CONTINGENCY	@	**25.0%**	$52,389
	01 Account, Lands & Damage	Real Estate	**LS**	5,000
	02 Account, Relocations	Relocations	**LS**	0
	xx Account, Environmental Mitigation		**LS**	0
	30 Account, Plan, Engr.& Design	@	**6.2%**	13,000
	31 Account, Constr. Management	@	**3.3%**	7,000
	ESCALATION, FY-06	@	**0.0%**	0
				$286,946
				rounded
	TOTAL PROJECT COST, FY-2007			**$287,000**

Notes.

Estimate Excludes:

Operational & Maintenance Cost
Permanent Intrastructure
Relocations (pipelines, etc.)
Equipment (by Other Appropriations)

PROGRAMMING & PLANNING COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"**
LOCATION: **Mississippi**
WORK ITEM: ***Existing Structure, 6' off low ground***

ITEM NO. --
SHEET NO.
PREPARED: Don Whitmore
BASIS of ESTIMATE: by project delv'd. team
FILE NAME:

DATE 22-Sep-07
OF
CHECKED:

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Raise Structure on Segmented Piles*	1,600	sf	70.00	$112,000
Aerator System - Assume to be installed on 10% on the structures	0.1	job	8,486.04	$849
Asbestos Abatement	1	job	1,697.21	$1,697
Temporary Housing Allowance	2	mo	848.60	$1,697
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0

Note: See MII reports for unit price backup and justification.

* Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house.

	Current Contract Cost, FY 07			$116,243
	CONTINGENCY	@	**25.0%**	29,061
	01 Account, Lands & Damage	Real Estate	**LS**	5,000
	02 Account, Relocations	Relocations	**LS**	0
	xx Account, Environmental Mitigation		**LS**	0
	30 Account, Plan, Engr.& Design	@	**11.2%**	13,000
	31 Account, Constr. Management	@	**6.0%**	7,000
	ESCALATION, FY-06	@	**0.0%**	0
				$170,304
				rounded
	TOTAL PROJECT COST, FY-2007			**$170,000**

Notes.

Estimate Excludes:

Operational & Maintenance Cost
Permanent Intrastructure
Relocations (pipelines, etc.)
Equipment (by Other Appropriations)

PROGRAMMING & PLANNING COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. -- DATE 22-Sep-07
LOCATION: **Mississippi** SHEET NO. OF
PREPARED: Don Whitmore CHECKED:
WORK ITEM: ***Existing Structure, 15' off low ground*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME:

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Raise Structure on Segmented Piles*	1,600	sf	80.00	$128,000
Misc.- Storage Area	300	sf	15.17	$4,552
Aerator System - Assume to be installed on 10% on the structures	0.1	job	8,486.04	$849
Asbestos Abatement	1	job	1,697.21	$1,697
Temporary Housing Allowance	2	mo	848.60	$1,697
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0

Note: See MII reports for unit price backup and justification.

* Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house. He said that costs would likely be higher than this for a raise as high as 15' off low ground. Therefore, add $10/SF to cover this higher raise.

	Current Contract Cost, FY 07			136,795
	CONTINGENCY	@	**25.0%**	34,199
	01 Account, Lands & Damage	Real Estate	**LS**	5,000
	02 Account, Relocations	Relocations	**LS**	0
	xx Account, Environmental Mitigation		**LS**	0
	30 Account, Plan, Engr.& Design	@	**9.5%**	13,000
	31 Account, Constr. Management	@	**5.1%**	7,000
	ESCALATION, FY-06	@	**0.0%**	0
				$195,994
				rounded
	TOTAL PROJECT COST, FY-2007			**$196,000**

Notes.

Estimate Excludes:

Operational & Maintenance Cost
Permanent Intrastructure
Relocations (pipelines, etc.)
Equipment (by Other Appropriations)

PROGRAMMING & PLANNING COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. -- DATE 22-Sep-07
LOCATION: **Mississippi** SHEET NO. OF
PREPARED: Don Whitmore CHECKED:
WORK ITEM: ***New Prefab Structure, 6' off low ground*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME:

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Timber Piles*	38	ea	815.66	$30,995
4x4 Cross Bracing*	620	lf	4.36	$2,703
Treated Lumber, 2x10*	400	lf	2.64	$1,057
Structure Above Sill Plate**	1,000	sf	70.28	$70,282
Misc.- Other***	1	job	12,425.27	$12,425
Misc.- Utility hookups	1	job	5,091.63	$5,092
Aerator System - Assume to be installed on 10% on the structures	0.1	job	8,486.04	$849
Asbestos Abatement	1	job	1,697.21	$1,697
Temporary Housing Allowance	2	mo	848.60	$1,697
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0

Note: See MII reports for unit price backup and justification.

*Assume a 6' grid for a house that is 25' x 40' (i.e., a 1000 SF house).

**Cost estimated by Marshall-Swift for an average quality 1000 SF structure in the Gulfport, MS area. Price is assumed to include all setup and prep work such as mob/de-mob. Foundation costs have been subtracted from the Marshall-Swift estimate.

***This price has been taken from LRH's floodproofing model in MCACES 5.31 and includes items such as site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanup.

	Current Contract Cost, FY 07			$126,797
	CONTINGENCY	@	**20.0%**	25,359
	01 Account, Lands & Damage	Real Estate	**LS**	5,000
	02 Account, Relocations	Relocations	**LS**	0
	xx Account, Environmental Mitigation		**LS**	0
	30 Account, Plan, Engr.& Design	@	**10.3%**	13,000
	31 Account, Constr. Management	@	**5.5%**	7,000
	ESCALATION, FY-06	@	**0.0%**	0
				$177,157
				rounded
	TOTAL PROJECT COST, FY-2007			**$177,000**

Notes.

Estimate Excludes:

Operational & Maintenance Cost
Permanent Intrastructure
Relocations (pipelines, etc.)
Equipment (by Other Appropriations)

PROGRAMMING & PLANNING COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. -- DATE 22-Sep-07
LOCATION: **Mississippi** SHEET NO. OF
PREPARED: Don Whitmore CHECKED:
WORK ITEM: ***New Prefab Structure, 15' off low ground*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME:

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Timber Piles*	38	ea	978.79	$37,194
4x4 Cross Bracing*	620	lf	4.36	$2,703
Treated Lumber, 2x10*	400	lf	2.64	$1,057
Structure Above Sill Plate**	1,000	sf	70.28	$70,282
Misc.- Storage Area	300	sf	15.17	$4,552
Misc.- Other***	1	job	14,166.60	$14,167
Misc.- Utility hookups	1	job	5,091.63	$5,092
Aerator System - Assume to be installed on 10% on the structures	0.1	job	8,486.04	$849
Asbestos Abatement	1	job	1,697.21	$1,697
Temporary Housing Allowance	2	mo	848.60	$1,697
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0

Note: See MII reports for unit price backup and justification.

*Assume a 6' grid for a house that is 25' x 40' (i.e., a 1000 SF house).

**Cost estimated by Marshall-Swift for an average quality 1000 SF structure in the Gulfport, MS area. Price is assumed to include all setup and prep work such as mob/de-mob. Foundation costs have been subtracted from the Marshall-Swift estimate.

***This price has been taken from LRH's floodproofing model in MCACES 5.31 and includes items such as site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanup.

		Current Contract Cost, FY 07		$139,290
	CONTINGENCY	@	**20.0%**	$27,858
	01 Account, Lands & Damage	Real Estate	**LS**	5,000
	02 Account, Relocations	Relocations	**LS**	0
	xx Account, Environmental Mitigation		**LS**	0
	30 Account, Plan, Engr.& Design	@	**9.3%**	13,000
	31 Account, Constr. Management	@	**5.0%**	7,000
	ESCALATION, FY-06	@	**0.0%**	0
				$192,148
				rounded
	TOTAL PROJECT COST, FY-2007			**$192,000**

Notes.

Estimate Excludes:

Operational & Maintenance Cost
Permanent Intrastructure
Relocations (pipelines, etc.)
Equipment (by Other Appropriations)

PROGRAMMING & PLANNING COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. -- DATE 22-Sep-07
LOCATION: **Mississippi** SHEET NO. OF
PREPARED: Don Whitmore CHECKED:
WORK ITEM: ***Existing Structure, 6' off low ground*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME:

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Raise Structure on Segmented Piles*	1,000	sf	70.00	$70,000
Aerator System - Assume to be installed on 10% on the structures	0.1	job	8,486.04	$849
Asbestos Abatement	1	job	1,697.21	$1,697
Temporary Housing Allowance	2	mo	848.60	$1,697
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0

Note: See MII reports for unit price backup and justification.

* Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house.

	Current Contract Cost, FY 07			$74,243
	CONTINGENCY	@	**20.0%**	$14,849
	01 Account, Lands & Damage	Real Estate	**LS**	5,000
	02 Account, Relocations	Relocations	**LS**	0
	xx Account, Environmental Mitigation		**LS**	0
	30 Account, Plan, Engr.& Design	@	**17.5%**	13,000
	31 Account, Constr. Management	@	**9.4%**	7,000
	ESCALATION, FY-06	@	**0.0%**	0
				$114,092
				rounded
	TOTAL PROJECT COST, FY-2007			**$114,000**

Notes.

Estimate Excludes:

Operational & Maintenance Cost
Permanent Intrastructure
Relocations (pipelines, etc.)
Equipment (by Other Appropriations)

PROGRAMMING & PLANNING COST ESTIMATE

PROJECT: **Mississippi Coastal Improvement Program "MsCIP"** ITEM NO. -- DATE 22-Sep-07
LOCATION: **Mississippi** SHEET NO. OF
PREPARED: Don Whitmore CHECKED:
WORK ITEM: ***Existing Structure, 15' off low ground*** BASIS of ESTIMATE: by project delv'd. team
FILE NAME:

DESCRIPTION	Quantity	Unit	Unit Price	ESTIMATED AMOUNT
Raise Structure on Segmented Piles*	1,000	sf	80.00	$80,000
Misc.- Storage Area	300	sf	15.17	$4,552
Aerator System - Assume to be installed on 10% on the structures	0.1	job	8,486.04	$849
Asbestos Abatement	1	job	1,697.21	$1,697
Temporary Housing Allowance	2	mo	848.60	$1,697
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0

Note: See MII reports for unit price backup and justification.

* Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house. He said that costs would likely be higher than this for a raise as high as 15' off low ground. Therefore, ad

	Current Contract Cost, FY 07			88,795
	CONTINGENCY	@	**20.0%**	$17,759
	01 Account, Lands & Damage	Real Estate	**LS**	5,000
	02 Account, Relocations	Relocations	**LS**	0
	xx Account, Environmental Mitigation		**LS**	0
	30 Account, Plan, Engr.& Design	@	**14.6%**	13,000
	31 Account, Constr. Management	@	**7.9%**	7,000
	ESCALATION, FY-06	@	**0.0%**	0
				$131,554
				rounded
	TOTAL PROJECT COST, FY-2007			**$132,000**

Notes.

Estimate Excludes:

Operational & Maintenance Cost
Permanent Intrastructure
Relocations (pipelines, etc.)
Equipment (by Other Appropriations)

Preliminary Estimate of Project Cost

for the

Floodproofing of Residential Structures

associated with the

Mississippi Coastal Improvement Program Comprehensive Study

at a Price Level equivalent to

1 October 2007

Model Cost Estimates

MII Estimates

Recon level cost estimate for the floodproofing of Residential Structures by means of elevating structure or replacing structure.

Estimated by	CELRH-ECT
Designed by	CELRH-PD, CELRH-ECD
Prepared by	Donald Whitmore, P.E.
Preparation Date	9/22/2007
Effective Date of Pricing	10/1/2007
Estimated Construction Time	Days

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Project Notes iv
Summary 1
Construct New Site Built Structure - 6 feet off low ground 1
Construct New Site Built Structure - 15 feet off low ground 1
Raise Existing Slab Foundation Structure - 6 feet off low ground 1
Raise Existing Slab Foundation Structure - 15 feet off low ground 1
Construct New Modular Structure - 6 feet off low ground 1
Construct New Modular Structure - 15 feet off low ground 1
Raise Existing Prefab Structure - 6 feet off low ground 1
Raise Existing Prefab Structure - 15 feet off low ground 1
Detail 2
Construct New Site Built Structure - 6 feet off low ground 2
01 - Lands & Damages 2
11 - Levees, Floodwalls, and Floodproofing 2
30 - Preconstruction Engineering & Design 3
31 - Supervision & Administration 3
Construct New Site Built Structure - 15 feet off low ground 3
01 - Lands & Damages 3
11 - Levees, Floodwalls, and Floodproofing 3
30 - Preconstruction Engineering & Design 4
31 - Supervision & Administration 4
Raise Existing Slab Foundation Structure - 6 feet off low ground 5
01 - Lands & Damages 5
11 - Levees, Floodwalls, and Floodproofing 5
30 - Preconstruction Engineering & Design 5
31 - Supervision & Administration 5
Raise Existing Slab Foundation Structure - 15 feet off low ground 5
01 - Lands & Damages 5
11 - Levees, Floodwalls, and Floodproofing 5
30 - Preconstruction Engineering & Design 6
31 - Supervision & Administration 6
Construct New Modular Structure - 6 feet off low ground 6
01 - Lands & Damages 6
11 - Levees, Floodwalls, and Floodproofing 7
30 - Preconstruction Engineering & Design 7
31 - Supervision & Administration 8
Construct New Modular Structure - 15 feet off low ground 8
01 - Lands & Damages 8
11 - Levees, Floodwalls, and Floodproofing 8
30 - Preconstruction Engineering & Design 9

31 - Supervision & Administration 9
Raise Existing Prefab Structure - 6 feet off low ground 9
01 - Lands & Damages 9
11 - Levees, Floodwalls, and Floodproofing 9
30 - Preconstruction Engineering & Design 10
31 - Supervision & Administration 10
Raise Existing Prefab Structure - 15 feet off low ground 10
01 - Lands & Damages 10
11 - Levees, Floodwalls, and Floodproofing 10
30 - Preconstruction Engineering & Design 11
31 - Supervision & Administration 11

Date	Author	Note
9/22/2007	Don Whitmore	SCOPE

This cost estimate is comprised of 8 model estimates. Each of these estimates pertains to the floodproofing of residential structures on the Gulf Coast.

1. New house construction on pier foundation at a finished first floor of 6 FT above low ground.

2. New house construction on pier foundation at a finished first floor of 15 FT above low ground.

3. Raising of existing house on slab foundation to a finished first floor of 6 Ft above low ground.

4. Raising of existing house on slab foundation to a finished first floor of 15 Ft above low ground.

5. New mobile home construction on pier foundation at a finished first floor of 6 FT above low ground.

6. New mobile home construction on pier foundation at a finished first floor of 15 FT above low ground.

7. Raising of existing mobile home to a finished first floor of 6 Ft above low ground.

8. Raising of existing mobile home to a finished first floor of 15 Ft above low ground.

ASSUMPTION AND EXCLUSIONS

1. All existing structures are assumed to be either a permanent structure with a slab foundation or a mobile home.

2. For the permanent structure alternatives (models 1 - 4), each structure is assumed to have a living area of 1,600 SF. This assumption applies to either the structure replacement alternative or the structure raise alternative. For the purposes of this estimate, the cost engineer has assumed a simple rectangular house with outside dimensions of 25' x 64'. This yields an area of 1,600 SF and a perimeter of 178 LF.

3. The replacement of permanent structures is based on wooden pier construction to the appropriate elevation (in this case, either 6' or 15' above low ground) and the construction of a new house on this foundation. The foundation quantities and costs for this alternative were detailed by the cost engineer based on the above assumptions. The cost of the new structure above the sill plate was estimated using the Marshall & Swift Residential Estimator 7 software, assuming the construction of an average quality home in the Gulfport, MS area.

4. The raising of an existing permanent construction home has been based on a segmental conrete pile foundation. The prime example of this technology is the "Davie Shoring" system (see www.davieshoring.com). It involves tunneling by hand under the slab foundation, cutting existing pile (if applicable), and installing the conrete piles one segment at a time by hydraulic jack until the piles reach refusal. The house is then raised on these piles and a new foundation is constructed. Depending on the structure's final height above low ground, the final foundation would be either the concrete segmental piles with a decorative facade or it would be CIP reinforced concrete with continuous grade beams. For these alternatives, the cost engineer simply obtained a quote from Davie for cost of providing a turnkey structure elevation.

5. For the mobile home construction (models 5 - 8), the replacement of eligible structures would be to construct a wooden pier foundation and place a modular home on this foundation. The structure is assumed to have a living area of 1,000 SF. For the purposes of this estimate, the cost engineer has assumed a simple rectangular mobile home with outside dimension of 14' x 72', which is very conservative by most standards for mobile homes. This yields an area of 1,008 SF and a perimeter of 172 LF. The foundation and living area cost has been estimated in a manner similar to that of the permanent structures (assumption #3), which is also considered by the cost engineer to be very conservative for modular home construction.

6. The raising of an existing mobel home assumes the same method of raising as the permanent construction approach (assumption #4, above). The primary difference is the structure area has been reduced from 1,600 SF to 1,000 SF.

Date Author **Note**

7. In each of the higher elevation alternatives (i.e., those involving a structure whose first floor elevation is 15' above low ground), a 300 SF storage area has been included as part of the foundation.

8. In all cases, allowances have been made for the following:
- asbestos abatement ($1000 per structure)
- aerator systems to be installed on 10% of the structures
- temporary housing
- utility connections (except for the raise alternatives whose quoted price already included utility hookup)

9. Site work costs for items such as landscaping, sidewalks and driveways as well as exterminating, landscaping and construction cleanup have been based on LRH's 202 floodproofing cost model. Parameters were used as input into the model that would fit each of the above descriptions (models 1 - 8), and the total values for these items have been included in this estimate as lump sums.

10. Davis-Bacon labor rates were not used in this estimate. According to the PDT, the project will be formulated such that the requirement to use Davis-Bacon will not apply. At this time, the precise labor rate requirement is unknown. Consequently, the cost engineer left the labor rates undisturbed for each of the various cost sources. As an example, the MEANS cost manuals are based on national average labor rates. However, no attempt was made to adjust the items priced by the MEANS cost manual to account for a different labor rate.

FEATURE ACCOUNTS

01 Lands & Damages: Since these estimates only apply to the floodproofing of structures on site and not the acquisition and demolition of structures, the only costs shown in this account are for administration purposes. An allowance of $5,000 per structure has been made based on LRH's Section 202 floodproofing program. This price would include contingencies.

11 Levees, Floodwalls, & Floodproofing: Costs have been developed in accordance with the above assumptions.

30 Preconstruction Engineering & Design: An allowance of $13,000 per structure has been made based on LRH's Section 202 floodproofing program. This price would include contingencies.

31 Supervision & Administration: An allowance of $7,000 per structure has been made based on LRH's Section 202 floodproofing program. This price would include contingencies.

LEVEL OF EFFORT

This estimate is considered to be preliminary in nature and is to be used as such. The scopes provided to the cost engineer were very general. Indeed, the level of effort put forth by the cost engineer is commensurate to the general nature of the design.

PRICE LEVEL

The costs contained within this estimate have been prepared at a Price Level equivalent to 1 October 2007. Contingency has been included at 25% for model estimates 1 - 4. For the mobile home alternatives, however, a contingency of only 20% was applied due to the very conservative nature of the approach in estimating.

COST SOURCES

A variety of cost sources were used in preparing this estimate. The primary sources were:

- Marshall & Swift Residential Estimator 7
- LRH's Section 202 Implementation Floodproofing Cost Model

Date	Author	Note
		- MEANS Heavy Construction, 2005

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
Summary			**1,280,877.95**	**248,763.24**	**1,529,641.19**
Construct New Site Built Structure - 6 feet off low ground	**1,600.00**	**SF**	*133.85* **214,158.55**	**47,289.64**	*163.41* **261,448.18**
Construct New Site Built Structure - 15 feet off low ground	**1,600.00**	**SF**	*146.60* **234,556.53**	**52,389.13**	*179.34* **286,945.67**
Raise Existing Slab Foundation Structure - 6 feet off low ground	**1,600.00**	**SF**	*88.28* **141,243.02**	**29,060.76**	*106.44* **170,303.78**
Raise Existing Slab Foundation Structure - 15 feet off low ground	**1,600.00**	**SF**	*101.12* **161,794.94**	**34,198.73**	*122.50* **195,993.67**
Construct New Modular Structure - 6 feet off low ground	**1,000.00**	**SF**	*151.80* **151,797.34**	**25,359.47**	*177.16* **177,156.81**
Construct New Modular Structure - 15 feet off low ground	**1,000.00**	**SF**	*164.29* **164,289.62**	**27,857.92**	*192.15* **192,147.54**
Raise Existing Prefab Structure - 6 feet off low ground	**1,000.00**	**SF**	*99.24* **99,243.02**	**14,848.60**	*114.09* **114,091.63**
Raise Existing Prefab Structure - 15 feet off low ground	**1,000.00**	**SF**	*113.79* **113,794.94**	**17,758.99**	*131.55* **131,553.92**

Description	Quantity	UOM	CostToPrime	PrimeCMU	ContractCost	Contingency	ProjectCost
Detail			**1,115,594.43**	**165,283.52**	**1,280,877.95**	**248,763.24**	**1,529,641.19**
			105.39		*133.85*		*163.41*
Construct New Site Built Structure - 6 feet off low ground	**1,600.00**	**SF**	**168,629.89**	**45,528.65**	**214,158.55**	**47,289.64**	**261,448.18**
			5,000.00		*5,000.00*		*5,000.00*
01 - Lands & Damages	**1.00**	**EA**	**5,000.00**	**0.00**	**5,000.00**	**0.00**	**5,000.00**
Real Estate Admin	1.00	LS	5,000.00	0.00	5,000.00	0.00	5,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			143,629.89		*189,158.55*		*236,448.18*
11 - Levees, Floodwalls, and Floodproofing	**1.00**	**EA**	**143,629.89**	**45,528.65**	**189,158.55**	**47,289.64**	**236,448.18**
			53.19		*70.28*		*87.85*
Structure Above Sill Plate	**1,600.00**	**SF**	**85,104.00**	**27,346.85**	**112,450.85**	**28,112.71**	**140,563.57**
			53.19		*70.28*	*25.00*	*87.85*
New Structure - Above Sill Plate	1,600.00	SF	85,104.00	27,346.85	112,450.85	28,112.71	140,563.57
(Note: Cost estimated by Marshall-Swift for an average quality 1600 SF structure in the Gulfport, MS area. See backup sheet from Marshall Swift. Estimated unit price is $68.35/SF including O&P. Since the pier foundation is estimated elsewhere in this estimate, the standard CIP wall foundation should be deleted from this Marshall-Swift estimate. Also, the overhead and profit should be deleted here. MII will add O&P to the direct cost unit price under the Project Item tab. O&P is estimated to be 14.5% in the Marshall-Swift program. The foundation is estimated to cost $67/LF of perimeter (MEANS), including O&P. $67/LF x (25x2 + 64x2) = $11,926. Now, $11,926 / 1600 SF = $7.45/SF that is to be deducted from the estimated unit price for new construction. So, $68.35/SF - $7.45/SF = $60.90/SF (w/ O&P) Subtracting O&P, $60.90/SF / 1.145 = $53.19/SF<---)								
			41,585.06		*54,947.78*		*68,684.73*
Foundation & Structure Below Sill Plate	**1.00**	**EA**	**41,585.06**	**13,362.72**	**54,947.78**	**13,736.95**	**68,684.73**
			617.30		*815.66*		*1,019.58*
Timber Piles	**60.00**	**EA**	**37,038.06**	**11,901.61**	**48,939.67**	**12,234.92**	**61,174.59**
(Note: Assume a 6' grid for a house that is 25' x 64' (i.e., a 1600 SF house).)							
			13.72		*18.13*	*25.00*	*22.66*
Timber Piles	2,700.00	VLF	37,038.06	11,901.61	48,939.67	12,234.92	61,174.59
(Note: Material price taken from MEANS. Piles are assumed to be 12" diameter at the head and are to be embedded 40' into the ground.)							
			4,547.00		*6,008.11*		*7,510.14*
Pressure Treated Lumber	**1.00**	**EA**	**4,547.00**	**1,461.11**	**6,008.11**	**1,502.03**	**7,510.14**
(Note: Assume 2 9' braces per span. A 6x6 grid for a 25 x 64 house yields 60 piles with 55 spans. Therefore, total bracing = 2 x 9 x 55 = 990 LF of 4x4 bracing<---)							
			2.00		*2.64*	*25.00*	*3.30*
Pressure Treated Lumber, 2x10	640.00	LF	1,280.00	411.31	1,691.31	422.83	2,114.14
(Note: Reference LRH's 202 floodproofing implementation model.)							
			3.30		*4.36*	*25.00*	*5.45*
4x4 Cross Bracing	990.00	LF	3,267.00	1,049.80	4,316.80	1,079.20	5,396.00
(Note: Reference LRH's 202 floodproofing implementation model for cost. Assume 2 9' braces per span. A 6x6 grid for a 25 x 64 house yields 60 piles with 55 spans. Therefore, total bracing = 2 x 9 x 55 = 990 LF of 4x4 bracing<---)							
Misc	**1.00**	**LS**	**16,940.83**	**4,819.08**	**21,759.91**	**5,439.98**	**27,199.89**
Misc - 6' off low ground	1.00	LS	9,673.49	2,751.78	12,425.27	3,106.32	15,531.58
(Note: This item of work covers the cost of site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanup for a structure whose first floor is 6' off low ground. Price estimated by LRH's 202 floodproofing implementation model.)							
			3,964.00		*5,091.63*	*25.00*	*6,364.53*
Utility Hookups	1.00	EA	3,964.00	1,127.62	5,091.63	1,272.91	6,364.53
(Note: This is an allowance to cover the costs of installing (or having installed) the water, electric, and gas meters.)							

Description	Quantity	UOM	CostToPrime	PrimeCMU	ContractCost	Contingency	ProjectCost
Aerator System	0.10	LS	660.67	187.94	848.60	212.15	1,060.76
(Note: Assume that 1 out of every 10 houses will need an aerator system installed. The price of $5000 has been taken from LRH's 202 floodproofing model.)							
Asbestos Abatement	1.00	LS	1,321.33	375.87	1,697.21	424.30	2,121.51
(Note: This is an allowance based on historical data from LRH's 202 program for an average cost per structure for asbestos abatement of a large sample of structures.)							
			660.67		*848.60*	*25.00*	*1,060.76*
Temporary Housing Allowance	2.00	MO	1,321.33	375.87	1,697.21	424.30	2,121.51
(Note: Assume $500 per month.)							
			13,000.00		*13,000.00*		*13,000.00*
30 - Preconstruction Engineering & Design	**1.00**	**EA**	**13,000.00**	**0.00**	**13,000.00**	**0.00**	**13,000.00**
Engineering & Design	1.00	LS	13,000.00	0.00	13,000.00	0.00	13,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			7,000.00		*7,000.00*		*7,000.00*
31 - Supervision & Administration	**1.00**	**EA**	**7,000.00**	**0.00**	**7,000.00**	**0.00**	**7,000.00**
Supervision & Administration	1.00	LS	7,000.00	0.00	7,000.00	0.00	7,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			115.13		*146.60*		*179.34*
Construct New Site Built Structure - 15 feet off low ground	**1,600.00**	**SF**	**184,204.02**	**50,352.52**	**234,556.53**	**52,389.13**	**286,945.67**
			5,000.00		*5,000.00*		*5,000.00*
01 - Lands & Damages	**1.00**	**EA**	**5,000.00**	**0.00**	**5,000.00**	**0.00**	**5,000.00**
Real Estate Admin	1.00	LS	5,000.00	0.00	5,000.00	0.00	5,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			159,204.02		*209,556.53*		*261,945.67*
11 - Levees, Floodwalls, and Floodproofing	**1.00**	**EA**	**159,204.02**	**50,352.52**	**209,556.53**	**52,389.13**	**261,945.67**
			53.19		*70.28*		*87.85*
Structure Above Sill Plate	**1,600.00**	**SF**	**85,104.00**	**27,346.85**	**112,450.85**	**28,112.71**	**140,563.57**
			53.19		*70.28*	*25.00*	*87.85*
New Structure - Above Sill Plate	1,600.00	SF	85,104.00	27,346.85	112,450.85	28,112.71	140,563.57
(Note: Cost estimated by Marshall-Swift for an average quality 1600 SF structure in the Gulfport, MS area. See backup sheet from Marshall Swift. Estimated unit price is $68.35/SF including O&P. Since the pier foundation is estimated elsewhere in this estimate, the standard CIP wall foundation should be deleted from this Marshall-Swift estimate. Also, the overhead and profit should be deleted here. MII will add O&P to the direct cost unit price under the Project Item tab. O&P is estimated to be 14.5% in the Marshall-Swift program. The foundation is estimated to cost $67/LF of perimeter (MEANS), including O&P. $67/LF x (25x2 + 64x2) = $11,926. Now, $11,926 / 1600 SF = $7.45/SF that is to be deducted from the estimated unit price for new construction. So, $68.35/SF - $7.45/SF = $60.90/SF (w/ O&P) Subtracting O&P, $60.90/SF / 1.145 = $53.19/SF<---)							
			52,259.68		*69,052.52*		*86,315.64*
Foundation & Structure Below Sill Plate	**1.00**	**EA**	**52,259.68**	**16,792.84**	**69,052.52**	**17,263.13**	**86,315.64**
			740.76		*978.79*		*1,223.49*
Timber Piles	**60.00**	**EA**	**44,445.68**	**14,281.93**	**58,727.61**	**14,681.90**	**73,409.51**
(Note: Assume a 6' grid for a house that is 25' x 64' (i.e., a 1600 SF house).)							
			13.72		*18.13*	*25.00*	*22.66*
Timber Piles	3,240.00	VLF	44,445.68	14,281.93	58,727.61	14,681.90	73,409.51
(Note: Material price taken from MEANS. Piles are assumed to be 12" diameter at the head and are to be embedded 40' into the ground.)							
			7,814.00		*10,324.91*		*12,906.13*
Pressure Treated Lumber	**1.00**	**EA**	**7,814.00**	**2,510.91**	**10,324.91**	**2,581.23**	**12,906.13**
			2.00		*2.64*	*25.00*	*3.30*

Description	Quantity	UOM	CostToPrime	PrimeCMU	ContractCost	Contingency	ProjectCost
Pressure Treated Lumber, 2x10	640.00	LF	1,280.00	411.31	1,691.31	422.83	2,114.14
(Note: Reference LRH's 202 floodproofing implementation model.)							
			3.30		*4.36*	*25.00*	*5.45*
4x4 Cross Bracing	1,980.00	LF	6,534.00	2,099.60	8,633.60	2,158.40	10,792.00
(Note: Reference LRH's 202 floodproofing implementation model. Assume 4 9' braces per span. A 6x6 grid for a 25 x 64 house yields 60 piles with 55 spans. Therefore, total bracing = 4 x 9 x 55 = 1980 LF of 4x4 bracing<---)							
Misc	**1.00**	**LS**	**21,840.34**	**6,212.82**	**28,053.16**	**7,013.29**	**35,066.45**
			11.81		*15.17*		*18.97*
300 SF Stoarge Area	**300.00**	**SF**	**3,543.82**	**1,008.09**	**4,551.91**	**1,137.98**	**5,689.89**
(Note: This would only apply to structures that area greater than 6 FT above low ground. In this estimate, that means that it only applies to the 6' - 15' raise category.)							
			6.53		*8.38*	*25.00*	*10.48*
4" Concrete Pad	300.00	SF	1,958.22	557.05	2,515.26	628.82	3,144.08
(Note: Price from LRH's floodproofing model for 4" concrete = $370/CY, direct cost. SAY = $400/CY for the gulf coast. Now, $400/CY x (4in/36in/yd) = $44.44/SY. So, $44.44/SY / 9 SF/SY = $4.94/SF<---)							
			13.21		*16.97*	*25.00*	*21.22*
Siding	80.00	EA	1,057.07	300.70	1,357.77	339.44	1,697.21
(Note: = 10 x 2 + 30 x 2 = 80 SF)							
			264.27		*339.44*	*25.00*	*424.30*
Door	1.00	EA	264.27	75.17	339.44	84.86	424.30
Electrical Allowance	1.00	LS	264.27	75.17	339.44	84.86	424.30
			18,296.52		*23,501.25*		*29,376.56*
Other	**1.00**	**EA**	**18,296.52**	**5,204.73**	**23,501.25**	**5,875.31**	**29,376.56**
			3,964.00		*5,091.63*	*25.00*	*6,364.53*
Utility Hookups	1.00	EA	3,964.00	1,127.62	5,091.63	1,272.91	6,364.53
(Note: This is an allowance to cover the costs of installing (or having installed) the water, electric, and gas meters.)							
Misc - 15' off low ground	1.00	LS	11,029.18	3,137.42	14,166.60	3,541.65	17,708.25
(Note: This item of work covers the cost of site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanupfor a structure whose first floor is 15' off low ground. Price estimated by LRH's 202 floodproofing implementation model.)							
Aerator System	0.10	LS	660.67	187.94	848.60	212.15	1,060.76
(Note: Assume that 1 out of every 10 houses will need an aerator system installed. The price of $5000 has been taken from LRH's 202 floodproofing model.)							
Asbestos Abatement	1.00	LS	1,321.33	375.87	1,697.21	424.30	2,121.51
(Note: This is an allowance based on historical data from LRH's 202 program for an average cost per structure for asbestos abatement of a large sample of structures.)							
			660.67		*848.60*	*25.00*	*1,060.76*
Temporary Housing Allowance	2.00	MO	1,321.33	375.87	1,697.21	424.30	2,121.51
(Note: Assume $500 per month.)							
			13,000.00		*13,000.00*		*13,000.00*
30 - Preconstruction Engineering & Design	**1.00**	**EA**	**13,000.00**	**0.00**	**13,000.00**	**0.00**	**13,000.00**
Engineering & Design	1.00	LS	13,000.00	0.00	13,000.00	0.00	13,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			7,000.00		*7,000.00*		*7,000.00*
31 - Supervision & Administration	**1.00**	**EA**	**7,000.00**	**0.00**	**7,000.00**	**0.00**	**7,000.00**
Supervision & Administration	1.00	LS	7,000.00	0.00	7,000.00	0.00	7,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			87.69		*88.28*		*106.44*

Description	Quantity	UOM	CostToPrime	PrimeCMU	ContractCost	Contingency	ProjectCost
Raise Existing Slab Foundation Structure - 6 feet off low ground	**1,600.00**	**SF**	**140,303.34**	**939.69**	**141,243.02**	**29,060.76**	**170,303.78**
(Note: This price already includes all contractor markups. Therefore, none have been added here.)							
			5,000.00		*5,000.00*		*5,000.00*
01 - Lands & Damages	**1.00**	**EA**	**5,000.00**	**0.00**	**5,000.00**	**0.00**	**5,000.00**
Real Estate Admin	1.00	LS	5,000.00	0.00	5,000.00	0.00	5,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			115,303.34		*116,243.02*		*145,303.78*
11 - Levees, Floodwalls, and Floodproofing	**1.00**	**EA**	**115,303.34**	**939.69**	**116,243.02**	**29,060.76**	**145,303.78**
			112,000.00		*112,000.00*		*140,000.00*
Raise	**1.00**	**EA**	**112,000.00**	**0.00**	**112,000.00**	**28,000.00**	**140,000.00**
			70.00		*70.00*	*25.00*	*87.50*
Raise Structure on Segmented Piles to 6' off low ground	1,600.00	SF	112,000.00	0.00	112,000.00	28,000.00	140,000.00
(Note: Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house. This price would be for a slab foundation struture whose finished first floor would be greater than 4' above low ground. It is suspected that Pat pays significantly less than Davis-Bacon wages. PD was consulted on this issue. PD recommended that since this project is to be formulated on the basis that Davis-Bacon is not a requirement, the pricing info provided by Mr. Davie is acceptable.)							
			3,303.34		*4,243.02*		*5,303.78*
Misc	**1.00**	**EA**	**3,303.34**	**939.69**	**4,243.02**	**1,060.76**	**5,303.78**
Aerator System	0.10	LS	660.67	187.94	848.60	212.15	1,060.76
(Note: Assume that 1 out of every 10 houses will need an aerator system installed. The price of $5000 has been taken from LRH's 202 floodproofing model.)							
Asbestos Abatement	1.00	LS	1,321.33	375.87	1,697.21	424.30	2,121.51
(Note: This is an allowance based on historical data from LRH's 202 program for an average cost per structure for asbestos abatement of a large sample of structures.)							
			660.67		*848.60*	*25.00*	*1,060.76*
Temporary Housing Allowance	2.00	MO	1,321.33	375.87	1,697.21	424.30	2,121.51
(Note: Assume $500 per month.)							
			13,000.00		*13,000.00*		*13,000.00*
30 - Preconstruction Engineering & Design	**1.00**	**EA**	**13,000.00**	**0.00**	**13,000.00**	**0.00**	**13,000.00**
Engineering & Design	1.00	LS	13,000.00	0.00	13,000.00	0.00	13,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			7,000.00		*7,000.00*		*7,000.00*
31 - Supervision & Administration	**1.00**	**EA**	**7,000.00**	**0.00**	**7,000.00**	**0.00**	**7,000.00**
Supervision & Administration	1.00	LS	7,000.00	0.00	7,000.00	0.00	7,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			99.90		*101.12*		*122.50*
Raise Existing Slab Foundation Structure - 15 feet off low ground	**1,600.00**	**SF**	**159,847.16**	**1,947.78**	**161,794.94**	**34,198.73**	**195,993.67**
(Note: This price already includes all contractor markups. Therefore, none have been added here.)							
			5,000.00		*5,000.00*		*5,000.00*
01 - Lands & Damages	**1.00**	**EA**	**5,000.00**	**0.00**	**5,000.00**	**0.00**	**5,000.00**
Real Estate Admin	1.00	LS	5,000.00	0.00	5,000.00	0.00	5,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			134,847.16		*136,794.94*		*170,993.67*
11 - Levees, Floodwalls, and Floodproofing	**1.00**	**EA**	**134,847.16**	**1,947.78**	**136,794.94**	**34,198.73**	**170,993.67**
			128,000.00		*128,000.00*		*160,000.00*
Raise	**1.00**	**EA**	**128,000.00**	**0.00**	**128,000.00**	**32,000.00**	**160,000.00**

Description	Quantity	UOM	CostToPrime	PrimeCMU	ContractCost	Contingency	ProjectCost
			80.00		*80.00*	*25.00*	*100.00*
Raise Structure on Segmented Piles to 15' off low ground	1,600.00	SF	128,000.00	0.00	128,000.00	32,000.00	160,000.00
(Note: Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house. He said that costs would likely be higher than this for a raise as high as 15' off low ground. Therefore, add $10/SF to cover this higher raise. This price would be for a slab foundation struture whose finished first floor would be greater than 15' above low ground. PD was consulted on this issue. PD recommended that since this project is to be formulated on the basis that Davis-Bacon is not a requirement, the pricing info provided by Mr. Davie is acceptable.)							
			11.81		*15.17*		*18.97*
300 SF Stoarge Area	**300.00**	**SF**	**3,543.82**	**1,008.09**	**4,551.91**	**1,137.98**	**5,689.89**
(Note: This would only apply to structures that area greater than 6 FT above low ground. In this estimate, that means that it only applies to the 6' - 15' raise category.)							
			6.53		*8.38*	*25.00*	*10.48*
4" Concrete Pad	300.00	SF	1,958.22	557.05	2,515.26	628.82	3,144.08
(Note: Price from LRH's floodproofing model for 4" concrete = $370/CY, direct cost. SAY = $400/CY for the gulf coast. Now, $400/CY x (4in/36in/yd) = $44.44/SY. So, $44.44/SY / 9 SF/SY = $4.94/SF<---)							
			13.21		*16.97*	*25.00*	*21.22*
Siding	80.00	EA	1,057.07	300.70	1,357.77	339.44	1,697.21
(Note: = 10 x 2 + 30 x 2 = 80 SF)							
			264.27		*339.44*	*25.00*	*424.30*
Door	1.00	EA	264.27	75.17	339.44	84.86	424.30
Electrical Allowance	1.00	LS	264.27	75.17	339.44	84.86	424.30
			3,303.34		*4,243.02*		*5,303.78*
Misc	**1.00**	**EA**	**3,303.34**	**939.69**	**4,243.02**	**1,060.76**	**5,303.78**
Aerator System	0.10	LS	660.67	187.94	848.60	212.15	1,060.76
(Note: Assume that 1 out of every 10 houses will need an aerator system installed. The price of $5000 has been taken from LRH's 202 floodproofing model.)							
Asbestos Abatement	1.00	LS	1,321.33	375.87	1,697.21	424.30	2,121.51
(Note: This is an allowance based on historical data from LRH's 202 program for an average cost per structure for asbestos abatement of a large sample of structures.)							
			660.67		*848.60*	*25.00*	*1,060.76*
Temporary Housing Allowance	2.00	MO	1,321.33	375.87	1,697.21	424.30	2,121.51
(Note: Assume $500 per month.)							
			13,000.00		*13,000.00*		*13,000.00*
30 - Preconstruction Engineering & Design	**1.00**	**EA**	**13,000.00**	**0.00**	**13,000.00**	**0.00**	**13,000.00**
Engineering & Design	1.00	LS	13,000.00	0.00	13,000.00	0.00	13,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			7,000.00		*7,000.00*		*7,000.00*
31 - Supervision & Administration	**1.00**	**EA**	**7,000.00**	**0.00**	**7,000.00**	**0.00**	**7,000.00**
Supervision & Administration	1.00	LS	7,000.00	0.00	7,000.00	0.00	7,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			121.43		*151.80*		*177.16*
Construct New Modular Structure - 6 feet off low ground	**1,000.00**	**SF**	**121,434.27**	**30,363.07**	**151,797.34**	**25,359.47**	**177,156.81**
			5,000.00		*5,000.00*		*5,000.00*
01 - Lands & Damages	**1.00**	**EA**	**5,000.00**	**0.00**	**5,000.00**	**0.00**	**5,000.00**
Real Estate Admin	1.00	LS	5,000.00	0.00	5,000.00	0.00	5,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			96,434.27		*126,797.34*		*152,156.81*

Description	Quantity	UOM	CostToPrime	PrimeCMU	ContractCost	Contingency	ProjectCost
11 - Levees, Floodwalls, and Floodproofing	**1.00**	**EA**	**96,434.27**	**30,363.07**	**126,797.34**	**25,359.47**	**152,156.81**
			53.19		*70.28*		*84.34*
Structure Above Sill Plate	**1,000.00**	**SF**	**53,190.00**	**17,091.78**	**70,281.78**	**14,056.36**	**84,338.14**
			53.19		*70.28*	*20.00*	*84.34*
New Structure - Above Sill Plate	1,000.00	SF	53,190.00	17,091.78	70,281.78	14,056.36	84,338.14
(Note: Cost estimated by Marshall-Swift for an average quality 1000 SF structure in the Gulfport, MS area. See backup sheet from Marshall Swift. Estimated unit price is $68.35/SF including O&P. Since the pier foundation is estimated elsewhere in this estimate, the standard CIP wall foundation should be deleted from this Marshall-Swift estimate. Also, the overhead and profit should be deleted here. MII will add O&P to the direct cost unit price under the Project Item tab. O&P is estimated to be 14.5% in the Marshall-Swift program. The foundation is estimated to cost $67/LF of perimeter (MEANS), including O&P. $67/LF x (25x2 + 64x2) = $11,926. Now, $11,926 / 1600 SF = $7.45/SF that is to be deducted from the estimated unit price for new construction. So, $68.35/SF - $7.45/SF = $60.90/SF (w/ O&P) Subtracting O&P, $60.90/SF / 1.145 = $53.19/SF<---)							
			26,303.44		*34,755.64*		*41,706.77*
Foundation & Structure Below Sill Plate	**1.00**	**EA**	**26,303.44**	**8,452.20**	**34,755.64**	**6,951.13**	**41,706.77**
			617.30		*815.66*		*978.79*
Timber Piles	**38.00**	**EA**	**23,457.44**	**7,537.69**	**30,995.13**	**6,199.03**	**37,194.15**
(Note: Assume a 6' grid.)							
			13.72		*18.13*	*20.00*	*21.75*
Timber Piles	1,710.00	VLF	23,457.44	7,537.69	30,995.13	6,199.03	37,194.15
(Note: Material price taken from MEANS. Piles are assumed to be 12" diameter at the head and are to be embedded 40' into the ground.)							
			2,846.00		*3,760.52*		*4,512.62*
Pressure Treated Lumber	**1.00**	**EA**	**2,846.00**	**914.52**	**3,760.52**	**752.10**	**4,512.62**
(Note: Assume 2 9' braces per span.)							
			3.30		*4.36*	*20.00*	*5.23*
4x4 Cross Bracing	620.00	LF	2,046.00	657.45	2,703.45	540.69	3,244.14
(Note: Reference LRH's 202 floodproofing implementation model.)							
			2.00		*2.64*	*20.00*	*3.17*
Pressure Treated Lumber, 2x10	400.00	LF	800.00	257.07	1,057.07	211.41	1,268.48
(Note: Reference LRH's 202 floodproofing implementation model.)							
Misc	**1.00**	**LS**	**16,940.83**	**4,819.08**	**21,759.91**	**4,351.98**	**26,111.90**
Misc	1.00	LS	9,673.49	2,751.78	12,425.27	2,485.05	14,910.32
(Note: This item of work covers the cost of site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanup for a structure whose first floor is 6' off low ground. Price estimated by LRH's 202 floodproofing implementation model.)							
			3,964.00		*5,091.63*	*20.00*	*6,109.95*
Utility Hookups	1.00	EA	3,964.00	1,127.62	5,091.63	1,018.33	6,109.95
(Note: This is an allowance to cover the costs of installing (or having installed) the water, electric, and gas meters.)							
Aerator System	0.10	LS	660.67	187.94	848.60	169.72	1,018.33
(Note: Assume that 1 out of every 10 houses will need an aerator system installed. The price of $5000 has been taken from LRH's 202 floodproofing model.)							
Asbestos Abatement	1.00	LS	1,321.33	375.87	1,697.21	339.44	2,036.65
(Note: This is an allowance based on historical data from LRH's 202 program for an average cost per structure for asbestos abatement of a large sample of structures.)							
			660.67		*848.60*	*20.00*	*1,018.33*
Temporary Housing Allowance	2.00	MO	1,321.33	375.87	1,697.21	339.44	2,036.65
(Note: Assume $500 per month.)							
			13,000.00		*13,000.00*		*13,000.00*
30 - Preconstruction Engineering & Design	**1.00**	**EA**	**13,000.00**	**0.00**	**13,000.00**	**0.00**	**13,000.00**
Engineering & Design	1.00	LS	13,000.00	0.00	13,000.00	0.00	13,000.00

Description	Quantity	UOM	CostToPrime	PrimeCMU	ContractCost	Contingency	ProjectCost
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			7,000.00		*7,000.00*		*7,000.00*
31 - Supervision & Administration	**1.00**	**EA**	**7,000.00**	**0.00**	**7,000.00**	**0.00**	**7,000.00**
Supervision & Administration	1.00	LS	7,000.00	0.00	7,000.00	0.00	7,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			131.03		*164.29*		*192.15*
Construct New Modular Structure - 15 feet off low ground	**1,000.00**	**SF**	**131,025.27**	**33,264.35**	**164,289.62**	**27,857.92**	**192,147.54**
			5,000.00		*5,000.00*		*5,000.00*
01 - Lands & Damages	**1.00**	**EA**	**5,000.00**	**0.00**	**5,000.00**	**0.00**	**5,000.00**
Real Estate Admin	1.00	LS	5,000.00	0.00	5,000.00	0.00	5,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			106,025.27		*139,289.62*		*167,147.54*
11 - Levees, Floodwalls, and Floodproofing	**1.00**	**EA**	**106,025.27**	**33,264.35**	**139,289.62**	**27,857.92**	**167,147.54**
			53.19		*70.28*		*84.34*
Structure Above Sill Plate	**1,000.00**	**SF**	**53,190.00**	**17,091.78**	**70,281.78**	**14,056.36**	**84,338.14**
			53.19		*70.28*	*20.00*	*84.34*
New Structure - Above Sill Plate	1,000.00	SF	53,190.00	17,091.78	70,281.78	14,056.36	84,338.14
(Note: Cost estimated by Marshall-Swift for an average quality 1000 SF structure in the Gulfport, MS area. See backup sheet from Marshall Swift. Estimated unit price is $68.35/SF including O&P. Since the pier foundation is estimated elsewhere in this estimate, the standard CIP wall foundation should be deleted from this Marshall-Swift estimate. Also, the overhead and profit should be deleted here. MII will add O&P to the direct cost unit price under the Project Item tab. O&P is estimated to be 14.5% in the Marshall-Swift program. The foundation is estimated to cost $67/LF of perimeter (MEANS), including O&P. $67/LF x (25x2 + 64x2) = $11,926. Now, $11,926 / 1600 SF = $7.45/SF that is to be deducted from the estimated unit price for new construction. So, $68.35/SF - $7.45/SF = $60.90/SF (w/ O&P) Subtracting O&P, $60.90/SF / 1.145 = $53.19/SF<---)							
			30,994.93		*40,954.67*		*49,145.60*
Foundation & Structure Below Sill Plate	**1.00**	**EA**	**30,994.93**	**9,959.74**	**40,954.67**	**8,190.93**	**49,145.60**
			740.76		*978.79*		*1,174.55*
Timber Piles	**38.00**	**EA**	**28,148.93**	**9,045.22**	**37,194.15**	**7,438.83**	**44,632.98**
(Note: Assume a 6' grid.)							
			13.72		*18.13*	*20.00*	*21.75*
Timber Piles	2,052.00	VLF	28,148.93	9,045.22	37,194.15	7,438.83	44,632.98
(Note: Material price taken from MEANS. Piles are assumed to be 12" diameter at the head and are to be embedded 40' into the ground.)							
			2,846.00		*3,760.52*		*4,512.62*
Pressure Treated Lumber	**1.00**	**EA**	**2,846.00**	**914.52**	**3,760.52**	**752.10**	**4,512.62**
			3.30		*4.36*	*20.00*	*5.23*
4x4 Cross Bracing	620.00	LF	2,046.00	657.45	2,703.45	540.69	3,244.14
(Note: Reference LRH's 202 floodproofing implementation model. Assume 2 9' braces per span.)							
			2.00		*2.64*	*20.00*	*3.17*
Pressure Treated Lumber, 2x10	400.00	LF	800.00	257.07	1,057.07	211.41	1,268.48
(Note: Reference LRH's 202 floodproofing implementation model.)							
Misc	**1.00**	**LS**	**21,840.34**	**6,212.82**	**28,053.16**	**5,610.63**	**33,663.80**
			11.81		*15.17*		*18.21*
300 SF Stoarge Area	**300.00**	**SF**	**3,543.82**	**1,008.09**	**4,551.91**	**910.38**	**5,462.30**
(Note: This would only apply to structures that area greater than 6 FT above low ground. In this estimate, that means that it only applies to the 6' - 15' raise category.)							

Description	Quantity	UOM	CostToPrime	PrimeCMU	ContractCost	Contingency	ProjectCost
			6.53		*8.38*	*20.00*	*10.06*
4" Concrete Pad	300.00	SF	1,958.22	557.05	2,515.26	503.05	3,018.32
(Note: Price from LRH's floodproofing model for 4" concrete = $370/CY, direct cost. SAY = $400/CY for the gulf coast. Now, $400/CY x (4in/36in/yd) = $44.44/SY. So, $44.44/SY / 9 SF/SY = $4.94/SF<---)							
			13.21		*16.97*	*20.00*	*20.37*
Siding	80.00	EA	1,057.07	300.70	1,357.77	271.55	1,629.32
(Note: = 10 x 2 + 30 x 2 = 80 SF)							
			264.27		*339.44*	*20.00*	*407.33*
Door	1.00	EA	264.27	75.17	339.44	67.89	407.33
Electrical Allowance	1.00	LS	264.27	75.17	339.44	67.89	407.33
			18,296.52		*23,501.25*		*28,201.50*
Other	**1.00**	**EA**	**18,296.52**	**5,204.73**	**23,501.25**	**4,700.25**	**28,201.50**
			3,964.00		*5,091.63*	*20.00*	*6,109.95*
Utility Hookups	1.00	EA	3,964.00	1,127.62	5,091.63	1,018.33	6,109.95
(Note: This is an allowance to cover the costs of installing (or having installed) the water, electric, and gas meters.)							
Misc - 15' off low ground	1.00	LS	11,029.18	3,137.42	14,166.60	2,833.32	16,999.92
(Note: This item of work covers the cost of site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanupfor a structure whose first floor is 15' off low ground. Price estimated by LRH's 202 floodproofing implementation model.)							
Asbestos Abatement	1.00	LS	1,321.33	375.87	1,697.21	339.44	2,036.65
(Note: This is an allowance based on historical data from LRH's 202 program for an average cost per structure for asbestos abatement of a large sample of structures.)							
Aerator System	0.10	LS	660.67	187.94	848.60	169.72	1,018.33
(Note: Assume that 1 out of every 10 houses will need an aerator system installed. The price of $5000 has been taken from LRH's 202 floodproofing model.)							
			660.67		*848.60*	*20.00*	*1,018.33*
Temporary Housing Allowance	2.00	MO	1,321.33	375.87	1,697.21	339.44	2,036.65
(Note: Assume $500 per month.)							
			13,000.00		*13,000.00*		*13,000.00*
30 - Preconstruction Engineering & Design	**1.00**	**EA**	**13,000.00**	**0.00**	**13,000.00**	**0.00**	**13,000.00**
Engineering & Design	1.00	LS	13,000.00	0.00	13,000.00	0.00	13,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			7,000.00		*7,000.00*		*7,000.00*
31 - Supervision & Administration	**1.00**	**EA**	**7,000.00**	**0.00**	**7,000.00**	**0.00**	**7,000.00**
Supervision & Administration	1.00	LS	7,000.00	0.00	7,000.00	0.00	7,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			98.30		*99.24*		*114.09*
Raise Existing Prefab Structure - 6 feet off low ground	**1,000.00**	**SF**	**98,303.34**	**939.69**	**99,243.02**	**14,848.60**	**114,091.63**
(Note: This price already includes all contractor markups. Therefore, none have been added here.)							
			5,000.00		*5,000.00*		*5,000.00*
01 - Lands & Damages	**1.00**	**EA**	**5,000.00**	**0.00**	**5,000.00**	**0.00**	**5,000.00**
Real Estate Admin	1.00	LS	5,000.00	0.00	5,000.00	0.00	5,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			73,303.34		*74,243.02*		*89,091.63*
11 - Levees, Floodwalls, and Floodproofing	**1.00**	**EA**	**73,303.34**	**939.69**	**74,243.02**	**14,848.60**	**89,091.63**
			70,000.00		*70,000.00*		*84,000.00*

Description	Quantity	UOM	CostToPrime	PrimeCMU	ContractCost	Contingency	ProjectCost
Raise	**1.00**	**EA**	**70,000.00**	**0.00**	**70,000.00**	**14,000.00**	**84,000.00**
			70.00		*70.00*	*20.00*	*84.00*
Raise Structure on Segmented Piles to 6' off low ground	1,000.00	SF	70,000.00	0.00	70,000.00	14,000.00	84,000.00
(Note: Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house. This price would be for a slab foundation struture whose finished first floor would be greater than 4' above low ground. It is suspected that Pat pays significantly less than Davis-Bacon wages. PD was consulted on this issue. PD recommended that since this project is to be formulated on the basis that Davis-Bacon is not a requirement, the pricing info provided by Mr. Davie is acceptable.)							
			3,303.34		*4,243.02*		*5,091.63*
Misc	**1.00**	**EA**	**3,303.34**	**939.69**	**4,243.02**	**848.60**	**5,091.63**
Aerator System	0.10	LS	660.67	187.94	848.60	169.72	1,018.33
(Note: Assume that 1 out of every 10 houses will need an aerator system installed. The price of $5000 has been taken from LRH's 202 floodproofing model.)							
Asbestos Abatement	1.00	LS	1,321.33	375.87	1,697.21	339.44	2,036.65
(Note: This is an allowance based on historical data from LRH's 202 program for an average cost per structure for asbestos abatement of a large sample of structures.)							
			660.67		*848.60*	*20.00*	*1,018.33*
Temporary Housing Allowance	2.00	MO	1,321.33	375.87	1,697.21	339.44	2,036.65
(Note: Assume $500 per month.)							
			13,000.00		*13,000.00*		*13,000.00*
30 - Preconstruction Engineering & Design	**1.00**	**EA**	**13,000.00**	**0.00**	**13,000.00**	**0.00**	**13,000.00**
Engineering & Design	1.00	LS	13,000.00	0.00	13,000.00	0.00	13,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			7,000.00		*7,000.00*		*7,000.00*
31 - Supervision & Administration	**1.00**	**EA**	**7,000.00**	**0.00**	**7,000.00**	**0.00**	**7,000.00**
Supervision & Administration	1.00	LS	7,000.00	0.00	7,000.00	0.00	7,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			111.85		*113.79*		*131.55*
Raise Existing Prefab Structure - 15 feet off low ground	**1,000.00**	**SF**	**111,847.16**	**1,947.78**	**113,794.94**	**17,758.99**	**131,553.92**
(Note: This price already includes all contractor markups. Therefore, none have been added here.)							
			5,000.00		*5,000.00*		*5,000.00*
01 - Lands & Damages	**1.00**	**EA**	**5,000.00**	**0.00**	**5,000.00**	**0.00**	**5,000.00**
Real Estate Admin	1.00	LS	5,000.00	0.00	5,000.00	0.00	5,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			86,847.16		*88,794.94*		*106,553.92*
11 - Levees, Floodwalls, and Floodproofing	**1.00**	**EA**	**86,847.16**	**1,947.78**	**88,794.94**	**17,758.99**	**106,553.92**
			80,000.00		*80,000.00*		*96,000.00*
Raise	**1.00**	**EA**	**80,000.00**	**0.00**	**80,000.00**	**16,000.00**	**96,000.00**
			80.00		*80.00*	*20.00*	*96.00*
Raise Structure on Segmented Piles to 15' off low ground	1,000.00	SF	80,000.00	0.00	80,000.00	16,000.00	96,000.00
(Note: Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house. He said that costs would likely be higher than this for a raise as high as 15' off low ground. Therefore, add $10/SF to cover this higher raise. This price would be for a slab foundation struture whose finished first floor would be greater than 15' above low ground. PD was consulted on this issue. PD recommended that since this project is to be formulated on the basis that Davis-Bacon is not a requirement, the pricing info provided by Mr. Davie is acceptable.)							
			11.81		*15.17*		*18.21*
300 SF Stoarge Area	**300.00**	**SF**	**3,543.82**	**1,008.09**	**4,551.91**	**910.38**	**5,462.30**
(Note: This would only apply to structures that area greater than 6 FT above low ground. In this estimate, that means that it only applies to the 8' - 15' raise category.)							

Description	Quantity	UOM	CostToPrime	PrimeCMU	ContractCost	Contingency	ProjectCost
			6.53		*8.38*	*20.00*	*10.06*
4" Concrete Pad	300.00	SF	1,958.22	557.05	2,515.26	503.05	3,018.32
(Note: Price from LRH's floodproofing model for 4" concrete = $370/CY, direct cost. SAY = $400/CY for the gulf coast. Now, $400/CY x (4in/36in/yd) = $44.44/SY. So, $44.44/SY / 9 SF/SY = $4.94/SF<---)							
			13.21		*16.97*	*20.00*	*20.37*
Siding	80.00	EA	1,057.07	300.70	1,357.77	271.55	1,629.32
(Note: = 10 x 2 + 30 x 2 = 80 SF)							
			264.27		*339.44*	*20.00*	*407.33*
Door	1.00	EA	264.27	75.17	339.44	67.89	407.33
Electrical Allowance	1.00	LS	264.27	75.17	339.44	67.89	407.33
			3,303.34		*4,243.02*		*5,091.63*
Misc	**1.00**	**EA**	**3,303.34**	**939.69**	**4,243.02**	**848.60**	**5,091.63**
Aerator System	0.10	LS	660.67	187.94	848.60	169.72	1,018.33
(Note: Assume that 1 out of every 10 houses will need an aerator system installed. The price of $5000 has been taken from LRH's 202 floodproofing model.)							
Asbestos Abatement	1.00	LS	1,321.33	375.87	1,697.21	339.44	2,036.65
(Note: This is an allowance based on historical data from LRH's 202 program for an average cost per structure for asbestos abatement of a large sample of structures.)							
			660.67		*848.60*	*20.00*	*1,018.33*
Temporary Housing Allowance	2.00	MO	1,321.33	375.87	1,697.21	339.44	2,036.65
(Note: Assume $500 per month.)							
			13,000.00		*13,000.00*		*13,000.00*
30 - Preconstruction Engineering & Design	**1.00**	**EA**	**13,000.00**	**0.00**	**13,000.00**	**0.00**	**13,000.00**
Engineering & Design	1.00	LS	13,000.00	0.00	13,000.00	0.00	13,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							
			7,000.00		*7,000.00*		*7,000.00*
31 - Supervision & Administration	**1.00**	**EA**	**7,000.00**	**0.00**	**7,000.00**	**0.00**	**7,000.00**
Supervision & Administration	1.00	LS	7,000.00	0.00	7,000.00	0.00	7,000.00
(Note: This is an allowance based on historical data from LRH's 202 program.)							

Annual Funding Stream by Federal Fiscal Year
Fully Funded Project Costs - Waveland, Mississippi Coastal Improvement Program
Federal Fiscal Year Calendar
(1 October - 30 September)

		Cost ($1000's)				
	Feature Account	FY09	FY10	FY11	FY12	Grand Total
Non-Fully Funded (10/1/2008)						
01	Lands and Damages	0	60	67	7	**134**
02	Relocations		1,252	1,408	469	**3,130**
30	Engineering and Design	341	223	223	106	**893**
31	Supervision and Administration		107	121	40	**268**
Non-Fully Funded (10/1/2008) Total		**341**	**1,643**	**1,819**	**622**	**4,425**
Fully Funded Estimate (Including Inflation)						
01	Lands and Damages	0	63	72	8	**143**
02	Relocations		1,279	1,469	500	**3,248**
30	Engineering and Design	341	232	241	119	**933**
31	Supervision and Administration		111	130	45	**287**
Fully Funded Estimate (Including Inflation) Total		**341**	**1,686**	**1,913**	**671**	**4,611**

Annual Funding Stream by Federal Fiscal Year
Fully Funded Project Costs - Moss Pointe, Mississippi Coastal Improvement Program
Federal Fiscal Year Calendar
(1 October - 30 September)

	Feature Account	Cost ($1000's) FY09	FY10	FY11	FY12	FY13	Grand Total
Non-Fully Funded (10/1/2008)							
01	Lands and Damages	0	40	47	40	7	**134**
02	Relocations		1,686	2,950	2,950	843	**8,429**
30	Engineering and Design	311	401	401	401	90	**1,603**
31	Supervision and Administration		129	226	226	65	**646**
Non-Fully Funded (10/1/2008) Total		**311**	**2,256**	**3,624**	**3,617**	**1,004**	**10,811**
Fully Funded Estimate (Including Inflation)							
01	Lands and Damages	0	42	51	45	8	**145**
02	Relocations		1,723	3,077	3,139	915	**8,854**
30	Engineering and Design	311	417	433	450	105	**1,716**
31	Supervision and Administration		134	244	254	75	**708**
Fully Funded Estimate (Including Inflation) Total		**311**	**2,316**	**3,805**	**3,888**	**1,103**	**11,424**

		Cost at PL 1 October 2008 (Rounded to nearest Thousand)			
Municipal Facilitiy	**Total Floor Area**	**Estimated ($)**	**Contingency (25.0%)**	**Total ($)**	**Unit ($/SF)**
City Hall & Public Works Facility	7,400	1,349,000	338,000	1,687,000	227.97
Police Station & Courthouse	10,400	3,008,000	752,000	3,760,000	361.54
Fire Station	5,900	1,196,000	299,000	1,495,000	253.39
Recreation Center	17,000	2,847,000	711,000	3,558,000	209.29
<< Additional PED >>	-	249,000	62,000	311,000	n/a
TOTAL	**40,700**	**8,649,000**	**2,162,000**	**10,811,000**	**265.63**

	Cost at PL 1 October 2008 (Rounded to nearest Thousand)			
Feature Account	**Estimated ($)**	**Contingency (25.0%)**	**Total ($)**	**Unit Cost ($/SF)** (Average for Total Floor Area)
01 - Lands & Damages	107,000	27,000	134,000	3.29
02 - Relocations	6,743,000	1,685,000	8,428,000	207.08
-Substructure	*435,181*	*108,795*	*543,977*	*13.37*
-Shell	*2,077,773*	*519,443*	*2,597,216*	*63.81*
-Interiors	*1,063,169*	*265,792*	*1,328,961*	*32.65*
-Services	*1,974,393*	*493,598*	*2,467,992*	*60.64*
-Equipment & Furnishings	*191,027*	*47,757*	*238,784*	*5.87*
-Special Construction	*0*	*0*	*0*	*0.00*
-Additives	*406,253*	*101,563*	*507,816*	*12.48*
-Site Work	*493,312*	*123,328*	*616,640*	*15.15*
-Associated Items	*102,021*	*25,505*	*127,526*	*3.13*
30 - Engineering & Design	1,282,000	321,000	1,603,000	39.39
-PED per Structure	*1,033,382*	*258,346*	*1,291,728*	*31.74*
-Advance Engineering (Prepare Report)	*197,248*	*49,312*	*246,560*	*6.06*
-Implementation	*34,304*	*8,576*	*42,880*	*1.05*
-Project Closeout	*17,152*	*4,288*	*21,440*	*0.53*
31 - Supervision & Administration	517,000	129,000	646,000	15.87
TOTAL	**8,649,000**	**2,162,000**	**10,811,000**	**265.62**

Note: This cost estimate was originally developed using the RS MEANS Square Foot Costs Cost 2007 Manual, 28th Annual Edition. Subsequent to this initial effort, the estimate has been updated to FY 2009 costs (PL 1 October 2008) using OMB inflation factors. The factors used were 1.072 (7.2%) for labor costs and 1.050 (5.0%) for non-labor costs. The cost model used can be found on pages 220 and 221. USACE-CELRH-EC-CE provided parametric inputs such as building construction type, building size, and a basic description of site work and land requirements. The MEANS model has been replicated in this worksheet so as to readily make the proper adjustments.

Structure Function: City Hall & Public Works Facility

Input Parameters:

Price Level (PL) =	1-Oct-2008
Area of New Building (SF) =	7,400
Length of Building (LF) =	110.00
Number of Stories (EA) =	1
Story Height (FT) =	12.00
Total Area of New Site (ACR) =	1.00
Existing Facility to Be Demolished (SF) =	5,000
Interior Partition Height (FT) =	10.00
Roof / Footprint Ratio (SF/SF) =	1.10

Calculated Parameters:

Width of Building (LF) =	67.00
Perimeter of New Building (LF) =	354
Area-Perimeter Ratio (SF/LF) =	20.90
Width-Length Ratio (LF/LF) =	0.61
Exterior Wall Area (SF) =	4,248
Unit Price, Project Cost ($/SF) =	227.95
Roof Area (SF) =	8,140

Building Element	Construction Task		Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Substructure:								
Standard Foundations	Poured concrete; strip and spread footings		7,400	S.F. Ground	1.51	11,185	1.51	02
Slab on Grade	4" reinforced concrete with vapor barrier and granular base		7,400	S.F. Slab	4.67	34,563	4.67	02
Foundation Excavation	Site preparation for slab and trench for foundation wall and footing		7,400	S.F. Ground	0.25	1,864	0.25	02
Foundation Walls	4' foundation wall		354	L.F. Wall	72.42	25,638	3.46	02
Shell								
Superstructure:								
Floor Construction	N/A		-	S.F. Floor	-	-	-	02
Roof Construction	Metal deck, open web steel joists, beams, interior columns		7,400	S.F. Roof	6.65	49,243	6.65	02
Exterior Closure:								
Walls	Face brick with concrete block backup	(70% of wall)	2,970	S.F. Wall	27.29	81,050	10.95	02
Exterior Windows	Metal outward projecting	(30% of wall)	40	Each	661.25	26,450	3.57	02
Exterior Doors	Metal and glass with transom		3	Each	2,335.36	7,006	0.95	02
-	N/A			-	-			-
Roofing:								
Roof Coverings	Built-up tar & gravel with flashing; perlite/EPS composite insulation		8,140	S.F. Roof	5.43	44,171	5.97	02
Roof Openings	Skylights, roof hatches		8,140	S.F. Roof	-	-	-	02
Interiors:								
Partitions	Gypsum board on metal studs	(20 sf floor area / lf partition)	4,440	S.F. Partition	8.31	36,909	4.99	02
Interior Doors	Wood solid core	(200 sf/door)	37	Each	546.84	20,233	2.73	02
Fittings	Toilet partitions		7,400	S.F. Floor	0.49	3,651	0.49	02
Stair Construction	N/A		-	Flight	-	-	-	02
Wall Finishes	90% paint, 10% ceramic tile		8,880	S.F. Surface	1.33	11,837	1.60	02
Floor Finishes	70% carpet tile, 15% terrazzo, 15% vinyl composition tile		7,400	S.F. Floor	7.36	54,447	7.36	02

Building Element	Construction Task		Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Ceiling Finishes	Mineral fiber tile on concealed zee bars	(100% of area)	7,400	S.F. Ceiling	4.94	36,583	4.94	02
Services								
Conveying:								
Elevators & Lifts	N/A		-	Each	-	-	-	02
Plumbing:								
Plumbing, fixtures	Kitchen, Toilet and Service Fixtures, supply and drainage	(1 fixture/500 sf)	15	Each	2,760.45	41,407	5.60	02
Domestic Water Distribution	Gas fired water heater		7,400	S.F. Floor	1.10	8,155	1.10	02
Rain Water Drainage	Roof drains		8,140	S.F. Roof	0.68	5,553	0.75	02
HVAC								
Energy Supply	N/A			-	-			-
Heat Generating Systems	N/A			-	-			-
Cooling Generating Systems	N/A			-	-			-
Terminal & Package Units	Multizone unit, gas heating, electric cooling		7,400	S.F. Floor	8.33	61,670	8.33	02
Other HVAC Sys. & Equipment	N/A			-	-			-
Fire Protection								
Sprinklers	Wet pipe sprinkler system		7,400	S.F. Floor	2.52	18,641	2.52	02
Standpipes	N/A			-	-			-
Electrical:								
Service & Distribution	400 ampere service, panel board and feeders		7,400	S.F. Floor	1.77	13,126	1.77	02
Lighting & Power	Fluorescent fixtures, receptacles, switches, A.C. and misc. power		7,400	S.F. Floor	9.44	69,826	9.44	02
Communications & Security	Alarm systems, communications systems and emergency lighting		7,400	S.F. Floor	2.52	18,641	2.52	02
Other Electrical Systems	Emergency generator, 15 kW		7,400	S.F. Floor	0.14	1,010	0.14	-
Additives								
Directory Boards	Aluminum 48" x 32"		1	EA	928.90	929	0.13	02
Flagpoles, Complete	Aluminum, 20' high		1	EA	3,280.00	3,280	0.44	02
Smoke Detectors	Duct type	(1 dectector/500 sf)	15	EA	461.82	6,927	0.94	02
						-	-	
						-	-	
						-	-	
						-	-	
						-	-	
Storage:								
Safe, Office Type	4-hour rating, 30" x 18" x 18"		1	EA	4,277.12	4,277	0.58	02
Vaults	Door & frame, 4-hour test, 32" door		2	Openings	6,008.96	12,018	1.62	02
Vaults	Time lock movement,; two movements		1	EA	1,941.76	1,942	0.26	02
Electrical:								
Emergency Lighting	25 watt, nickel cadmium battery		8	EA	808.19	6,466	0.87	02
			-	EA	-	-	-	02
Site Work:								
Cut/Fill Site Excavation	Excavation to prepare site for construction		1	LS	52,480.00	52,480	7.09	02
Roads & Parking	Construct New Roads & Parking:		800	SY	20.99	16,794	2.27	02
Site Improvements	Clearing, Grubbing, Hardscaping, and Landscaping		1	LS	31,488.00	31,488	4.26	02
Utilities	Sewage Treatment		-	SY	-	-	-	02

Building Element	Construction Task	Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Utilities	Telephone Service	-	Job	-	-	-	02
Utilities	Electric Service	-	Job	-	-	-	02
Utilities	Water Filtration & Purification System, w/ Building	-	Job	-	-	-	02
Utilities	Cable Service	-	Job	-	-	-	02
		-	Job	-	-	-	02
Associated Items:							
Demo of Existing Building	Demolish existing building and restore site	5,000	SF	8.40	41,984	5.67	02

Building Element	Construction Task	Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
	SUB-TOTALS =				861,443	116.41	
	Contractor's Markups @ 25.0% =				215,361	29.10	
	Total Estimate Contract Cost =				1,076,803	145.51	
	Contingency @ 25% =				269,201	36.38	
	Total Construction Cost =				1,346,004	181.89	
	Real Estate Costs to acquire 1 acre(s) of land =				31,488	4.26	
	Engineering & Design @ 15.3% =				206,249	27.87	
	Supervision & Administration @ 7.7% =				103,124	13.94	
	Total Estimated Cost (PL 1-Oct-2008) =				**$ 1,686,865**	**$ 227.95**	

	Cost (PL 1-Oct-2008)		
Feature Account	**Estimated**	**Contingency**	**Total**
01 - Lands & Damages	25,190	6,298	31,488
02 - Relocations	1,076,803	269,201	1,346,004
30 - Engineering & Design	164,999	41,250	206,249
31 - Supervision & Administration	82,499	20,625	103,124
TOTAL	**1,349,492**	**337,373**	**1,686,865**

Therefore, the total estimated cost at PL 1-Oct-2008 to relocate a 7,400 SF city hall & public works facility is $1,687,000 which equates to $228 per SF. This estimate is based on assumed dimensions of 110 LF by 67 LF yielding a perimeter of 354 LF. Also, the structure was assumed to be 1 story tall with an assumed story height of 12.00 FT. The demo of a 5,000 SF existing structure has been included. The purchase and development of 1.00 acre of land is included.

Note: This cost estimate was originally developed using the RS MEANS Square Foot Costs Cost 2007 Manual, 28th Annual Edition. Subsequent to this initial effort, the estimate has been updated to FY 2009 costs (PL 1 October 2008) using OMB inflation factors. The factors used were 1.072 (7.2%) for labor costs and 1.050 (5.0%) for non-labor costs. The cost model used can be found on pages 184 and 185. USACE-CELRH-EC-CE provided parametric inputs such as building construction type, building size, and a basic description of site work and land requirements. The MEANS model has been replicated in this worksheet so as to readily make the proper adjustments.

Structure Function: Police Station & Courthouse

Input Parameters:

Price Level (PL) =	1-Oct-2008
Area of New Building (SF) =	10,400
Length of Building (LF) =	120.00
Number of Stories (EA) =	2
Story Height (FT) =	12.00
Total Area of New Site (ACR) =	0.75
Existing Facility to Be Demolished (SF) =	0
Interior Partition Height (FT) =	10.00
Roof / Footprint Ratio (SF/SF) =	1.10

Calculated Parameters:

Width of Building (LF) =	87.00
Perimeter of New Building (LF) =	414
Area-Perimeter Ratio (SF/LF) =	25.12
Width-Length Ratio (LF/LF) =	0.73
Exterior Wall Area (SF) =	9,936
Unit Price, Project Cost ($/SF) =	361.54
Roof Area (SF) =	5,720

Building Element	Construction Task		Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Substructure:								
Standard Foundations	Poured concrete; strip and spread footings		5,200	S.F. Ground	2.54	13,208	1.27	02
Slab on Grade	4" reinforced concrete with vapor barrier and granular base		5,200	S.F. Slab	4.67	24,288	2.34	02
Basement Excavation	Site preparation for slab and trench for foundation wall and footing		5,200	S.F. Ground	0.25	1,310	0.13	02
Basement Walls	4' foundation wall		207	L.F. Wall	72.42	14,991	1.44	02
Shell								
Superstructure:								
Floor Construction	Open web steel joists, slab form, concrete		5,200	S.F. Floor	10.79	56,107	5.39	02
Roof Construction	Metal deck on open web steel joists		5,200	S.F. Roof	4.26	22,159	2.13	02
Exterior Enclosure:								
Exterior Walls	Limestone with concrete block backup	(80% of wall)	7,950	S.F. Wall	66.12	525,692	50.55	02
Exterior Windows	Metal horizontal sliding	(20% of wall)	63	Each	956.19	60,240	5.79	02
Exterior Doors	Hollow metal		10	Each	2,169.52	21,695	2.09	02
-	N/A			-	-			-
Roofing:								
Roof Coverings	Built-up tar & gravel with flashing; perlite/EPS composite insulation		5,720	S.F. Roof	5.94	33,981	3.27	02
Roof Openings	N/A			S.F. Roof	-			02
Interiors:								
Partitions	Concrete block	(20 sf floor area / lf partition)	6,240	S.F. Partition	8.08	50,431	4.85	02
Interior Doors	Single leaf kalamein fire door	(200 sf/door)	52	Each	855.42	44,482	4.28	02
Fittings	Toilet partitions		10,400	S.F. Floor	0.91	9,497	0.91	02
Stair Construction	Concrete filled metal pan		1	Flight	14,484.48	14,484	1.39	02
Wall Finishes	90% paint, 10% ceramic tile		12,480	S.F. Surface	3.32	41,393	3.98	02
Floor Finishes	70% vinyl tile, 20% carpet tile, 10% ceramic tile		10,400	S.F. Floor	4.15	43,118	4.15	02

Building Element	Construction Task	Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Ceiling Finishes	Mineral fiber tile on concealed zee bars	5,200	S.F. Ceiling	4.94	25,707	2.47	02
Services							
Conveying:							
Elevators & Lifts	One hydraulic passenger elevator	1	Each	69,389.06	69,389	6.67	02
Plumbing:							
Plumbing, fixtures	Toilet and Service Fixtures, supply and drainage (1 fixture/580 sf)	18	Each	2,787.74	50,179	4.82	02
Domestic Water Distribution	Oil fired water heater	10,400	S.F. Floor	2.53	26,307	2.53	02
Rain Water Drainage	Roof drains	5,720	S.F. Roof	1.97	11,287	1.09	02
HVAC							
Energy Supply	Oil fired hot water, wall fin radiation	10,400	S.F. Floor	9.04	93,985	9.04	-
Heat Generating Systems	N/A		-	-			-
Cooling Generating Systems	N/A		-	-			-
Terminal & Package Units	Split systems with air cooled condensing units	10,400	S.F. Floor	9.45	98,243	9.45	02
Other HVAC Sys. & Equipment	N/A		-	-			-
Fire Protection							
Sprinklers	Wet pipe sprinkler system	10,400	S.F. Floor	2.71	28,163	2.71	02
Standpipes	N/A		-	-			-
Electrical:							
Electrical Service/Distribution	400 ampere service, panel board and feeders	10,400	S.F. Floor	1.77	18,448	1.77	02
Lighting & Branch Wiring	Fluorescent fixtures, receptacles, switches, A.C. and misc. power	10,400	S.F. Floor	10.00	104,028	10.00	02
Communications & Security	Alarm systems and emergency lighting	10,400	S.F. Floor	0.66	6,877	0.66	02
Other Electrical Systems	Emergency generator, 15kW	10,400	S.F. Floor	0.19	1,965	0.19	-
Equipment & Furnishings							
Institutional Equipment	lockers, detention rooms, cells, gasoline despensers	10,400	S.F. Floor	12.62	131,208	12.62	02
Vehicular Equipment	Gasoline dispenser system	10,400	S.F. Floor	2.08	21,613	2.08	02
Lockers & Accessories	N/A	-	EA	64.03	-	-	02
							02
Special Construction							
Integrated Construction	N/A	-	S.F. Floor	-	-	-	02
Special Facilities	N/A	-	S.F. Floor	-	-	-	02
Additives							
Cells Prefabricated	5'-6' wide, 7'-8- high, 7'-8' deep	5	EA	11,440.64	57,203	5.50	02
Elevators, Hydraulic Passenger	2 stops, 2500# capacity	1	EA	56,258.56	56,259	5.41	02
Flagpoles, Complete	Aluminum, 20' high	1	EA	3,280.00	3,280	0.32	02
		-	EA	-	-	-	02
Storage:							
Lockers & Accessories	Lockers, steel, single tier, 72"	20	Openings	306.48	6,130	0.59	02
Lockers & Accessories	Locker, bench, lam. maple top only	15	LF	20.99	315	0.03	02
Lockers & Accessories	Pedestals, steel pipe	5	EA	64.03	320	0.03	02
Safe, Office Type	4-hour rating, 30" x 18" x 18"	1	EA	4,277.12	4,277	0.41	02
Shooting Range	Including bullet traps, targets provisions and control	1	EA	32,642.56	32,643	3.14	02
Smoke Detectors	Duct type (1 dectector/500 sf)	21	EA	461.82	9,698	0.93	02
Electrical:							

Building Element	Construction Task	Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Sound System	Amplifier, 250 watts	1	EA	2,230.40	2,230	0.21	02
Sound System	Speaker, trumpet	1	EA	351.62	352	0.03	02
Emergency Lighting	25 watt, nickel cadmium battery	8	EA	808.19	6,466	0.62	03
Site Work:							
Cut/Fill Site Excavation	Excavation to prepare site for construction	1	LS	52,480.00	52,480	5.05	02
Roads & Parking	Construct New Roads & Parking:	800	SY	20.99	16,794	1.61	02
Site Improvements	Clearing, Grubbing, Hardscaping, and Landscaping	1	LS	31,488.00	31,488	3.03	02
Utilities	Sewage Treatment	-	Job	-	-	-	02
Utilities	Telephone Service	-	Job	-	-	-	02
Utilities	Electric Service	-	Job	-	-	-	02
Utilities	Water Filtration & Purification System, w/ Building	-	Job	-	-	-	02
Utilities	Cable Service	-	Job	-	-	-	02
Associated Items:							
Demo of Existing Building	Demolish existing building and restore site	-	SF	8.40	-	-	02

Building Element	Construction Task	Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
	SUB-TOTALS =				1,944,410	186.96	

Contractor's Markups @ 25.0% =	486,102	46.74
Total Estimate Contract Cost =	2,430,512	233.70
Contingency @ 25% =	607,628	58.43
Total Construction Cost =	3,038,140	292.13
Real Estate Costs to acquire 0.75 acre(s) of land =	23,616	2.27
Engineering & Design @ 15.3% =	465,534	44.76
Supervision & Administration @ 7.7% =	232,767	22.38
Total Estimated Cost (PL 1-Oct-2008) =	**$ 3,760,057**	**$ 361.54**

	Cost (PL 1-Oct-2008)		
Feature Account	Estimated	Contingency	Total
01 - Lands & Damages	18,893	4,723	23,616
02 - Relocations	2,430,512	607,628	3,038,140
30 - Engineering & Design	372,427	93,107	465,534
31 - Supervision & Administration	186,214	46,553	232,767
TOTAL	**3,008,046**	**752,011**	**3,760,057**

Therefore, the total estimated cost at PL 1-Oct-2008 to relocate a 10,400 SF police station & courthouse is $3,760,000 which equates to $362 per SF. This estimate is based on assumed dimensions of 120 LF by 87 LF yielding a perimeter of 414 LF. Also, the structure was assumed to be 2 stories tall with an assumed story height of 12.00 FT. The demo of no existing structure has been included. The purchase and development of 0.75 acres of land is included.

Note: This cost estimate was originally developed using the RS MEANS Square Foot Costs Cost 2007 Manual, 28th Annual Edition. Subsequent to this initial effort, the estimate has been updated to FY 2009 costs (PL 1 October 2008) using OMB inflation factors. The factors used were 1.072 (7.2%) for labor costs and 1.050 (5.0%) for non-labor costs. The cost model used can be found on pages 126 and 127. USACE-CELRH-EC-CE provided parametric inputs such as building construction type, building size, and a basic description of site work and land requirements. The MEANS model has been replicated in this worksheet so as to readily make the proper adjustments.

Structure Function: Fire Station

Input Parameters:

Price Level (PL) =	1-Oct-2008
Area of New Building (SF) =	5,900
Length of Building (LF) =	98.00
Number of Stories (EA) =	1
Story Height (FT) =	14.00
Total Area of New Site (ACR) =	0.50
Existing Facility to Be Demolished (SF) =	4,720
Interior Partition Height (FT) =	10.00
Roof / Footprint Ratio (SF/SF) =	1.10

Calculated Parameters:

Width of Building (LF) =	60.00
Perimeter of New Building (LF) =	316
Area-Perimeter Ratio (SF/LF) =	18.67
Width-Length Ratio (LF/LF) =	0.61
Exterior Wall Area (SF) =	4,424
Unit Price, Project Cost ($/SF) =	253.38
Roof Area (SF) =	6,490

Building Element	Construction Task		Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Substructure:								
Standard Foundations	Poured concrete; strip and spread footings		5,900	S.F. Ground	2.96	17,463	2.96	02
Slab on Grade	6" reinforced concrete with vapor barrier and granular base		5,900	S.F. Slab	6.19	36,537	6.19	02
Foundation Excavation	Site preparation for slab and trench for foundation wall and footing		5,900	S.F. Ground	0.44	2,601	0.44	02
Foundation Walls	4" reinforced concrete with vapor barrier and granular base		316	L.F. Wall	72.42	22,885	3.88	02
Shell								
Superstructure:								
Floor Construction	N/A		-	S.F. Floor	-	-	-	02
Roof Construction	Metal deck, open web steel joists, beams, interior columns		5,900	S.F. Roof	8.76	51,709	8.76	02
Exterior Closure:								
Walls	Face brick with concrete block backup	(75% of wall)	3,320	S.F. Wall	16.27	54,012	9.15	02
Exterior Windows	Aluminum insulated glass	(10% of wall)	14	Each	776.70	10,874	1.84	02
Doors	Single aluminum and glass, overhead, hollow metal	(15% of wall)	664	S.F. Door	32.54	21,592	3.66	02
-	N/A		-	-	-	-	-	-
Roofing:								
Roof Coverings	Built-up tar & gravel with flashing; perlite/EPS composite insulation		6,490	S.F. Roof	5.90	38,283	6.49	02
Roof Openings	Skylights, roof hatches		6,490	S.F. Roof	0.17	1,090	0.18	02
Interiors:								
Partitions	Concrete block	(17 sf floor area / lf partition)	4,859	S.F. Partition	8.08	39,269	6.66	02
Interior Doors	Single leaf hollow metal	(500 sf/door)	12	Each	855.42	10,265	1.74	02
Fittings	Toilet partitions		5,900	S.F. Floor	0.57	3,344	0.57	02
Stair Construction	N/A		-	Flight	-	-	-	02
Wall Finishes	Paint		9,718	S.F. Surface	1.84	17,849	3.03	02
Floor Finishes	50% vinyl tile, 50% paint		5,900	S.F. Floor	2.44	14,367	2.44	02

Building Element	Construction Task	Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Ceiling Finishes	Fiberglass board on exposed grid, suspended (50% of area)	2,950	S.F. Ceiling	4.94	14,584	2.47	02
Services							
Conveying:							
Elevators & Lifts	N/A	-	Each	-	-	-	02
				-			
Plumbing:				-			
Plumbing, fixtures	Kitchen, Toilet and Service Fixtures, supply and drainage (1 fixture/375 sf)	16	Each	2,668.08	42,689	7.24	02
Domestic Water Distribution	Gas fired water heater	5,900	S.F. Floor	1.58	9,322	1.58	02
Rain Water Drainage	Roof drains	6,490	S.F. Roof	0.72	4,673	0.79	02
HVAC							
Energy Supply	N/A	-	-	-	-	-	-
Heat Generating Systems	N/A	-	-	-	-	-	-
Cooling Generating Systems	N/A	-	-	-	-	-	-
Terminal & Package Units	Rooftop multizone unit system	5,900	S.F. Floor	22.58	133,204	22.58	02
Other HVAC Sys. & Equipment	N/A	-	-	-	-	-	-
Fire Protection							
Sprinklers	Wet pipe sprinkler system	5,900	S.F. Floor	3.24	19,135	3.24	02
Standpipes	N/A	-	-	-	-	-	-
Electrical:							
Service & Distribution	200 ampere service, panel board and feeders	5,900	S.F. Floor	1.35	7,989	1.35	02
Lighting & Power	Fluorescent fixtures, receptacles, switches, A.C. and misc. power	5,900	S.F. Floor	6.13	36,165	6.13	02
Communications & Security	Alarm systems, communications systems and emergency lighting	5,900	S.F. Floor	0.40	2,353	0.40	02
Other Electrical Systems	N/A	-	-	-	-	-	-
Additives							
Appliances:							
Stoves/Ranges	Cooking range, 30" free standing, 1 oven	1	EA	1,968.00	1,968	0.33	02
Stoves/Ranges	Hood for range, 2 speed, vented, 30" wide	1	EA	1,028.61	1,029	0.17	02
Stoves/Ranges	Microwave oven	1	EA	755.71	756	0.13	02
Disposers/Compactors	Compactor, residential, 4-1 compaction	1	EA	760.96	761	0.13	02
Disposers/Compactors	Garbage disposer, sink type	1	EA	294.94	295	0.05	02
Dishwashers	Dishwashers, built-in, 4 cycles	1	EA	1,180.80	1,181	0.20	02
Refrigerators	Refrigerator, no frost, 18-20 CF	1	EA	1,102.08	1,102	0.19	02
Storage:							
Lockers & Accessories	Lockers, steel, single tier, 72"	30	Openings	306.48	9,194	1.56	02
Lockers & Accessories	Locker, bench, lam. maple top only	25	LF	20.99	525	0.09	02
Lockers & Accessories	Pedestals, steel pipe	6	EA	64.03	384	0.07	02
Electrical:							
Sound System	Amplifier, 250 watts	1	EA	2,230.40	2,230	0.38	02
Sound System	Speaker, trumpet	5	EA	351.62	1,758	0.30	02
Site Work:							
Cut/Fill Site Excavation	Excavation to prepare site for construction	1	LS	52,480.00	52,480	8.89	02
Roads & Parking	Construct New Roads & Parking:	600	SY	20.99	12,595	2.13	02
Site Improvements	Clearing, Grubbing, Hardscaping, and Landscaping	1	LS	31,488.00	31,488	5.34	02
Utilities	Sewage Treatment	-	Job	-	-	-	02

Building Element	Construction Task	Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Utilities	Telephone Service	-	Job	-	-	-	02
Utilities	Electric Service	-	Job	-	-	-	02
Utilities	Water Filtration & Purification System, w/ Building	-	Job	-	-	-	02
Utilities	Cable Service	-	Job	-	-	-	02
Associated Items:							
Demo of Existing Building	Demolish existing building and restore site	4,720	SF	8.40	39,633	6.72	02

Building Element	Construction Task	Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
	SUB-TOTALS =				769,632	130.45	

Contractor's Markups @ 25.0% =	192,408	32.61
Total Estimate Contract Cost =	962,041	163.06
Contingency @ 25% =	240,510	40.76
Total Construction Cost =	1,202,551	203.82
Real Estate Costs to acquire 0.5 acre(s) of land =	15,744	2.67
Engineering & Design @ 15.3% =	184,433	31.26
Supervision & Administration @ 7.7% =	92,217	15.63
Total Estimated Cost (PL 1-Oct-2008) =	**$ 1,494,944**	**$ 253.38**

	Cost (PL 1-Oct-2008)		
Feature Account	Estimated	Contingency	Total
01 - Lands & Damages	12,595	3,149	15,744
02 - Relocations	962,041	240,510	1,202,551
30 - Engineering & Design	147,546	36,887	184,433
31 - Supervision & Administration	73,773	18,443	92,217
TOTAL	**1,195,955**	**298,989**	**1,494,944**

Therefore, the total estimated cost at PL 1-Oct-2008 to relocate a 5,900 SF fire station is $1,495,000 which equates to $253 per SF. This estimate is based on assumed dimensions of 98 LF by 60 LF yielding a perimeter of 316 LF. Also, the structure was assumed to be 1 story tall with an assumed story height of 14.00 FT. The demo of a 4,720 SF existing structure has been included. The purchase and development of 0.50 acres of land is included.

Note: This cost estimate was originally developed using the RS MEANS Square Foot Costs Cost 2007 Manual, 28th Annual Edition. Subsequent to this initial effort, the estimate has been updated to FY 2009 costs (PL 1 October 2008) using OMB inflation factors. The factors used were 1.072 (7.2%) for labor costs and 1.050 (5.0%) for non-labor costs. The cost model used can be found on pages 144 and 145. USACE-CELRH-EC-CE provided parametric inputs such as building construction type, building size, and a basic description of site work and land requirements. The MEANS model has been replicated in this worksheet so as to readily make the proper adjustments.

Structure Function: Recreation Center

Input Parameters:

Price Level (PL) =	1-Oct-2008
Area of New Building (SF) =	17,000
Length of Building (LF) =	150.00
Number of Stories (EA) =	1
Story Height (FT) =	25.00
Total Area of New Site (ACR) =	2.00
Existing Facility to Be Demolished (SF) =	0
Interior Partition Height (FT) =	10.00
Roof / Footprint Ratio (SF/SF) =	1.10

Calculated Parameters:

Width of Building (LF) =	113.00
Perimeter of New Building (LF) =	526
Area-Perimeter Ratio (SF/LF) =	32.32
Width-Length Ratio (LF/LF) =	0.75
Exterior Wall Area (SF) =	13,150
Unit Price, Project Cost ($/SF) =	209.32
Roof Area (SF) =	18,700

ding Element	Construction Task		Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Substructure:								
Standard Foundations	Poured concrete; strip and spread footings		17,000	S.F. Ground	1.56	26,586	1.56	02
Slab on Grade	4" reinforced concrete with vapor barrier and granular base		17,000	S.F. Slab	4.67	79,402	4.67	02
Basement Excavation	Site preparation for slab and trench for foundation wall and footing		17,000	S.F. Ground	0.15	2,498	0.15	02
Basement Walls	4" foundation wall		526	L.F. Wall	62.98	33,125	1.95	02
Shell								
Superstructure:								
Floor Construction	N/A		-	-	-	-	-	02
Roof Construction	Wood deck on laminated wood arches		17,000	S.F. Roof	17.78	302,264	17.78	02
Exterior Closure:								
Walls	Reinforced concrete block (end walls included)	(88% of wall)	11,570	S.F. Wall	11.56	133,704	7.86	02
Exterior Windows	Metal horizontal pivoted	(10% of wall)	42	Each	472.32	19,837	1.17	02
Doors	Aluminum and glass, hollow metal, steel overhead	(2% of wall)	7	Each	1,651.02	11,557	0.68	02
-	N/A		-	-	-	-	-	-
Roofing:								
Roof Coverings	EPDM, 60 mils, fully adhered, polyisocyanurate insulation		18,700	S.F. Roof	4.79	89,501	5.26	02
Roof Openings	N/A		-	-	-	-	-	-
Interiors:								
Partitions	Concrete block	(50 sf floor area / lf partition)	3,400	S.F. Partition	8.08	27,479	1.62	02
Interior Doors	Single leaf hollow metal	(500 sf floor area / door)	34	Each	855.42	29,084	1.71	02
Fittings	Toilet partitions		17,000	S.F. Floor	0.35	5,888	0.35	02
Stair Construction	N/A		-	Flight	-	-	-	02
Wall Finishes	50% paint, 50% ceramic tile		6,800	S.F. Surface	8.95	60,881	3.58	02
Floor Finishes	90% hardwood, 10% ceramic tile		17,000	S.F. Floor	13.07	222,148	13.07	02

ding Element	Construction Task		Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Ceiling Finishes	Mineral fiber tile onconcealed zee bars	(15% of area)	2,550	S.F. Ceiling	4.94	12,606	0.74	02
Services								
Conveying:								
Elevators & Lifts	N/A		-	Each	-	-	-	-
Excalators & Moving Walks	N/A		-	Each	-	-	-	-
Plumbing:								
Plumbing, fixtures	Toilet and Service Fixtures, supply and drainage	(1 fixture / 515 sf)	34	Each	2,583.07	87,824	5.17	02
Domestic Water Distribution	Electric water heater		17,000	S.F. Floor	4.62	78,510	4.62	02
Rain Water Drainage	N/A		-	S.F. Roof	-	-	-	-
HVAC								
Energy Supply	N/A		-	-	-	-	-	-
Heat Generating Systems	N/A		-	-	-	-	-	-
Cooling Generating Systems	N/A		-	-	-	-	-	-
Terminal & Package Units	Single zone rooftop unit, gas heating, electric cooling		17,000	S.F. Floor	10.37	176,291	10.37	02
Other HVAC Sys. & Equipment	N/A		-	-	-	-	-	-
Fire Protection								
Sprinklers	Wet pipe sprinkler system		17,000	S.F. Floor	2.52	42,824	2.52	02
Standpipes	N/A		-	-	-	-	-	-
Electrical:								
Electrical Service & Distribution	400 ampere service, panel board and feeders		17,000	S.F. Floor	0.98	16,594	0.98	02
Lighting & Branch Wiring	Fluorescent fixtures, receptacles, switches, A.C. and misc. power		17,000	S.F. Floor	8.37	142,210	8.37	02
Communications & Security	Alarm systems, sound systems and emergency lighting		17,000	S.F. Floor	1.76	29,977	1.76	02
Other Electrical Systems	Emergency generator, 7.5 kW		17,000	S.F. Floor	0.17	2,855	0.17	-
Equipment & Furnishings								
Commercial Equipment	N/A		-	S.F. Floor	-	-	-	02
Institutional Equipment	N/A		-	S.F. Floor	-	-	-	02
Vehicular Equipment	N/A		-	S.F. Floor	-	-	-	02
Other Equipment	Bleachers, sauna, weight room		-	S.F. Floor	5.77	-	-	02
Special Construction								
Integrated Construction	N/A		-	S.F. Floor	-	-	-	02
Special Facilities	N/A		-	S.F. Floor	-	-	-	02
Additives								
Gym divider Curtain, Mesh top	Manual roll-up	(150 sf floor area / lf partition)	2,833	S.F. Curtain	11.97	33,902	1.99	02
Gym Mats	2" Nylon	(5% of floor area)	850	S.F. Mat	7.19	6,111	0.36	02
Gym Mats	1-1/2" wall pads	(5% of exterior wall area)	660	S.F. Mat	9.39	6,200	0.36	02
Gym Mats	1" wrestling mats	(5% of floor area)	850	S.F. Mat	6.35	5,398	0.32	02
Scoreboard	Basketball, one side		1	EA	7,347.20	7,347	0.43	02
Basketball Backstop	Swing up, wall mtd.		2	EA	6,848.64	13,697	0.81	02
Storage:								
Lockers & Accessories	Lockers, steel, single tier, 72"		25	Openings	306.48	7,662	0.45	02
Lockers & Accessories	Locker, bench, lam. maple top only		20	LF	20.99	420	0.02	02
Lockers & Accessories	Pedestals, steel pipe		10	EA	64.03	640	0.04	02
Electrical:								
Sound System	Amplifier, 250 watts		1	EA	2,230.40	2,230	0.13	02

ding Element	Construction Task	Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
Sound System	Speaker, trumpet	1	EA	351.62	352	0.02	02
Emergency Lighting	25 watt, nickel cadmium battery	6	EA	808.19	4,849	0.29	02
Site Work:							
Cut/Fill Site Excavation	Excavation to prepare site for construction	1	LS	52,480.00	52,480	3.09	02
Roads & Parking	Construct New Roads & Parking:	600	SY	20.99	12,595	0.74	02
Lockers	2 tier, 72" total w benchs 15 openings, 30' of bench	1	LS	31,488.00	31,488	1.85	02
Site Improvements	Clearing, Grubbing, Hardscaping, and Landscaping	-	SY	-	-	-	02
Utilities	Sewage Treatment	-	Job	-	-	-	02
Utilities	Telephone Service	-	Job	-	-	-	02
Utilities	Electric Service	-	Job	-	-	-	02
Utilities	Water Filtration & Purification System, w/ Building	-	Job	-	-	-	02
Utilities	Cable Service	-	Job	-	-	-	02
Associated Items:							
Demo of Existing Building	Demolish existing building and restore site	-	SF	8.40	-	-	02

ding Element	Construction Task	Quantity	Unit	Unit Cost	Total Direct Cost (PL 1 Oct 2007)	Cost Per S.F.	Feature Account
	SUB-TOTALS =				1,819,019	107.00	
	Contractor's Markups @ 25.0% =				454,755	26.75	
	Total Estimate Contract Cost =				2,273,774	133.75	
	Contingency @ 25% =				568,443	33.44	
	Total Construction Cost =				2,842,217	167.19	
	Real Estate Costs to acquire 2 acre(s) of land =				62,976	3.70	
	Engineering & Design @ 15.3% =				435,513	25.62	
	Supervision & Administration @ 7.7% =				217,757	12.81	
	Total Estimated Cost (PL 1-Oct-2008) =				**$ 3,558,463**	**$ 209.32**	

	Cost (PL 1-Oct-2008)		
Feature Account	**Estimated**	**Contingency**	**Total**
01 - Lands & Damages	50,381	12,595	62,976
02 - Relocations	2,273,774	568,443	2,842,217
30 - Engineering & Design	348,410	87,103	435,513
31 - Supervision & Administration	174,205	43,551	217,757
TOTAL	**2,846,770**	**711,693**	**3,558,463**

Therefore, the total estimated cost at PL 1-Oct-2008 to relocate a 17,000 SF recreation center is $3,558,000 which equates to $209 per SF. This estimate is based on assumed dimensions of 150 LF by 113 LF yielding a perimeter of 526 LF. Also, the structure was assumed to be 1 story tall with an assumed story height of 25.00 FT. The demo of no existing structure has been included. The purchase and development of 2.00 acres of land is included.

PROGRAMMING & PLANNING COST ESTIMATE

(Updated July 2008)

PROJECT:	**Mississippi Coastal Improvement Project "MsCIP"**	ITEM NO.	Structure W01	DATE	11-Dec-07
LOCATION:	**Hancock County, MS**	SHEET NO.	N/A	OF	
		PREPARED:	Don Whitmore	CHECKED:	
WORK ITEM:	***Waveland Proposed Pilot Project***	BASIS of ESTIMATE:	Survey Data (attached)		
		FILE NAME:	Waveland_Field_Data.pdf		

DESCRIPTION	Quantity	Unit	Unit Price*	ESTIMATED AMOUNT
Raise Structure on Segmented Piles, 6.24 FT above low ground**	3,000	SF	77.95	$233,852
Misc.- Storage Area	300	SF	15.93	$4,780
Aerator System	0.1	EA	8,910.30	$891
Asbestos Abatement	1	EA	1,782.07	$1,782
Temporary Housing	1	LS	1,782.07	$1,782
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0

* Price includes all contractor markups, but no contingency.

** Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house 4 FT abouve low ground. He stated that the price would increase from there based on

	Current Contract Cost, FY 07			243,087
	CONTINGENCY	@	**25.0%**	60,772
	01 Account, Lands & Damage	Real Estate	**LS**	5,360
	02 Account, Relocations	Relocations	**LS**	0
	xx Account, Environmental Mitigation		**LS**	0
	30 Account, Plan, Engr.& Design	@	**6.6%**	16,080
	31 Account, Constr. Management	@	**4.4%**	10,720
	ESCALATION, FY-08	@	**0.0%**	0
				$336,019
				rounded
	TOTAL PROJECT COST, Oct 2008			**$336,000**

Notes.

Estimate Excludes:

Operational & Maintenance Cost

Permanent Intrastructure

Relocations (pipelines, etc.)

Equipment (by Other Appropriations)

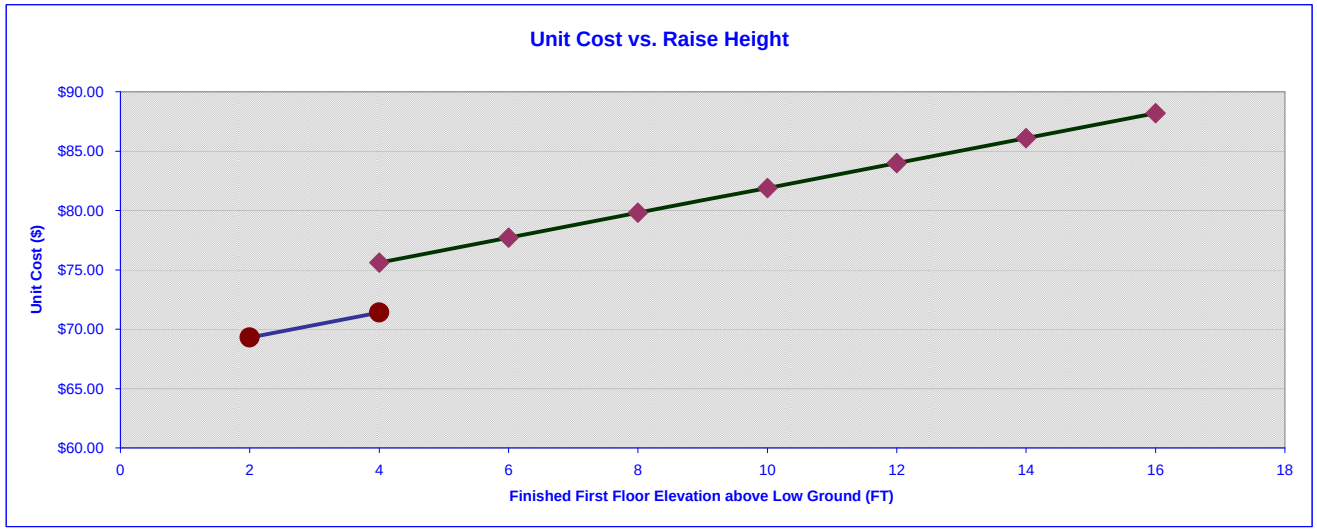
	STRUCTURE DATA								
Estimate Number	Structure Number	Parcel Number	LENGTH	WIDTH	First Floor Area	FFE Above LGE	Foundation Type	Aerator Factor	Asbestos Factor
1	W01	162K-0-10-006.000	60	50	3,000	6.24	Slab	0.1	1.0
2	W02	162K-0-10-007.002	42	28	1,176	6.57	Slab	0.1	1.0
3	W03	162K-0-10-007.001	40	28	1,120	6.00	Slab	0.1	1.0
4	W04	162K-0-10-007.003	28	42	1,176	6.00	Slab	0.1	1.0
5	W05	162G-0-03-300.006	24	40	960	6.00	Slab	0.1	1.0
6	W06	162G-0-03-300.004	24	40	960	6.00	Slab	0.1	1.0
7	W07	162G-0-03-300.003	24	36	864	6.00	Slab	0.1	1.0
8	W08	162G-0-03-300.002	24	40	960	6.00	Slab	0.1	1.0
9	W09	162G-0-03-300.000	28	40	1,120	6.00	Slab	0.1	1.0
10	W10	162G-0-03-283.001	30	50	1,500	5.00	Slab	0.1	1.0
11	W11	162G-0-03-283.000	28	40	1,120	5.00	Slab	0.1	1.0
12	W12	162G-0-03-300.001	42	30	1,260	6.00	Slab	0.1	1.0
13	W13	162G-0-03-300.005	40	20	800	6.00	Slab	0.1	1.0
14	W14	162G-0-03-293.002	45	30	1,350	6.00	Slab	0.1	1.0
15	W15	162G-0-03-293.001	30	42	1,260	5.42	Slab	0.1	1.0
16	W16	162G-0-03-294.000	36	50	1,800	6.00	Slab	0.1	1.0
17	W17	162G-0-03-295.000	24	35	840	6.00	Slab	0.1	1.0
18	W18	162G-0-03-291.000	20	42	840	5.57	Slab	0.1	1.0
19	W19	162G-0-03-290.000	20	42	840	6.00	Slab	0.1	1.0
20	W20	162F-1-04-163.000	25	35	875	6.00	Slab	0.1	1.0
21	W21	162F-1-04-162.000	25	35	875	6.00	Slab	0.1	1.0
22	W22	162F-1-04-161.000	25	35	875	6.00	Slab	0.1	1.0
23	W23	162F-1-04-158.000	45	30	1,350	6.00	Slab	0.1	1.0
24	W24	162F-1-04-157.000	60	30	1,800	6.32	Slab	0.1	1.0
25	W25	162F-1-04-156.000	20	40	800	6.19	Slab	0.1	1.0

							CONSTRUCTION COSTS, PL 1 October 2008								NON-CONSTRUCTION COSTS, PL 1 October 2008				
Estimate Number	Structure Number	First Floor Area	Foundation Type	FFE Above LGE	Aerator Factor	Asbestos Factor	Raise	Storage Area	Aerator System	Asbestos Abatement	Temporary Housing	Sub-Total	Contingency (25%)	Total Construction (02 Accnt)	Real Estate (01 Accnt)	PED (30 Accnt)	S&A (31 Accnt)	Total Non-Construction	TOTAL COST
1	W01	3,000	Slab	6.24	0.1	1	233,852	4,780	891	1,782	1,782	243,087	60,772	303,859	5,360	16,080	10,720	32,160	**336,019**
2	W02	1,176	Slab	6.57	0.1	1	92,077	4,780	891	1,782	1,782	101,312	25,328	126,640	5,360	16,080	10,720	32,160	**158,800**
3	W03	1,120	Slab	6.00	0.1	1	87,024	4,780	891	1,782	1,782	96,259	24,065	120,323	5,360	16,080	10,720	32,160	**152,483**
4	W04	1,176	Slab	6.00	0.1	1	91,375	4,780	891	1,782	1,782	100,610	25,152	125,762	5,360	16,080	10,720	32,160	**157,922**
5	W05	960	Slab	6.00	0.1	1	74,592	4,780	891	1,782	1,782	83,827	20,957	104,783	5,360	16,080	10,720	32,160	**136,943**
6	W06	960	Slab	6.00	0.1	1	74,592	4,780	891	1,782	1,782	83,827	20,957	104,783	5,360	16,080	10,720	32,160	**136,943**
7	W07	864	Slab	6.00	0.1	1	67,133	4,780	891	1,782	1,782	76,367	19,092	95,459	5,360	16,080	10,720	32,160	**127,619**
8	W08	960	Slab	6.00	0.1	1	74,592	4,780	891	1,782	1,782	83,827	20,957	104,783	5,360	16,080	10,720	32,160	**136,943**
9	W09	1,120	Slab	6.00	0.1	1	87,024	4,780	891	1,782	1,782	96,259	24,065	120,323	5,360	16,080	10,720	32,160	**152,483**
10	W10	1,500	Slab	5.00	0.1	1	114,975	0	891	1,782	1,782	119,430	29,858	149,288	5,360	16,080	10,720	32,160	**181,448**
11	W11	1,120	Slab	5.00	0.1	1	85,848	0	891	1,782	1,782	90,303	22,576	112,879	5,360	16,080	10,720	32,160	**145,039**
12	W12	1,260	Slab	6.00	0.1	1	97,902	4,780	891	1,782	1,782	107,137	26,784	133,921	5,360	16,080	10,720	32,160	**166,081**
13	W13	800	Slab	6.00	0.1	1	62,160	4,780	891	1,782	1,782	71,395	17,849	89,243	5,360	16,080	10,720	32,160	**121,403**
14	W14	1,350	Slab	6.00	0.1	1	104,895	4,780	891	1,782	1,782	114,130	28,532	142,662	5,360	16,080	10,720	32,160	**174,822**
15	W15	1,260	Slab	5.42	0.1	1	97,136	0	891	1,782	1,782	101,592	25,398	126,989	5,360	16,080	10,720	32,160	**159,149**
16	W16	1,800	Slab	6.00	0.1	1	139,860	4,780	891	1,782	1,782	149,095	37,274	186,368	5,360	16,080	10,720	32,160	**218,528**
17	W17	840	Slab	6.00	0.1	1	65,268	4,780	891	1,782	1,782	74,503	18,626	93,128	5,360	16,080	10,720	32,160	**125,288**
18	W18	840	Slab	5.57	0.1	1	64,886	0	891	1,782	1,782	69,341	17,335	86,677	5,360	16,080	10,720	32,160	**118,837**
19	W19	840	Slab	6.00	0.1	1	65,268	4,780	891	1,782	1,782	74,503	18,626	93,128	5,360	16,080	10,720	32,160	**125,288**
20	W20	875	Slab	6.00	0.1	1	67,988	4,780	891	1,782	1,782	77,222	19,306	96,528	5,360	16,080	10,720	32,160	**128,688**
21	W21	875	Slab	6.00	0.1	1	67,988	4,780	891	1,782	1,782	77,222	19,306	96,528	5,360	16,080	10,720	32,160	**128,688**
22	W22	875	Slab	6.00	0.1	1	67,988	4,780	891	1,782	1,782	77,222	19,306	96,528	5,360	16,080	10,720	32,160	**128,688**
23	W23	1,350	Slab	6.00	0.1	1	104,895	4,780	891	1,782	1,782	114,130	28,532	142,662	5,360	16,080	10,720	32,160	**174,822**
24	W24	1,800	Slab	6.32	0.1	1	140,456	4,780	891	1,782	1,782	149,691	37,423	187,114	5,360	16,080	10,720	32,160	**219,274**
25	W25	800	Slab	6.19	0.1	1	62,319	4,780	891	1,782	1,782	71,554	17,888	89,442	5,360	16,080	10,720	32,160	**121,602**
TOTALS							2,292,093	100,370	22,276	44,552	44,552	2,503,842	625,961	3,129,803	134,000	402,000	268,000	804,000	**3,933,803**

Height of Raise (FT)	Unit Price (< 4 FT)	Unit Price (>= 4 FT)
2	$ 69.30	
4	$ 71.40	$ 75.60
6		$ 77.70
8		$ 79.80
10		$ 81.90
12		$ 84.00
14		$ 86.10
16		$ 88.20

		$m_{<4'}$	$b_{<4'}$	
For x < 4'	y = mx + b	1.05	67.20	Therefore, the Unit Price per SF = 1.05 x Height of raise + 67.20 for heights of raise less than 4 FT.

		$m_{>=4'}$	$b_{>=4'}$	
For x >= 4'	y = mx + b	1.05	71.40	Therefore, the Unit Price per SF = 1.05 x Height of raise + 71.40 for heights of raise equal to or greater than 4 FT.



Estimated Total Project Costs
Moss Pointe and Waveland, Mississippi Coastal Improvement Program
PL 1 October 2008 (FY 2009)

Pilot	FeatID	FeatAccount	December 2007	January 2008	July 2008	Grand Total
Moss Pointe			**9,966,000**	**290,000**	**555,177**	**10,811,177**
	01	Lands & Damages	128,000	-	5,824	133,824
	02	Relocations	8,031,000	-	397,913	8,428,913
	30	Engineering & Design	1,205,000	290,000	107,575	1,602,575
	31	Supervision & Administration	602,000	-	43,865	645,865
Waveland			**3,730,765**	**458,000**	**236,014**	**4,424,779**
	01	Lands & Damages	125,000	-	9,000	134,000
	02	Relocations	2,980,765	-	149,038	3,129,803
	30	Engineering & Design	375,000	458,000	59,976	892,976
	31	Supervision & Administration	250,000	-	18,000	268,000
Grand Total			**13,696,765**	**748,000**	**791,191**	**15,235,955**

Notes:
1. The December 2007 effort amounted to the development of the original estimate.
2. Costs were added in January 2008 to account for LRH's participation during the implementation of the projects.
3. In July 2008, the cost estimates were inflated from PL 1 October 2007 to PL 1 October 2008 (FY 2008 to FY 2009)

MsCIP - Waveland FP and Moss Point Relocations Pilot Projects

Study/Report Costs

Waveland Floodproofing Pilot	Rate per hour fully loaded	Total Hours	Labor costs	Total Travel & Per Diem	Other Admin costs	Total cost
GS-13 Gene	$ 121.00	480	$ 58,080	$ 2,957		
GS-13 Don	$ 105.00	480	$ 50,400	$ 2,045		
GS-13 RE	$ 121.00	240	$ 29,040	$ 2,045		
GS-13 Gus	$ 121.00	480	$ 58,080	$ 2,045		
GS-12 LRH	$ 100.00	480	$ 48,000	$ 2,045		
GS-12 (Mobile District)	$ 100.00	300	$ 30,000	$ -		
Subtotal (Labor and Travel)			$ 273,600	$ 11,139	5,000	
Contingency 10%			$ 27,360	$ 1,114		
Total			$ 300,960	$ 12,253	$5,000	$ 318,213
						Rounded $318,000

Moss Point Relocations Pilot	Rate per hour fully loaded	Total Hours	Labor Costs	Total Travel and per diem	Other Admin costs	Total Cost
GS-13 Gene	$ 121.00	400	$ 48,400	$ 1,935		
GS-13 Don	$ 105.00	400	$ 42,000	$ 1,023		
GS-13 Wyatt	$ 129.00	400	$ 51,600	$ 1,023		
GS-12 LRH	$ 100.00	400	$ 40,000	$ 1,023		
GS-12 (Mobile District)	$ 100.00	200	$ 20,000	$ -		
Subtotal			$ 202,000	$ 5,004	2,500	
Contingency 10%			$ 20,200	$ 500		
Total			$ 222,200	$ 5,504	$2,500	$ 230,204
						Rounded $ 230,000

Implementation Costs

Waveland MS Floodproofing Pilot

Tasks	Labor	Per Diem	Mileage	Subtotals	Rounded	Total Implementation Cost
Public Workshop with Homeowners, contractor, AE's and public officials and program sign-up - onetime event	$ 8,800.00	$ 1,460.00	$ 922.00	$ 11,182.00	$ 12,000.00	
Site Inspections and meeting with Homeowners and AE's	$ 8,800.00	$ 1,460.00	$ 922.00	$ 11,182.00	$ 12,000.00	
Execution of FP agreements, site inspections of next groupings of structures and or inspections during construction and coordination of FP	$ 8,800.00	$ 1,460.00	$ 922.00	$ 11,182.00	$ 12,000.00	
Final Inspections, closeouts and disbursement of payment and coordination with local officials	$ 8,800.00	$ 1,460.00	$ 922.00	$ 11,182.00	$ 12,000.00	
					$ 36,000.00	
					25 structures being implemented in three groups requires a minimum of 3 sets of trips	**$ 120,000.00**

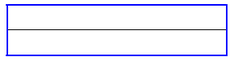
Moss Point Relocations Pilot Implementation Costs

Tasks	Labor	Per Diem	Mileage	Subtotals	Rounded	
Initial Trip to coordinate Plans with Municipal Officials (3 people)	$ 14,400.00	$ 3,066.00	$ 922.00	$ 18,388.00	$ 18,000.00	
Meetings with AE and Contractors (2 people)	$ 9,600.00	$ 1,460.00	$ 922.00	$ 11,982.00	$ 12,000.00	
Final Inspection trip (2 people)	$ 7,680.00	$ 876.00	$ 922.00	$ 9,478.00	$ 9,500.00	
				Total Implementation cost	**$ 39,500.00**	
					Say $40,000	

Summary costs	Waveland Floodproofing	Moss Point Relocations		Total
Report costs	$ 318,000	$ 230,000		$ 548,000
Implementation Costs	$ 120,000	$40,000		$ 160,000

Project Closeout Report	$ 20,000	$20,000		$ 40,000		
Totals	$ 458,000	$ 290,000		**$ 748,000**		

Remarks
Waveland study will include consideration of various raisng heights above the regulatory BFE.
Moss Point study will consider minimum BFE level of protection and 500 year level depending on available relocation sites



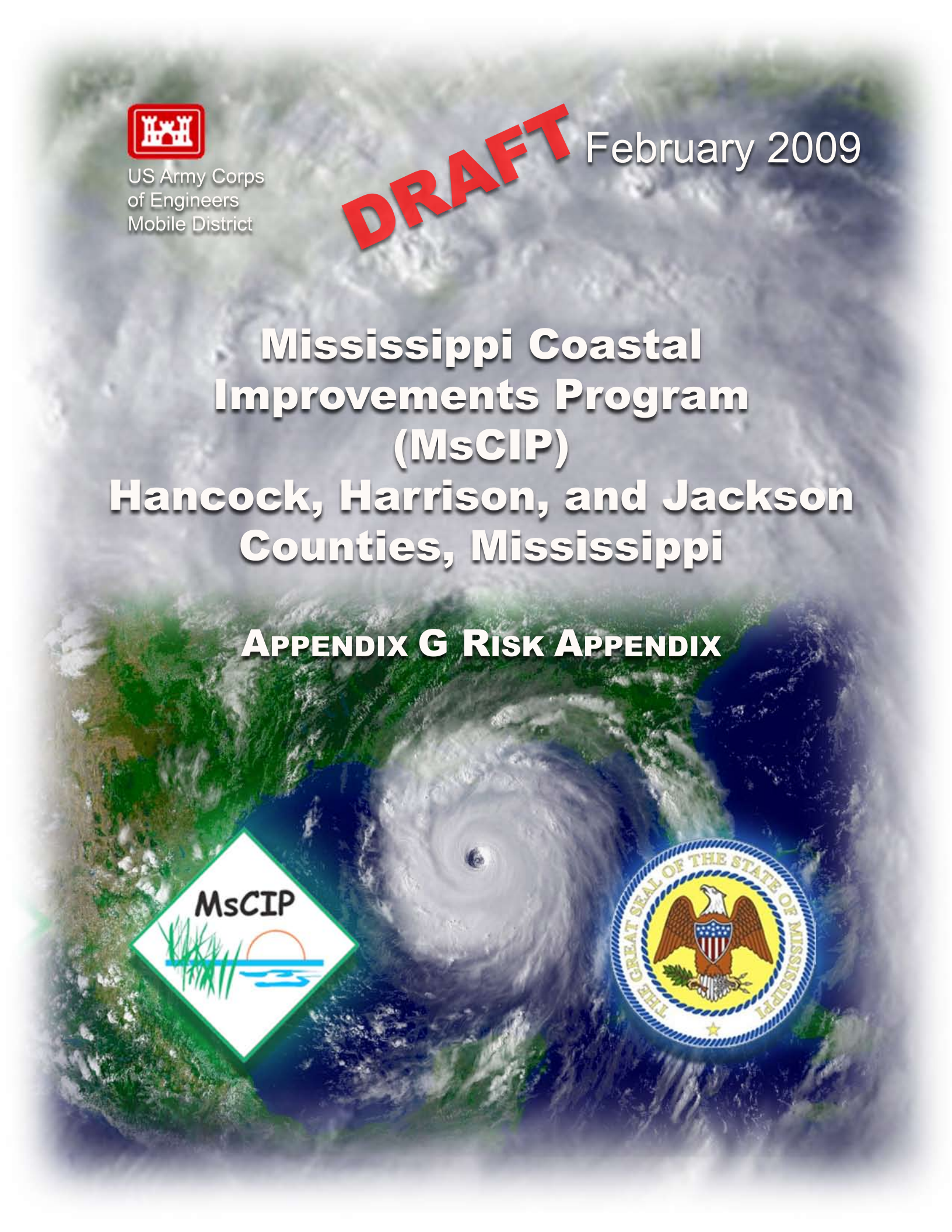
US Army Corps
of Engineers
Mobile District

DRAFT

February 2009

Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

Appendix G Risk Appendix



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Appendix G

Risk Appendix

Mississippi Coastal Improvements Program (MsCIP)

Comprehensive Plan Report
and
Integrated Environmental Impact Statement

AUGUST 2008

Planning, Environmental, Engineering, and Economics Sections; Mobile District;
Planning, Environmental and Economics Sub-CoPS; South Atlantic Division; and,
Engineer Research and Development Center
U.S. Army Corps of Engineers

FOREWORD

This document is one of a number of technical appendices to the *Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Feasibility Report and Environmental Impact Statement*.

The *Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Integrated Feasibility Report and Environmental Impact Statement* provides systems-based solutions and recommendations that address: hurricane and storm damage reduction, ecosystem restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion. The recommendations contained in the Main Report/EIS also provide measures that aid in: greater coastal environmental and societal resiliency, regional economic re-development, and measures to reduce long-term risk to the public and property, as a consequence of hurricanes and coastal storms. The recommendations cover a comprehensive package of projects and activities, which treat the environment, wildlife, and people, as an integrated system that requires a multi-tiered and phased approach to recovery and risk reduction, irrespective of implementation authority or agency.



The MsCIP Study Area

The purpose of the Comprehensive Plan Report is to present, to the Congress of the United States, the second of two packages of recommendations (i.e., the first being the "interim" recommendations funded in May 2007, and the second, this "final" response, as directed by the Congress), directed at recovery of vital water and related land resources damaged by the hurricanes of 2005, and development of recommendations for long-term risk reduction and community and environmental

resiliency, within the three-county, approximately 70 mile-long coastal zone, including Mississippi Sound and its barrier islands, of the State of Mississippi.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and an External Peer Review (EPR). Both review processes will have been conducted in accordance with the Corps "Peer Review of Decision Documents" process, has been reviewed by Corps staff outside the originating office, conducted by a Regional and national team of experts in the field, and coordinated by the National Center of Expertise in Hurricane and Storm Damage Protection, North Atlantic Division, U.S. Army Corps of Engineers.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing recommendations directed at assisting the people of the State of Mississippi in recovery, recommended actions and projects that would assist in the recovery of the physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

This Risk Appendix contains a discussion of the risk-based planning approach used by the MsCIP study team, for the analysis and characterization to the public and stakeholders of risks associated with existing and future without-project conditions, the potential risks, uncertainties and consequences associated with potential problem-solving measures (also known as "with-project" conditions), the incorporation of, and use of a stakeholder-involved risk-aware "weighting" process, referred to as a "Risk-Informed Decision Framework", or RIDF, that elicited stakeholder preferences on specific metrics used in the analysis, evaluation, and comparison of alternatives; and finally, the incorporation and consideration of all information received as stakeholder input, and a full consideration of all factors, in the screening of the final array of alternatives, and ultimately, the selection of recommendations contained in the Main Report/EIS.

The use of the Risk-Informed Decision Framework (RIDF) in the Mississippi Coastal Improvements Project, comprehensive plan development, was done better inform and involve stakeholders in the planning process, with the ultimate goal of creating solutions to reduce the potential for continued residual risk from flood and storm surge inundation, coastal wetlands loss and degradation, erosion, and saltwater intrusion, in ways that would promote greater resiliency in the future. The RIDF provided procedures that have aided decision makers in identifying planning objectives, performance metrics, and stakeholder priorities, in a transparent format. The RIDF utilizes techniques from the fields of risk and decision analysis to simply and clearly show decision makers and the public the risks, costs and consequences of flood control, coastal restoration, and hurricane protection by accommodating multiple objectives, conflicting stakeholder values, both qualitative and quantitative assessments of performance, and uncertainty in the natural, social, and economic environment.

Each appendix functions as a complete technical document, but is meant to support one particular aspect of the feasibility study process. However, because of the complexity of the plan formulation process used in this planning study, the information contained herein should not be used without parallel consideration and integration of all other appendices, and the Main Report/EIS that summarizes all findings and recommendations.

EXECUTIVE SUMMARY

This Risk Appendix outlines the approach taken in the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan study effort, to evaluating, communicating, and incorporating consideration of risks, uncertainties, and consequences, in the comparison, screening, and selection of alternative plans.

The MsCIP approach utilized a multi-step process, which incorporated:

1) Evaluation and assessment of potential risks, uncertainties and consequences associated with existing conditions, future "without-project" conditions, and numerous "with-project" plans;

2) Application of the Corps' "Risk and Uncertainty" analysis procedures, which assess and incorporate probabilities and uncertainties in the technical evaluation process;

3) Education of the public, agencies and other interests, in the inherent risks, uncertainties and potential consequences or any course of action, (including doing nothing), in various public forums and workshops;

4) Incorporation of the newly-implemented "Risk-Informed Decision Framework" (RIDF) methodology, that considered the factors (or "metrics") of greatest importance to the stakeholders and technical evaluators, solicitation of public and agency input on potential plans, and their prioritization (i.e., "Stakeholder Preferences") and potential selection of Locally-Preferred Plans, and finally;

5) Comparison of alternative plans, including all risk factors, in a "System of Accounts" format, screening, and selection of Federally-recommended plans, as part of the full consideration of all economic, environmental, technical, societal, risk factors, and explicit requirements (including Congressional) directed at the study effort.

Risk Analysis using this set of procedures was a new approach for a Corps of Engineers study, as it required a more thorough assessment of all the risk factors involved, but also integration of more public and agency involvement in the discussion of, and prioritization of risk factors, in a better articulated explanation of how risk may determine alternative recommendation in the plan selection process, in some cases with clear direction resulting from the risks and consequences possible under various plans.

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PART 1 – EVALUATION AND ASSESSMENT OF RISKS, UNCERTAINTIES, AND CONSEQUENCES

Evaluation and assessment of risk, uncertainties and consequences was the first step in the MsCIP risk assessment process.

The MsCIP team used standard conventions and definitions used in risk assessment, although some leeway was incorporated into the overall use of risk terminology, due to the on-going use of certain terms, such as "risk", in ways that are much broader than those in the risk assessment arena might use them. The broadest use of the term "Risk", as used in the MsCIP study, could be characterized as the potential for negative outcomes, under certain action and no-action conditions, both now and in the future. The public uses this term to refer to their own personal risks, be it risks to their health, income, residences, cultural integrity, or community, and thus, the MsCIP team had to adopt this convention. The MsCIP team also had to similarly use this term to characterize risks of environmental outcomes, such as functional damage to ecosystems, loss of species (or multiple species) integrity and survival, and many other negative outcomes. Because the public and stakeholders had to understand the nature of their risks and potential consequences for a large range of possible future conditions that by their nature were, in many cases, only qualitatively defined, the use of "risk" in this broader framework was by necessity, adopted.

"Risk ", in a narrower definition also used in the MsCIP study, could be defined as the probability of a certain outcome, under certain conditions. An example of this would be the probability (5% in any given year, for example) of a certain damage level, expressed in dollars ($10,000,000, for example), occurring in the event of a certain-sized hurricane-caused surge and wave depth and extent event. This could be expressed both as a probability of a certain outcome given a certain event, but can also be expressed as a sum of damages expected under a range of events, such as an average of all damages expected, over a time horizon such as fifty years, were nothing to be done to prevent those damages.

Risk, or the probability of certain events or outcomes, was more readily defined for some type of outcomes, such as hurricane-caused surge and wave depth, than for other types of outcomes, such as human reactions, or the number of deaths caused, by an oncoming hurricane. For some factors, probabilities were defined quantitatively; in many other cases, they could only be estimated qualitatively, as a range of possible outcomes.

The first phase of the data collection and characterization step involved the collection of all data associated with human and environmental outcomes to past hurricanes in this area of the Gulf Coast. Data collected included damages caused by various events, environmental conditions created by hurricanes and other large storm events, salinity and freshwater effects, erosion effects, and the human impacts of events, including deaths caused, human health and mental health effects, and human and environmental responses over time, economic (local, regional and national outcomes), response over time to relative sea level rise and developmental pressures, income and minority community responses, and many other probabilistic outcomes.

Most difficult to determine, were the hypothetical outcomes, both positive and negative, expected under future "without-project" conditions. This involved the development of outcomes in consideration of the numerous technical and environmental studies being developed in the course of the MsCIP study. In some cases, "risk" data were developed in express direction to expected negative outcomes resulting from certain course of action, particularly those concerned with human impacts as a result of certain plans being implemented.

The MsCIP study team used data furnished by a broad range of sources, to define risks associated with a large number of existing and future conditions, including the “No-Action”, and future with-project conditions for a large number of alternative plans. Many potential outcomes were developed in detailed discussions as to the nature of conditions under many future scenarios, and what the effects might be on the large array of resources. This data was used to populate a database, summarized in the System of Accounts tables given in the Main Report, where both quantitative and qualitative determinations of positive and negative outcomes are displayed, and the risks, uncertainties, and potential consequences of each, are compared.

“Uncertainty” as used in Corps studies, refers to the degree of uncertainty expressed by technical evaluators (or even in some cases by the public), that a certain outcome will occur under and certain condition. This could be expressed as a range of outcomes given a certain condition, an example being that experts predict that water depth may be as much as 20 feet and as little as 12 feet deep, under circumstances of a certain-magnitude hurricane event, at a certain location. In many cases, however, uncertainties regarding a certain outcome, could only be expressed in the broadest of terms. An example of this would the uncertainties regarding threats to human life under conditions such as the implementation of ring levees or surge barriers. It is, of course, highly uncertain as to how human beings will react to the approach of a hurricane event, given the uncertainties as to landfall, intensity, and other factors. This is complicated by the intervention of certain conditions like a surge barrier, behind which people may feel “protected”, or alternatively, very mush at risk. These determinations of risk and uncertainty played a large, although heavily dependent on qualitative assessment, role in decision-making on the part of the Federal response.

Assessment and characterization of risk and uncertainties led, as expected, to their incorporation in the technical analyses conducted under the MsCIP study effort, the second step of this process.

PART 2 – TECHNICAL RISK AND UNCERTAINTY

The second step of the risk assessment process was the incorporation of what the Corps refers to as "Risk and Uncertainty Analysis". This aspect of the risk analysis focuses on the evaluation of technical aspects of potential plans, that includes both estimation of probabilities of certain outcomes, but also the determination of uncertainties in any estimated outcome. Technical risk and uncertainty also included a measure of risk and uncertainty inherent in cost estimation.

Risk and uncertainty analysis is a comprehensive, statistically-based approach directed at identifying and incorporating uncertainties associated with key factors that are inherent in the determination of plans addressing flooding, hurricane surge, waves, and other destructive events, as well as those comprising key elements of ecosystem restoration planning, economic analysis, and cost estimating.

Key factors evaluated in the Risk and Uncertainty analysis conducted under the MsCIP study include: evaluating uncertainties in estimating surge (water surface) elevations and wave contributions to surge height, the extent of surge inundation by frequency of event (by use of multiple event modeling), the first floor elevation of structures, the magnitude of damages to both structures and contents, and risks in the estimation of costs associated with future events, including those of project or program implementation. In addition, uncertainty was an inherent factor in the environmental processes used to identify possible restoration sites. This uncertainty was primarily related to the scale of the existing data used to populate the GIS based Spatial Decision Support System (SDSS). In addition there is uncertainty in the benefit evaluation system used, the Hydrogeomorphic Methodology (HGM), due to the lack of time to completely ground truth the sites in question.

Risk and Uncertainty is a rigorous part of Corps of Engineer analyses and the planning process. Engineer Regulation 1105-2-101 defines risk as, "The probability an area will be flooded, resulting in undesirable consequences," and uncertainty as, "A measure of imprecision of knowledge of parameters and functions used to describe the hydraulic, hydrologic, geotechnical, and economic aspects of a project plan."

For the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan, both risk and uncertainty played a vital role throughout the planning and selection process as well as the work conducted by each of the various technical aspects. While this section will paint a broad picture of the application of techniques used to address risk and uncertainty, the engineering, environmental, real estate, and economic appendices go into greater detail on how each discipline addressed these issues.

Estimation of risks and uncertainties associated with the MsCIP Comprehensive Plan study area, as defined by Congress, included estimation of physical outcomes across the three coastal counties of Mississippi; Hancock, Harrison and Jackson Counties from west to east respectively. Hancock, Harrison, and Jackson Counties include over 1,361 square miles, roughly 100 square miles larger than the state of Rhode Island and populations of 40,421, 171,875, and 130,577 respectively. The Maximum Probable Intensity (MPI) footprint, or the estimate of the maximum surge footprint, includes over 138,000 residential and commercial structures. Within these areas, surge from Hurricane Katrina significantly destroyed (50% or more structural damage) 32,446 structures, with another 15,000 to 25,000 sustaining moderate to minor damage. The sheer magnitude and scale of this area, along with the extent of the damage sustained, set the stage for much larger degrees of risk and uncertainty than exist in typical Corps Feasibility Studies.

Forecasting future scenarios is an important part of the Corps planning process. In order to evaluate the true risk and impacts over the period of analysis, all forecasts were created based on historic

and existing information, as well as quantitative and qualitative assessments of what is most likely to happen within the study area in the future. One method used was to identify the 'most likely' future, or the best guess about what may happen based on observed variables and assumptions of both natural and human behaviors. Another method used was to conduct scenario planning, where multiple future scenarios are created in order to evaluate what would happen if observed variables or assumptions do not happen as projected. Scenario planning attempts to answer the 'what if' questions that arise when making forecasting assumptions and predictions. For the MsCIP Comprehensive Study, the former method was chosen due to the size, scope, and complexity of the overall analysis, but with scenario testing used for the multiple possible futures possible under sea level rise and re-development possibilities.

The use of scenario planning allowed the MsCIP PDT the ability to evaluate the impacts of large uncertainties such as varying redevelopment types and the effects of relative sea level rise. Four future without-project scenarios were developed based on two redevelopment scenarios and two potential relative sea level rise scenarios. Redevelopment was assumed as either the rebuilding of the study area exactly as it was pre-Hurricane Katrina (residential redevelopment) or rebuilding similar to pre-Hurricane Katrina levels except for the vast waterfront coastline, which would rebuild as either condominiums or casinos (commercial redevelopment). Sea level rise and land surface subsidence have been taken into account as part of this study and is reported as "relative sea level rise" which accounts for both as a single value.

After the identification of the four potential future without-project scenarios, the next step was the evaluation of those scenarios using hydrodynamic and economic models. Hydraulic and hydrologic modeling efforts by a team of USACE, FEMA, NOAA, private sector and academic researchers have been working toward the definition of a new system for estimating hurricane inundation probabilities. Their work includes the use of multiple models such as the Planetary Boundary Layer Model (TC-96) which evaluates wind pressure fields, the Wave Attenuation Model (WAM) which evaluates offshore waves, the STWAVE near shore wave model, and the Advanced Circulation (ADCIRC) model which incorporates output from the other models into the storm surge modeling effort. Modeling inputs included a storm suite of over 150 storms covering ranges in variable drivers such as central pressure, radius to maximum winds, and forward speed. Outputs of the models were statistically analyzed using a modified Joint Probability Method with Optimal Sampling (JPM-OS). The underlying concept of the JPM-OS methodology is to provide a good estimate of the surge in as small a number of dimensions as possible, while retaining the effects of additional dimensions by including an $\boldsymbol{\varepsilon}$ term within the estimated Cumulative Distribution Function (CDF) for surges. The $\boldsymbol{\varepsilon}$ term is considered to include, at a minimum, tides, random variations in the Holland B parameter, track variations not captured in storm set, model errors (including errors in bathymetry, errors in model physics, etc.), and errors in wind fields due to neglect of variations not included in the Planetary Boundary Layer model winds. More detail on the JPM-OS method can be found in the Engineering Appendix (Appendix E)

The output of the JPM-OS modeling effort was provided to the Mobile District Engineering Division for the estimation of exceedence probability functions that were incorporated into the Hydrologic Engineering Center – Flood Damage Analysis (HEC-FDA) program. The HEC-FDA program uses risk-based analysis methods for evaluating flood damage and flood damage reduction alternatives. The program relies on hydrologic, hydraulic, and economic data input. Uncertainties in these data are input and used by the model for computing expected annual damages. HEC-FDA input variables that include uncertainty are the exceedance probability functions, depth damage relationships, first floor elevations, and structure and content values. The program's risk-based analysis methods conform to Corps of Engineers policy regulations. Outputs of the HEC-FDA program for each of the future without-project scenarios are detailed in the Economic Appendix

(Appendix B), and are included in the Risk Informed Decision Framework (RIDF) process outlined in later sections of this appendix.

Although there is some uncertainty associated with the environmental restoration evaluation process it is felt that these uncertainties are within the ranges of values used within the various models. The environmental team ground truthed a portion of each of the recommended sites to ensure that the proposed restoration activities would be achievable and that the restored sites would function as designed. The project is also recommending implementation of an adaptive management process and monitoring for all the proposed environmental restoration project elements. The techniques being proposed for restoration, e.g. excavation of fill, filling man-made ditches, mowing and burning etc., are tried and true proven restoration methods. Further only sites that contain wetland soils and are in the near vicinity of water courses are proposed for restoration. This will increase the probability of success for those sites proposed for restoration as tidal fringe wetlands.

Risk and Uncertainty outcomes were also incorporated into the risk database, summarized in the System of Accounts tables given in the Main Report. All of this data was used in the later phases of risk assessment and screening of alternatives ultimately leading to the selection of recommended actions.

PART 3 – EDUCATION OF STAKEHOLDERS

The third step of the risk assessment process was the characterization of risk, in terms that everyone could understand, and the dissemination of this information to the stakeholders. This was an extremely important part of the process, since the stakeholders were so interested in the planning process and its potential outcomes, but was doubly important given their participation in the next phase of study, the integration of Risk-Informed Decision Framework (RIDF), in which they would very actively participate, and for which good information on risks, uncertainties, and consequences was so important.

Data on the potential risks and consequences of the no-action plan, and the large number of potential alternatives plans addressing numerous identified problem areas and sites, was assembled and discussed by members of the study team, agency participants, and technical experts in each field. It was recognized that much of the data would be confusing to the public, and in fact, could actually cause the public to believe information that would run contrary to what the study team believed was in the best interests of the stakeholders. Key among this was the discussion of "protection" and "100-year" storms. Both these concepts have negative outcomes, as the public interprets them. Early attempts at educating the stakeholders on risk led the study team to the recognition that the public would believe themselves to be "protected" from storm events, in the event of various structural plans being implemented, and that the concept of a "100-year level of protection" was guaranteed to result in many members of the public believing that a "100-year" hurricane was only possible 100 years in the future, since "we just had one."

The study team convened a group to re-characterize event frequency, and the risks and consequences of various magnitude events occurring, in terms that everyone in the study area could relate to. Frequency-inundation mapping was developed, to characterize events in terms of their depth, and re-occurrence based on past events the community has suffered, rather than an arbitrary frequency that the public could not understand. Risks and consequences associated with many other factors were also discussed and then re-characterized in simple, easy to understand terms.

The MsCIP team shared this information, through a series of public workshops. These workshops are discussed in greater detail in the Public Involvement Appendix. The key outcome of the initial public workshops, in regards to the education of stakeholders on risk issues, was the better understanding of all the factors involved in the eventuality of either no action, or any number of potential plans, in terms of both human and environmental impacts, risks or probabilities of certain outcomes given certain circumstances, and what that might mean to the individuals concerned, their institutions, and communities.

Education of the stakeholders was understood to be one important part of the process, but requiring additional tools to enlist greater public participation, and expression of stakeholder preferences on plans, in a risk-aware environment. This led to the following step in this process.

PART 4 – RISK INFORMED DECISION FRAMEWORK

Risk-Informed Decision Framework (RIDF) refers to a guided process by which stakeholders can "weigh in" on their preferences, in regards to concepts, measures, and alternative plans, in a manner that leads to group decision-making, at least in regards to stakeholder preferred actions.

The RIDF provides a robust and comprehensive approach toward identifying plans that the public and agencies feel best achieve the particular goals and objectives of that population, and draws from current practice in the fields of multi-criteria decision analysis (MCDA) and risk and uncertainty analysis. The RIDF is solidly grounded in and supports the Corps of Engineers' six-step planning process closely, in augmenting this planning process by incorporating specific techniques and methods from risk analysis and MCDA, to solicit and incorporate public and agency preferences in plan evaluation and selection. RIDF is the logical next step in the process of evaluating and incorporating risk in the planning process, in that it involves the public in the evaluation of potential measures that might be used to address problems, further educates them to the risks and consequences of each potential action, including a No-Action scenario, and allows them to weigh-in on a prioritization process that allows local decision-makers to see what the public desires, and how that might be used in the determination of preferred plans and activities.

The RIDF enhances the level of communication and collaboration among decision-makers and stakeholders by providing structured opportunities for interaction. The RIDF uses the information gained through the initial steps involving the public and agencies to develop a set of factors of importance (referred to as "metrics") in the analysis of specific problems and sites, for which the Study team then develops units of measurement for which to compare each metric later in the process, and solicits publically-, and agency-determined "weights" or preferences that reflect stakeholder priorities. This provides an analytically sound, defensible, and quantitative approach to aid in local decision-making. In this way, decision outcomes can more adequately satisfy the interests, values, and objectives of most importance to the individuals and agencies weighing in on each alternative plan.

Metrics evaluated during the MsCIP RIDF process included measures of the total cost as well as local implementation costs, acres of habitat lost or restored by No-Action or various restoration plan opportunities, potential impacts to physical and mental health, impacts to cultural integrity, regional economic well-being, residual risks and risk of failure of a given plan, and other factors.

The RIDF also incorporated information about uncertainty into the decision process and facilitates discussion of residual risks, which include the expected damages or consequences resulting from events, and which might result even in the event of construction of a large project or implementation of a program. Accurate forecasts about the future are difficult, and decisions that ignore these uncertainties may differ from and perform less well than those that do not. The MsCIP RIDF process also incorporated uncertainty originating from two additional sources of particular importance in this area, those of relative sea level rise (resulting from both global sea level rise and sinking of the land relative to the sea's surface) and the future potential patterns of re-development. Information about these uncertainties manifests itself in the outcome metrics and in the scoring and ranking of alternative plans.

Ultimately, the optimality of a prospective public and agency decision outcome depends upon values and beliefs that can vary across different stakeholder groups. Since the MsCIP decision process involves a broad spectrum of stakeholders, the RIDF evaluates the sensitivity of the recommendations to these values and beliefs to help decision-makers and stakeholders understand the prioritization of factors by any group or individual, and their emotion about each plan and its potential outcomes. Use of RIDF may further help to identify what additional studies may be needed

and what communication and negotiation efforts could be improved. These efforts help to build confidence in the planning process, involve the public and agencies in decision-making, and may enhance commitment to selected alternatives. RIDF also educates and obtains input on the role that adaptive management can play in the long-term outcomes of potential plans, and incorporates public and agency input on monitoring and maintaining the performance of projects and programs over longer planning horizons.

Detailed discussion on the models used, the creation, selection and characterization of metrics used, and the outcome of stakeholder weighting sessions, is contain in the attachment to this appendix.

PART 5 – COMPARISON, SCREENING, AND CONSIDERATION OF RISK, IN THE PLAN SELECTION PROCESS

The Fifth and final phase of Risk Analysis in the MsCIP Study process involved comparison of no-action and alternative plans, in a side-by-side trade-off presentation of plan outcomes, potential inherent and residual risks, associated with various No-Action and with-project scenarios, through display in a System of Accounts format. Screening of alternatives, by use of the System of Accounts tables, and consideration of all apparent risks, uncertainties, potential consequences and outcomes, led to screening of alternatives, weighing of the outcomes of each alternative, and identification, by Stakeholders, of a "Stakeholder-Preferred" (where applicable) Plan, and "Federally-recommended" courses of action for each problem area, based on the best-balance of objective outcomes, achievement of high cost-effectiveness, and inclusion as a key element of a comprehensive package of recommendations, directed at achieving a lower-risk, higher sustainability environment. The goal of this process was to generate a full range of tiered recommendations aimed at achievement of the study objectives, and identification of those measures for immediate or longer-term action as a result of the decision document being acted upon by Congress.

The Accounts displayed and used in this final part of the process, included the standard four accounts identified in the USACE Plan Formulation Guidance: "National Economic Development" (NED), "Regional Economic Development" (RED), "Environmental Quality" (EQ), "Other Social Effects" (OSE). In addition a "Risk" (RISK) account was added to fully identify the inherent risks associated with no action or the implementation of any one of the measures. The System of Accounts tables also display the Stakeholder Preference "scores" resulting from the public and agency RIDF process, as well as a final discussion of the selection result, based on those factors of greatest importance in that selection, for both "Stakeholder", and "Federally-Recommended" actions.

The stakeholder "scores" from the public and agency RIDF process, presented in the System of Accounts tables, resulted from a summary of the most recent series of public/agency workshops, and the application of the multi-criteria decision analysis. The summary of those scores waqs presented as the Stakeholder Preference score, for each of the final array of plans. This number rates each alternative, in concept, as a percentage of a theoretical "perfect plan" (in the eyes of the stakeholder group). The higher the score reflects the stakeholder belief that the alternative provides the best fit to their value judgments of the metrics. In other words, the higher the score, the more acceptable the alternative should be to that stakeholder group.

Because the stakeholders may possess very different life experiences and also may not have possessed full information on the nature and magnitude of potential risks associated with any plan of action, the MsCIP study application of the planning process required that the Corps' study team have ultimate responsibility for a Federally-recommended plan selection, based on full consideration of risk factors and potential consequences of plan implementation. This was determined to be especially important in the consideration of alternatives that had potentially negative outcomes under various future scenarios.

The study team engaged Corps and outside experts, to characterize residual or inherent risks, and to potentially recommend actions based on these over-riding criteria, in meeting the original mission as detailed by the Congress. This final part of the process was considered to be the key final level of input to the planning process, particularly in this high-risk situation.

An example of the evaluation, comparison, and rationale leading identification of plans recommended for implementation, as formulated to deal with a particular problem set at a specific site, is illustrated below, and also provided for each recommendation, within the body of the Main Report.

The Barrier Islands of the Gulf Coast form an important attribute in the system of islands, water bodies and mainland features of the coast of Mississippi. They function as a barrier to saltwater intrusion, maintaining a delicate salinity balance on which many species depend for survival within Mississippi Sound. The barrier islands attenuate wave and surge height. They also provide for a host of unique environmental conditions, both terrestrial and aquatic, and create unique conditions on which mainland values depend. Most of the barrier islands are managed by the National Park Service, with some being designated Wilderness Areas, and protected by stringent regulation.

Analysis of the effects of hurricanes Katrina, Rita, and others indicated a large number of problems caused by their erosion and degradation. Loss of the barrier islands has led to increased salinity within Mississippi Sound, increased potential wave and surge effects within the study area, and loss of aquatic species viability. Degradation of the many functions and values provided by the barrier islands, and their identification as a large focus of study effort, lead to the creation of a large number of potential measures by which restoration of the islands, and protection of resources might be achieved.

Many potential measures would be intrusive, and would violate Wilderness Act protections, due their active interference in natural processes. The list of potential measures was rapidly screened by the joint interagency sub-committee created to evaluate barrier islands options, to a shorter list containing only a No-Action Plan, restoration of the pre-hurricane island footprint plan (Plan A), a sand replenishment plan (Plan C), restoration of Ship Island breach only (Plan G), and a combination plan that would address sand replenishment and repair of Ship Island (Plan H).

Data on costs, benefits (both monetary damages prevented and ecological damages prevented), environmental quality issues, societal effects, “Stakeholder Preference” scores generated during the RIDF stakeholder involvement process, and risk factors assessment, were entered into the System of Accounts table shown below. This information was discussed with stakeholders, ranging from members of the public, to the State, and Federal agencies.

The final phase of risk incorporation in the MsCIP planning process, leading to plan selection for the barrier islands element, began with the side-by-side comparison of No-Action and action plan outcomes, with no one factor taking precedence. Examination of possible outcomes indicated that Plan H appeared to provide the most complete, effective, efficient and acceptable alternative plan. Plan H would achieve a high degree of restoration benefit, at less than half the cost of Plan A, and virtual identical damage reduction and protection of fisheries. It is a more complete solution than plans C or G, particularly in regards to protection of fisheries and restoration of tidal and non-tidal habitat. Plan H also would create positive monetary net benefits, demonstrating its cost-effectiveness (one of the primary charges given by Congress), with damage reduction benefits of approximately $18.8 million annually, protection of fisheries benefits of approximately $44 million annually, and restoration of 456 acres of tidal, and 694 acres of non-tidal habitat. Plan H would provide similar cultural, environmental quality, societal, and community benefits, at a lesser cost than Plan A. Stakeholder preference scores for Plan A and Plan H were almost identical, with Plan H receiving a marginally higher mean score. Evaluation of risks indicate that Plans A and H would provide similar reductions in several risk factors, including reduction of residual damages (primarily to reduction of wave effects on mainland development), will be minimally impacted by relative sea level rise, and have a low risk of failure (of plan outcomes). While no plan provides for significant positive benefits to life and safety, those are not factors that would be influenced strongly by this element of the comprehensive plan, but by others included in the package of recommendations.

Weighing of all considered factors above provided a clear indicator that Plan H provides the best balance, and indeed, the greatest number and magnitude of positive outcomes, of all plans considered, including the No-Action Plan.

System of Accounts table for Barrier Islands

Ecosystem Restoration and Hurricane and Storm Damage Reduction

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi					
Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.					
Item	**No Action**	**Plan A**	**Plan C**	**Plan G**	**Plan H**
A. PLAN DESCRIPTION	No Federal Action	Restore Island Footprint	Replenish Sand in Littoral Zone (Off-Shore & Inland River Sand Source)	Restoration of Ship Island Breach	Combination of C + G
B. IMPACT ASSESSMENT					
1. National Economic Development					
a. Beneficial Impacts					
(1) Damages Prevented	$0	$18,866,000	$10,468,000	$7,616,000	$18,866,000
(2) Emergency Costs Avoided	$0				
(3) Recreation	$0	$466,000	$117,000	$466,000	$466,000
(4) Total Beneficial Impacts	None.	$19,332,000	$10,585,000	$8,082,000	$19,332,000
b. Adverse Impacts					
(1) Project Cost	$0	$942,200,000	$147,400,000	$181,400,000	$328,800,000
(2) Interest During Construction	$0	$119,317,000	$18,667,000	$22,972,000	$41,639,000
(3) Average Annual First Cost	N/A	$58,376,000	$9,133,000	$11,239,000	$20,372,000
(4) Annual O&M	$0	$0	$0	$0	$0
(5) Total Avg. Annual Costs	$0	**$58,376,000**	**$9,133,000**	**$11,239,000**	**$20,372,000**
2. Environmental Quality (EQ)					
(1) Ecosystem Restoration	No benefit	Restoration of 644 acres of tidal habitat and 2036 acres of nontidal habitat.	Restoration of 326 acres of tidal habitat and 217acres of nontidal habitat.	Restoration of 130 acres of tidal habitat and 477 acres of nontidal habitat.	Restoration of 456 acres of tidal habitat and 694 acres of nontidal habitat.

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Plan A	Plan C	Plan G	Plan H
(2) Protection of Fisheries	**Loss of $43,618,143** in average annual fishery landings	Avoidance of **$43,618,143** in lost fishery landings.	Avoidance of **$6,542,721** in lost fishery landings.	Avoidance of **$21,809,072** in lost fishery landings.	Avoidance of **$43,618,143** in lost fishery landings.
(3) Water Circulation	Area would become more open Gulf in nature as islands erode	No anticipated effect.	No anticipated effect.	No anticipated effect.	No anticipated effect.
(4) Noise Level Changes	No change in noise levels	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction	Temporary increase in noise levels during construction
(5) Public Facilities	Loss of the barrier islands would result in loss of National Parks	National Parks would be preserved.	National Parks would be enhanced by supplemental sand supply.	National Parks would be enhanced by supplemental sand supply.	National Parks would be preserved.
(6) Aesthetic Values	Continued degradation of aesthetic values	Significant aesthetic improvement	Moderate aesthetic improvement	Moderate aesthetic improvement	Significant aesthetic improvement
(7) Natural Resources	Continued degradation of islands and loss of function of MS Sound.	Significant reduction in loss of island and function of MS Sound.	Minor reduction in loss of island and function of MS Sound.	Moderate reduction in loss of island and function of MS Sound.	Significant reduction in loss of island and function of MS Sound.
(8) Biological Resources	Continued degradation and loss of biological resources.	Significant improvement in biological resources.	Moderate improvement in biological resources.	Moderate improvement in biological resources.	Significant improvement in biological resources.
(9) Air Quality	No anticipated effect on air quality	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*	Air emission would be *de minimus*
(10) Water Quality	Water quality is anticipated to deteriorate with future loss of the island system (salinity increase will decrease size of estuarine zone).	Temporary negative impacts to water quality due to construction but overall long-term improvements to water quality are anticipated.	Temporary negative impacts to water quality due to construction but overall long-term improvements to water quality are anticipated.	Temporary negative impacts to water quality due to construction but overall long-term improvements to water quality are anticipated.	Temporary negative impacts to water quality due to construction but overall long-term improvements to water quality are anticipated.

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Plan A	Plan C	Plan G	Plan H
(11) Public Services	Possible increase in interruption of services as islands continue to erode	Increased stability of barrier islands would reduce likelihood of interruption of public services.	Increased stability of barrier islands would reduce likelihood of interruption of public services.	Increased stability of barrier islands would reduce likelihood of interruption of public services.	Increased stability of barrier islands would reduce likelihood of interruption of public services.
(12) Cultural and Historical Preservation	Alternative would result in future loss of important cultural resources at Ship Island.	Alternative would preserve cultural and historical artifacts, including Fort Massachusetts and the French Warehouse.	Alternative would provide some reduction in impact to cultural and historical artifacts, including Fort Massachusetts and the French Warehouse.	Alternative would preserve cultural and historical artifacts, including Fort Massachusetts and the French Warehouse.	Alternative would preserve cultural and historical artifacts, including Fort Massachusetts and the French Warehouse.
(13) Total Quality of the Environment	Significant negative impact on the total quality of this environment if the islands erode away	Significant positive impacts on the total quality of environment (i.e. future production of Mississippi Sound)	Significant positive impacts on the total quality of environment (i.e. future production of Mississippi Sound)	Significant positive impacts on the total quality of environment (i.e. future production of Mississippi Sound)	Significant positive impacts on the total quality of environment (i.e. future production of Mississippi Sound)
3. Regional Economic Development (RED)					
(1) Impact on Sales Volume	No impact to the local economy.	Increase of **$2,289,546,000** in additional sales volume.	Increase of **$358,182,000** in additional sales volume.	Increase of **$440,802,000** in additional sales volume.	Increase of **$798,984,000** in additional sales volume.
(2) Impact on Income	Negative impact to individuals involved in fishing industry as islands erode and MS Sound environment changes.	Increase of **$480,984,800** in additional local income.	Increase of **$75,246,410** in additional local income.	Increase of **$92,603,120** in additional local income.	Increase of **$167,849,530** in additional local income.

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Plan A	Plan C	Plan G	Plan H
(3) Impact on Employment	Negative impact to individuals involved in fishing industry as islands erode and MS Sound environment changes.	Increase of **14,100** new jobs.	Increase of **2,206** new jobs.	Increase of **2,714** new jobs.	Increase of **4,920** new jobs.
(4) Tax Changes	Possible negative impacts as islands erode and chance of storm damage increases	None	None	None	None
4. Other Social Effects (OSE)					
a. Beneficial Impacts					
(1) Security of Life, Health, and Safety	Continued risks to life, health and safety	Significant decrease in risks to life, health and safety.	Moderate decrease in risks to life, health and safety.	Moderate decrease in risks to life, health and safety.	Significant decrease in risks to life, health and safety.
(2) Community Cohesion	Negative impacts as islands continue to erode and damages from waves and storms increase above the existing level.	Positive impact as community observes coastal resources being restored and stability of barrier islands and MS Sound increased.	Positive impact as community observes coastal resources being restored and stability of barrier islands and MS Sound increased.	Positive impact as community observes coastal resources being restored and stability of barrier islands and MS Sound increased.	Positive impact as community observes coastal resources being restored and stability of barrier islands and MS Sound increased.
(3) Tax Values	Negative impacts as islands erode and chance of storm damage increases	Moderate increase in tax values due to decreased risk to properties.	Small increase in tax values due to decreased risk to properties.	Small increase in tax values due to decreased risk to properties.	Moderate increase in tax values due to decreased risk to properties.

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Plan A	Plan C	Plan G	Plan H
(4) Community Growth	Could have negative impact on growth as islands continue to erode	Moderate positive impact to community growth	Small positive impact to community growth	Small positive impact to community growth	Moderate positive impact to community growth
(5) Property Values	Negative impacts as islands erode and chance of storm damage increases	Moderate increase in property values due to decreased risk to properties.	Small increase in property values due to decreased risk to properties.	Small increase in property values due to decreased risk to properties.	Moderate increase in property values due to decreased risk to properties.
(6) Displacement of Businesses	Potential impacts to businesses from increased risk of surge damage.	Reduced risk of displacement of businesses.	Reduced risk of displacement of businesses.	Reduced risk of displacement of businesses.	Reduced risk of displacement of businesses.
(7) Public Facilities	Negative impacts to public facilities from increased risk of surge damage.	Reduced risk to public facilities.	Reduced risk to public facilities.	Reduced risk to public facilities.	Reduced risk to public facilities.
(8) Injurious Displacement of Farms	N/A	N/A	N/A	N/A	N/A
b. Preservation of life	Not anticipated to contribute to loss of life.	Not anticipated to contribute to loss of life.	Not anticipated to contribute to loss of life.	Not anticipated to contribute to loss of life.	Not anticipated to contribute to loss of life.
C. PLAN EVALUATION					
1. Contributions to Planning Objectives					
a. Flood, Hurricane and/or Storm Damage Reduction	Increased risk in damage reduction from further degradation of islands.	Significant avoidance of increased risk.	Minor avoidance of increased risk.	Moderate avoidance of increased risk.	Significant avoidance of increased risk.

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Plan A	Plan C	Plan G	Plan H
b. Recovery of lost environmental resources	Alternative will result in continued loss of environmental resources.	Barrier Island restoration will accrue unquantified benefits.	Barrier Island restoration will accrue unquantified benefits.	Barrier Island restoration will accrue unquantified benefits.	Barrier Island restoration will accrue unquantified benefits.
2. Response to Planning Constraints					
a. Avoid environmental impacts and minimize induced damages	Continued loss of pre-Katrina environmental resources.	Beneficial effect on environmental resources.	Beneficial effect on environmental resources.	Beneficial effect on environmental resources.	Beneficial effect on environmental resources.
b. Institutional Acceptability	Is not supported by state or local government	Is supported by local and state governments	Is supported by local and state governments	Is supported by local and state governments	Is supported by local and state governments
3. Response to Evaluation Criteria					
a. Acceptability	NO	No, does not meet all Federal policies and regulations (i.e. Wilderness Act)	YES	YES	YES
b. Completeness	NO	YES	NO, it does not avoid all of the future degradation.	NO, it does not avoid all of the future degradation.	YES
c. Effectiveness	NO	YES	NO, not a completely effective solution.	NO, not a completely effective solution.	YES
d. Efficiency (Cost-Effectiveness; i.e., most efficient use of Federal and Non-Federal Funds)	NO	No, over 2 1/2 times as expensive as plan H	No, less efficient than plan A and H.	No, less efficient than plan A and H.	YES, most efficient / cost effective plan.
e. Integration	N/A	Seamless addition to system.	Seamless addition to system.	Seamless addition to system.	Seamless addition to system.

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Plan A	Plan C	Plan G	Plan H
f. Reversibility	This issue does not apply	Alternative could be reversible, given means to remove sand.	Alternative could not be reversible, given placement in open-water.	Alternative could be reversible, given means to remove sand.	A portion of this alternative could not be reversible, given placement in open-water.
4. Stakeholder Preference Score (From MCDA weightings analysis)					
a. Summary Score	**15.53%**	**71.69%**	**62.28%**	**41.70%**	**72.03%**
Cluster Group A	27.16%	67.62%	63.08%	47.53%	73.93%
Cluster Group B	18.82%	70.58%	63.58%	45.57%	73.93%
Cluster Group C	11.83%	74.03%	63.92%	41.81%	73.58%
Cluster Group D	4.30%	74.51%	58.55%	31.90%	66.66%
b. Stakeholder Preference	All groups ranked this plan lowest	Plan ranked very high, but less than H.	Plan ranked lower than A and H.	Plan ranked lowest of all action plans.	Plan ranked highest overall
D. Implementation Responsibility	Does not have any implementation responsibilities	Elements would be joint Federal/Non-Federal implementation responsibility.	Elements would be joint Federal/Non-Federal implementation responsibility.	Elements would be joint Federal/Non-Federal implementation responsibility.	Elements would be joint Federal/Non-Federal implementation responsibility.
E. State and other Non-Federal Coordination	Would require no State or other Non-Federal coordination activities	Would require significant State or other Non-Federal coordination activities	Would require significant State or other Non-Federal coordination activities	Would require significant State or other Non-Federal coordination activities	Would require significant State or other Non-Federal coordination activities
F. Risk Evaluation					
1. Risk and Vulnerabilities					
a. Risk of Failure	N/A	Low	Moderate	Moderate	Low

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Plan A	Plan C	Plan G	Plan H
b. Residual Risk	All barrier islands will overtop during large surge events, and will not provide significant reduction of surge and waves.	All barrier islands will overtop during large surge events, and will not provide significant reduction of surge. Plan A would provide a significant reduction to waves.	All barrier islands will overtop during large surge events, and will not provide significant reduction of surge and waves.	All barrier islands will overtop during large surge events, and will not provide significant reduction of surge and waves.	All barrier islands will overtop during large surge events, and will not provide significant reduction of surge. Plan A would provide a moderate reduction to waves.
c. Reliability	N/A	Plan A would provide a moderate level of reliability, would be resistant to damage from storm events, and would not require significant maintenance.	This plan would provide a low level of reliability, would receive damage from storm events, and would require significant maintenance.	This plan would provide a low level of reliability, would receive damage from storm events, and would require significant maintenance.	Plan A would provide a moderate level of reliability, would be resistant to damage from storm events, and would not require significant maintenance
d. Relative Sea Level Rise	Problems will be substantially exacerbated by an increasing relative rise of sea level	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be moderately impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be moderately impacted by an increasing relative rise of sea level over the period of analysis	This Plan will be minimally impacted by an increasing relative rise of sea level over the period of analysis
e. Risk of Ecosystem Damage	Ecosystem damage will continue to accrue at a rate at least that of recent history with substantial negative	Risk of ecosystem damage will be minimal throughout the period of analysis.	Risk of ecosystem damage will be moderate throughout the period of analysis.	Risk of ecosystem damage will be moderate throughout the period of analysis.	Risk of ecosystem damage will be minimal throughout the period of analysis.

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Plan A	Plan C	Plan G	Plan H
	outcomes.				
f. Risk to Life and Safety	Significant threats to Life and Safety from storm surge will continue to rise due to continued deterioration of the Barrier Islands.	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide the least risk to life and safety.	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide less risk to life and safety than the No Action Plan.	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide less risk to life and safety than the No Action Plan and Plan C.	Significant threats to Life and Safety from storm surge will still exist, but this plan will provide the least risk to life and safety, except for Plan A.
g. Risk to Mental and Physical Health	Significant threats to Mental and Physical Health from storm surge will continue to rise due to continued deterioration of the Barrier Islands.	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide the least risk to Mental and Physical Health.	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide less risk to Mental and Physical Health than the No Action Plan.	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide less risk to Mental and Physical Health than the No Action Plan and Plan C.	Significant threats to Mental and Physical Health from storm surge will still exist, but this plan will provide the least risk to Mental and Physical Health, except for Plan A.
2. Recommendations and Preferences					

Problem Area: Barrier Island Restoration, Hancock, Harrison, and Jackson Counties, Mississippi

Problems ID: Damages suffered by hurricane-induced surge and wave attack; Potential future damages from storm and hurricane events.

Item	No Action	Plan A	Plan C	Plan G	Plan H
a. Federal Recommendation					This Plan has the highest NED benefits, substantial RED benefits, substantial EQ benefits, the greatest achievement of OSE outcomes, does not violate any local, state, or Federal statues, laws, and regulations, and is the most cost effective and efficient recommendation of the Barrier Island component of the Comprehensive Plan
b. Stakeholder Preference					This Plan has the highest stakeholder preference score, and creates a low risk environment.

1

ATTACHMENT 1

Risk-Informed Decision Framework for the Mississippi Coastal ImprovementsProgram (MsCIP)

Prepared for Mobile District, US Army Corps of Engineers

January 2008

Engineer Research and Development Center
U.S. Army Corps of Engineers
Vicksburg, MS

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GLOSSARY

Cluster: A set of data that share a common trait.

Eustatic: Changes in sea-level that are caused by global forces such as climate change.

Isostatic: Changes in sea-level that are caused by local forces such as land subsidence and glacial rebound.

Measure: A component of plans for risk reduction. Categories of risk reduction measures include structural, non-structural and coastal restoration.

Metric: A parameter for quantifying the performance of plans in respect to planning objectives.

Natural variability: The heterogeneity of some attribute in a population.

Plan: Any detailed scheme, program, or method worked out beforehand to accomplish an objective. A plan could incorporate structural, non-structural, and/or coastal restoration measures or combination of measures for risk reduction. Plans emerge from the plan formulation process.

Residual risk: The portion of risk remaining after the recommended plan has been implemented.

Risk: Risk is fully defined by an event probability, a set of factors on which that event probability is conditioned (scenarios), and the consequences of that event.

Uncertainty: A lack of knowledge that originates from an incomplete understanding of the structure and function of natural or manmade systems, the choice of a model to represent those systems, and the choice of the input values for the parameters of the chosen model.

Variance: A measure of statistical dispersion, averaging the squared distance of its possible values from the expected value (mean). Variance captures the mean's scale or degree of being spread out.

EXECUTIVE SUMMARY

This part of the Risk Appendix outlines a Risk-Informed Decision Framework (RIDF) for the Mississippi Coastal Improvements Program (MsCIP) effort. The RIDF provides a robust and comprehensive approach toward identifying plans that the public and agency stakeholders feel best achieve the particular goals and objectives of that population and draws from current practice in the fields of multi-criteria decision analysis (MCDA) and risk/uncertainty analysis. The RIDF is solidly grounded in and follows closely the Corps of Engineers six-step planning process closely, but augments this planning process by incorporating specific techniques and methods from risk analysis and MCDA. There are numerous advantages to this approach.

The RIDF enhances the level of communication and collaboration among decision-makers and stakeholders by providing structured opportunities for interaction. The RIDF uses the information gained through this process to define a set of decision objectives, outcome metrics, and preference weights that reflect stakeholder priorities and provide an analytically sound, defensible, and quantitative approach to decision making. In this way, decision outcomes can more adequately satisfy the interests, values, and objectives germane to the decision. The RIDF also incorporates information about uncertainty into the decision process and facilitates discussion of residual risks, which are the expected damages from storms that will remain after a storm defense is built. Accurate forecasts about the future are difficult, and decisions that ignore these uncertainties may differ from and perform less well than those that do not. Therefore, the RIDF explicitly considers uncertainty originating from two sources including relative sea level rise and the future pattern of development. Information about these uncertainties manifests itself in the outcome metrics and in the scoring and ranking of alternative plans.

The optimality of a prospective decision outcome depends upon values and beliefs that can vary across different stakeholder groups. Since the MsCIP decision process involves a broad spectrum of stakeholders, the RIDF evaluates the sensitivity of the recommendations to these values and beliefs to help decision-makers and stakeholders understand the robustness of recommendations and anticipated outcomes. In this way, the RIDF helps to identify what further studies may be needed and what communication and negotiation efforts could be improved. These efforts also build confidence in the planning process and commitment to the selected plans. We also recognize the role that adaptive management can play in connection with the RIDF as a mechanism for monitoring and maintaining the performance of decisions over longer planning horizons.

1. INTRODUCTION

1.1 Background

This report summarizes the results of a risk-informed decision framework (RIDF) as applied in the Mississippi Coastal Improvements Project (MsCIP) as part of the development of a comprehensive plan to reduce the residual risks from flood and storm surge inundation and coastal wetlands loss and degradation. The intent of the RIDF is to "**develop a decision framework in such a manner as to simply and clearly show to decision makers and the public the risks, costs and consequences of flood control, coastal restoration, and hurricane protection measures...[and] recommendations…will be supported…using the risk informed decision framework.**"

A comprehensive plan addresses a full range of risks to people, environment, property, and economy as well as infrastructure construction, operations, and maintenance costs. Risk is fully defined by an event probability, a set of factors on which that event probability is conditioned (scenarios), and the consequences of that event (Kaplan and Garrick 1981). With respect to flood risk management, residual risk has been defined by the National Research Council (2000) as that risk that remains after a flood damage reduction project is implemented.

This part of the Risk Appendix develops the risk-informed decision framework (RIDF). The RIDF has been developed by the Engineer Research and Development Center (ERDC) to integrate risk and decision science methods into the US Army Corps of Engineers (USACE) planning process while emphasizing consistency with existing USACE planning guidance.

The MsCIP decision process must consider a comprehensive set of planning objectives that include: 1) the reduction of risks to human life, property, and the regional economy; 2) the protection of the region's natural resources, and environmental quality; and 3) the construction, operations, and maintenance costs associated with any particular alternative. In addition to these numerous diverse interests that must be addressed through the planning process, the Mississippi coastal area is a dynamic environment that is rapidly changing in ways that are difficult to predict. Prudent decision makers will therefore take account of the uncertainty regarding economic, environmental, and other conditions that may affect the outcome of a project during the planning horizon.

The MsCIP decision problem is to recommend a comprehensive plan that will reduce the risks of flooding caused by storm surge and coastline degradation while considering a full range of risks to people, environment, property, and economy as well as infrastructure construction, operations, and maintenance costs. The RIDF is responsive to these and other decision support needs of MsCIP for which conventional decision support methods are poorly suited. The RIDF offers a decision approach that accounts for a comprehensive set of coastal assets in Mississippi and acknowledges the presence of a diverse group of stakeholders who exhibit conflicting interests and objectives. The RIDF approach also addresses uncertainty in certain environmental, social, and economic trends over the planning horizon that can affect the desirability of risk reduction strategies.

Conventional approaches to decision making have emphasized cost-benefit analysis, which is suitable only when decision outcomes can be fully monetized. There is now an increasing level of

consideration given to assets that are difficult to quantify in economic terms, such as wildlife habitat and cultural diversity, and tend to confound the application of that approach. Conventional decision methods have also emphasized a single decision objective built around national economic development objectives. However, the MsCIP planning guidance requires an accounting of regional economic development, environmental, and other social effects objectives as well. Therefore, a multi-attribute decision analysis method is needed. In addition to presence of multiple objectives, there is diverse set of stakeholders whose interests must also be taken into account. Conventional approaches to decision making have also tended to ignore uncertainty. By evaluating and communicating uncertainty during the planning process, RIDF helps lead decision makers to more well-reasoned and rational choices. The RIDF attempts to addresses all of the shortcomings of conventional decision approaches in a manner that is consistent with the USACE planning guidelines.

1.2 Overview of the Risk-Informed Decision Framework

1.2.1 RIDF is based on the Corps Planning Process, Outfitted to Incorporate Risk Analysis and Decision Analysis

The Risk-Informed Decision Framework (RIDF) is rooted in the Corps' standard approach to planning, but augments that approach with insights and techniques drawn from the fields of decision and risk analysis. RIDF provides procedures to help decision makers identify planning objectives, performance metrics, and stakeholder priorities.

RIDF draws on multi-criteria decision analysis (MCDA) techniques (specifically, multi-attribute utility theory (MAUT), because plan selection involves multiple, competing objectives denominated in in-commensurate terms. For example, this is the case when some attributes of an objective such as life-cycle infrastructure costs can be expressed in monetary terms and others, such as environmental quality, cannot.

RIDF draws on risk analysis (RA) techniques to characterize and assess the uncertainties that complicate the MsCIP decision. These include uncertainties in the economic and environmental conditions that will influence the outcome of a decision (such as the rate of sea-level rise) as well as the stochastic nature of storm surge events. The objective is to help planners characterize the critical uncertainties most important to the choice among plans and to identify robust risk reduction strategies, which are decision alternatives that perform relatively well across a wide range of future conditions.

1.2.2 Why is RIDF "Risk-Informed?"

RIDF is risk-informed because it:

- accounts for the consequences of low-probability storms including expected property damages, population at risk, and regional economic impacts.

1.2.3 What are the Advantages of RIDF?

The RIDF has several advantages.

- The framework engages stakeholders and decision makers in a process of issue identification and priority setting to formally establish project goals. The process helps decision makers to:
    - Identify and reveal hidden agendas
    - Identify, acknowledge and, when possible, fill data gaps that, if filled, could influence decisions;
- Objectives are expressed in the form of a multi-attribute utility function that:
    - gives objectives that are difficult to monetize the same consideration as monetary objectives, enabling environmental and social decision objectives to receive equal consideration with economic objectives.
    - allows decision makers to make explicit tradeoffs between objectives because progress on one objective can be used to compensate for lack of progress on another objective.

1.3 Scope of Risk Informed Decision Framework

Part 2 of the Risk Appendix provides an overview of the six planning steps in terms of the MsCIP risk-informed decision framework including:

- Introduction, background and scope
- Methods used to implement MCDA and the RIDF
- Detailed descriptions of metrics and scenarios
- Results of rankings and uncertainty
- Discussion
- Tables and figures showing outputs

2. BACKGROUND

2.1 Planning in the USACE – The Six-Step Planning Process

The *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (also known as Principles and Guidelines or P&G) and Engineering Regulation (ER) 1105-2-100, *Guidance for Conducting Civil Works Planning Studies* sets out a six-step planning process:

1. Specify problems and opportunities;
2. Inventory, forecast and analyze conditions relevant to the identified problems and opportunities;
3. Formulate alternative plans;
4. Evaluate the effects of the alternative plans;
5. Compare alternative plans;
6. Recommend a plan from the compared alternatives.

Since publication of the P&G in 1983, U.S. Army Corps of Engineers (USACE) planning and decision-making have been based, primarily, on a comparison of alternatives using economic factors (USACE 2003a). Planners have also been confronted with the challenge to provide for integrated systems that serve multiple objectives (e.g., a coastal system that provides for flood and storm damage reduction, navigation, and ecosystem restoration).

2.2 Changes to the Planning Landscape

In response to a USACE request for a review of P&G planning procedures, the National Research Council (1999) provided recommendations for streamlining planning processes, revising P&G guidelines, analyzing cost-sharing requirements and estimating the effects of risk and uncertainty integration in the planning process. Implementation guidance of the Environmental Operating Principles (EOP) (http://www.hq.usace.army.mil/cepa/envprinciples.htm) within USACE civil works planning directs that projects adhere to a concept of environmental sustainability that is defined as “a synergistic process whereby environmental and economic considerations are effectively balanced through the life of project planning, design, construction, operation and maintenance to improve the quality of life for present and future generations” (USACE 2003a). While adhering to the overall P&G methodology, USACE (2003b) advises project delivery teams to formulate acceptable, combined economic development/ecosystem restoration alternatives through use of multi-criteria/trade-off methods.

2.3 Corps Efforts to Address Planning Needs

Over the last several years, the Corps has been developing approaches and guidance for implementing multi-criteria decision analysis (MCDA) approaches for planning (Yoe, 2002; Linkov et al. 2004; Kiker et. al. 2005). This approach utilizes a comprehensive decision analytic framework that considers a broad array of objectives and criteria/metrics, including those associated with ecosystem restoration (Males, 2002). Guidance contained in *Trade-Off Analysis Planning and Procedures Guidebook (2002)* lays out a multi-criterion decision analytic approach for comparing and deciding between alternative plans and relates the P&G six-step planning process described above to outputs of the RIDF, as depicted in Figure 2-1.

Over the last several years, the Corps has been developing approaches and guidance for implementing multi-criteria decision analysis (MCDA) approaches for planning (Yoe, 2002; Linkov et al. 2004; Kiker et. al. 2005). The challenge has been to select and implement an analytical approach that best serves the Corps' needs and provides outputs that can be incorporated into existing decision-making processes, which is laid out in the Corp's *Trade-Off Analysis Planning and Procedures Guidebook (2002)*. In addition to serving the needs of Corps planning, the decision framework should provide structure and tools for interacting and communicating with partners, stakeholders, and the public about planning and risk. The approach utilizes a comprehensive decision analytic framework that considers a broad array of objectives and criteria/metrics, including those associated with ecosystem restoration (Males, 2002).

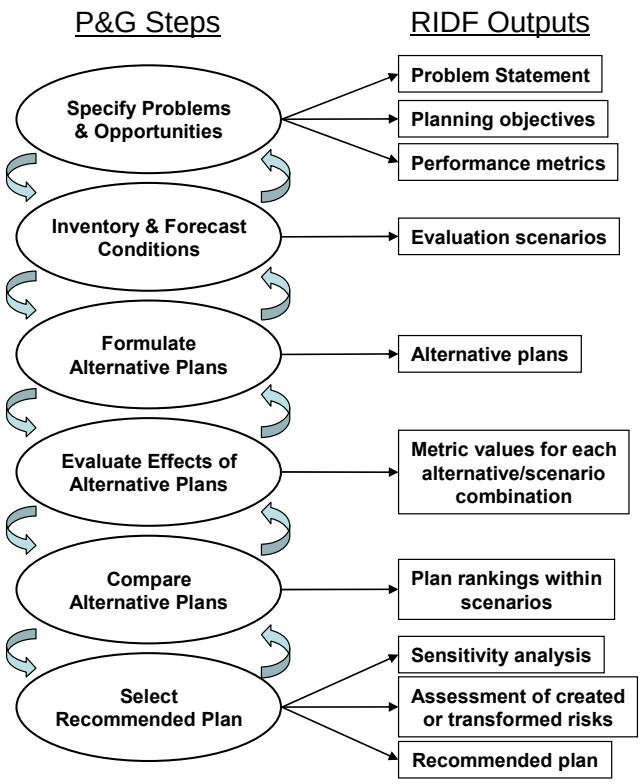


Figure 2-1: The 6 steps of the P&G and resultants outputs of the risk-informed decision framework.

2.4 How is RIDF an Incremental Improvement in Addressing Planning Needs?

Making effective and credible flood and storm damage reduction planning decisions requires an explicit structure for jointly considering the positive/negative impacts and risks, along with associated uncertainties, relevant to the selection of alternative plans. The complexity of flood and storm damage reduction and coastal landscape stabilization in south Mississippi requires integration of multiple models and tools as well as expert judgment. Integrating this heterogeneous and uncertain information demands a systematic and understandable framework to organize complex and often limited technical information and expert judgment.

Having the right combination of ***people*** is the first essential element in the decision process. The activity and involvement levels of three basic groups of people (decision makers, scientists and engineers [e.g., the MsCIP technical team], and stakeholders) are symbolized in Figure 2 by dark lines for direct involvement and dotted lines for less direct involvement. While the actual membership and function of these three groups may overlap or vary, the roles of each are essential in maximizing the utility of human input into the decision process. Each group has its own way of

viewing the world, its own method of envisioning solutions, and its own societal responsibility. Policy- and decision-makers spend most of their effort defining the restoration planning context and the overall constraints on the decision. In addition, they may have responsibility for final plan selection and implementation. Scientists and engineers, including the MsCIP technical team, have the most focused role in that they provide the measurements for metrics that quantify the degree to which the various alternatives satisfy the objectives of the project; while they may take a secondary role as stakeholders or decision-makers, their primary role is to provide the technical input necessary to inform the decision process. Stakeholders contribute the most input in helping formulate performance metrics and making value judgments for weighting the various metrics. Depending on the problem and restoration context, stakeholders may have some responsibility in ranking and selecting the final option.

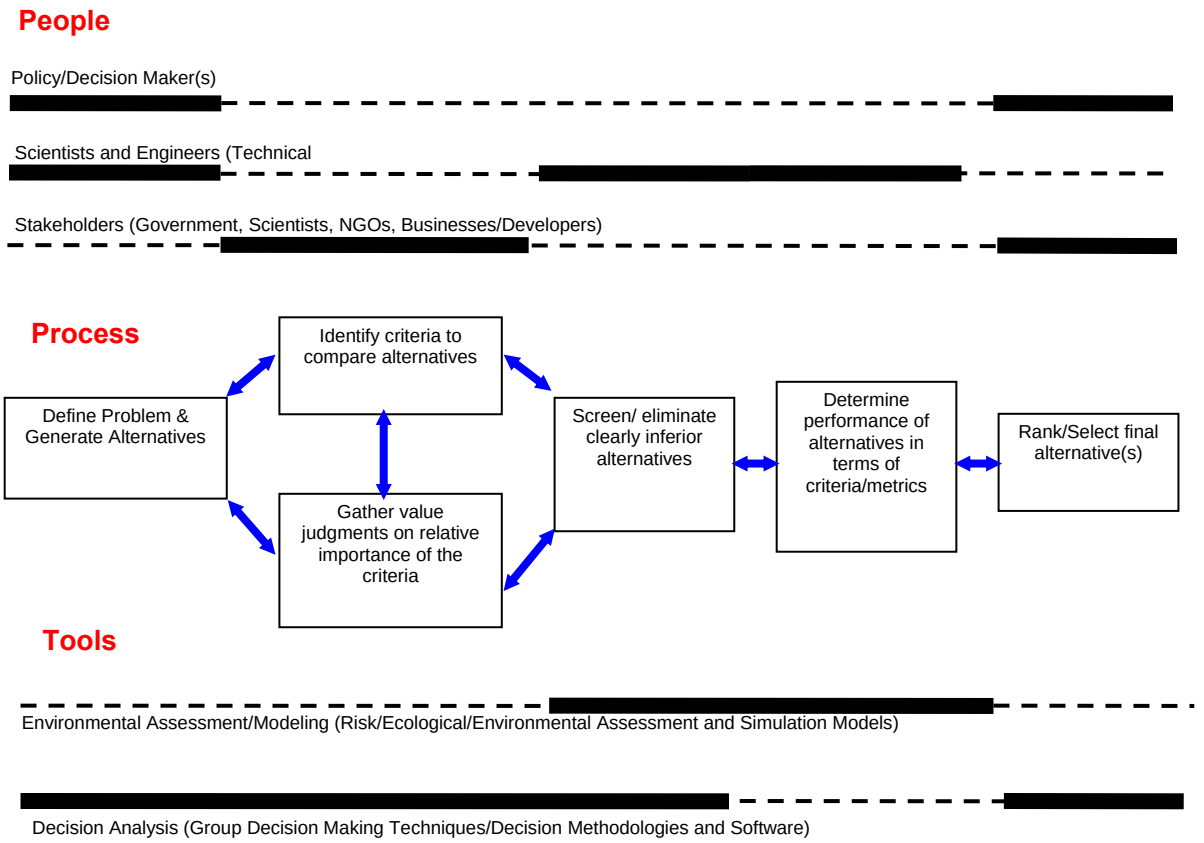


Figure 2-2: Proposed decision process (adapted from Linkov et al. 2004 and Kiker et al. 2005). Dark lines indicate direct involvement / applicability and dotted lines indicate less direct involvement / applicability.

The ***process*** depicted in Figure 2-2 is composed of two major elements: (i) generating alternative restoration scenarios, performance metrics, and value judgments and (ii) ranking the alternatives by applying value weights. The process generates and defines choices, performance levels, and preferences. The process also methodically screens non-feasible alternatives by first applying

screening mechanisms (*e.g.*, excessive cost, performance below minimal levels or unacceptable social consequences) and then evaluating, in detail, the remaining alternative restoration plans through the use of decision criteria/metrics that are parameterized with data from engineering models, experimental data, or expert judgment and then ranking those plans through use of MCDA techniques. MCDA separates out judgments about scaling the relative performance of alternatives using a metric from judgments about weighting those metrics (Clemen, 1995). We discuss scaling and weighting in subsection 3.5.1. While it is reasonable to expect that the process may vary in specific details for different planning projects (i.e., based on project needs), the planning accomplished through use of this framework operates within an overall adaptive management structure whereby learning, accomplished through additional study and monitoring, is being used to ensure that the process is responsive to changes in decision priorities or new knowledge that can affect alternative selection or implementation strategies.

The ***tools*** used within group decision making and scientific research are essential elements of the overall decision process. The applicability of the tools is symbolized in Figure 2-2 by solid lines (direct involvement) and dotted lines (indirect involvement). Decision analysis tools help to generate and map technical data as well as individual judgments into organized structures that can be linked with other technical tools from risk analysis, modeling, monitoring, and cost estimations. Decision analysis tools can also provide useful graphical techniques and visualization methods to express the gathered information in understandable formats. When changes occur in the requirements or the decision process, decision analysis tools can respond efficiently to the new inputs. Flood and storm damage reduction planning requires the use of multiple mechanistic, empirical, and stochastic models, and combinations thereof, for examining flood and storm inundation stage-frequencies to assess the performance of alternatives under several uncertain future conditions. Output from these models has been combined to calculate specific risk factors affecting coastal Mississippi. Finally, decision models incorporated individual risk model predictions and reconciled conflicting priorities expressed by different stakeholder groups through transparent and reproducible valuation protocols. The decision analysis tools were used to compare the alternative plans and conduct sensitivity analysis to assess the robustness in relative performance across future scenarios of the resulting rankings.

The entire process results in a comprehensive, structured process for selecting the optimal alternative in any given situation, drawing from stakeholder preferences and value judgments as well as scientific modeling and risk analysis.

2.5 Adaptive Management

The consequences of Hurricane Katrina have motivated the Corps to examine both its processes and institutional culture. The Corps' must be responsive and reliable, and change will be required to ensure that Corps remains so. Actions for Change were identified that will serve as catalysts for that change (see http://www.hq.usace.army.mil/cepa/releases/News_Release_-_USACE_12_Actions_for_Change.pdf). Key to the successful implementation of these actions is use of integrative and comprehensive systems-based approaches, adaptive planning, stakeholder involvement and risk communication.

3. IMPLEMENTATION OF THE RIDF

The Risk-Informed Decision Framework (RIDF) assists decision makers by condensing the decision process into a transparent and tractable format. RIDF can be described in terms that are closely aligned with the standard Corps approach to planning, but utilizes techniques from the fields of risk and decision analysis to accommodate multiple objectives, conflicting stakeholder values, both qualitative and quantitative assessments of performance, and uncertainty in the natural, social, and economic environment in which decisions will be played out.

As implemented for MsCIP, the RIDF procedure can be summarized as follows. Decision makers and stakeholders establish an objectives hierarchy to fully and uniquely characterize the important outcomes of each decision alternative. A set of outcome measures of performance is then chosen to represent the performance of each alternative in terms of achieving each of the decision objectives. The outcomes of the alternative plans is modeled and, to the extent there are uncertainties present that may significantly affect performance outcomes, this evaluation of plans would be replicated over a set of scenarios that represent a range of possible conditions during the performance phase. Once all of these evaluations are complete, a multi-attribute utility function is developed to assess the overall utility of each plan given its performance in terms of achieving the objectives.

The relationship between the six steps of the Corps planning process and RIDF is illustrated in Figure 2-1. In general, RIDF activities are closely related to the six step Corps planning process as follows:

1. Specify Problems & Opportunities: Frame the decision by developing a problem statement and identifying the spatial and temporal boundaries of analysis. Establish planning objectives and choose outcome measures of performance, or metrics, which reflect progress toward achieving the planning objectives.

2. Inventory and Forecast Conditions: Select models of physical and economic systems or other appropriate tools to simulate decision outcomes in terms of the selected performance metrics. Identify important sources of uncertainty in physical and economic models.

3. Formulate Alternative Plans: Formulate decision alternatives by identifying potential measures for flood risk reduction and environmental restoration, pre-screening infeasible measures, and formulating coast-wide plans from remaining measures.

4. Evaluate Effects of Alternative Plans: Model the outcome measures of performance for each alternative and each scenario.

5. Compare Alternative Plans: Obtain weights on objectives from the decision maker and/or stakeholder groups. Calculate multi-attribute utility and implement the decision analysis for each alternative, each scenario, and each stakeholder group. Screen out plans that are consistently dominated.

6. Select a Recommended Plan: Develop recommendations based on the analysis.

3.1 Step 1: Specify the problem and opportunities

Framing the problem to be solved is often one of the most difficult and critical tasks in the planning process because it forces planners to clarify their objectives. Framing also helps to identify what attributes should be considered in judging decision outcomes and what metrics should be used in assessing progress toward objectives. Framing helps to establish what spatial and temporal scales are needed for modeling decision outcomes. For example, the preferred alternative may change with the spatial resolution chosen for an analysis; therefore, factoring such spatial variation into how the framework is used along the coast should be considered. Similarly, the most preferred decision may vary as a function of the timeframe under consideration: a longer planning timeframe may lead to a preference for alternatives with higher fixed costs and lower operational/maintenance costs.

3.1.1 Problem Statement

Catastrophic impacts of the 2005 Atlantic Tropical Cyclone season in the Gulf of Mexico identified the need for investment in flood and storm damage risk reduction and coastal ecosystem restoration.

Traditional investigation methods were recognized as insufficient to identify plans for action in averting future disasters directly impacting major metropolitan centers, strategic regional national assets, and significant coastal resources located in south Mississippi. A new planning methodology based on risk and uncertainty would be required to augment traditional approaches, addressing direct adverse impacts as well as large indirect adverse effects of coastal disasters in Mississippi on the rest of the United States. A multi-objective, long range, comprehensive system-scale analysis is needed to identify a full range of measures for risk reduction and coastal landscape stabilization in the event of moderate/frequent and severe/rare storms.

The following problem statement was drafted with the above issues in mind: The people, economy, environment, and culture of coastal Mississippi, as well as the Nation, are at risk from severe and catastrophic hurricane storm events as manifested by:

1. Storm impacts to residential, public, and commercial infrastructure.
2. Storm impacts to people's quality of life.
3. Habitats damaged by saltwater intrusion.
4. Storm-caused erosion of coastal shoreline.
5. Degradation of fish and wildlife habitats that support an array of commercial and recreational activities coast wide.

The risks associated with the problem can rarely be eliminated or entirely prevented. Thus, residual risk remains and must be considered. The nature of the risks to the planning area is identified in the problem statement.

3.1.2 Planning Objectives

The purpose of this section is to delineate the objectives appropriate to a sound solution to the MsCIP decision problem that can be readily articulated to an array of audiences.

As a group, a good set of planning objectives must be collectively exhaustive. That is, nothing that really matters can be left out. However, and again with an eye to simplification, the list must be limited to only the ones that really do matter. A hierarchical arrangement of objectives (e.g., a principal objective branching to a tier or two of sub objectives) is often useful for structuring a complex decision. Each objective should be specific and succinct (Keeney and Raffia 1976). An objective must be unambiguous yet still succinctly stated, as brevity helps communication and clarifies thinking. Each objective must be amenable to measurement using one or a few metrics so that predictions can be quantified and performance ultimately can be assessed. Simultaneously, objectives must be realistically achievable and relevant. Finally, there must be concordance with practical time frames (Hobbs and Meier 2000). In other words, predictions must be possible within the planning time frame or monitoring of performance must be possible within a useful time frame.

The planning objectives for MsCIP are:

- Reduce risk to public health and safety from catastrophic storm inundation;
- Reduce storm damages to infrastructure from catastrophic storm inundation;
- Restore and protect upland and tidal wetland habitats, and;
- Reduce residual risk from catastrophic storm damage.

The objectives identified in the preceding paragraph were organized within the RIDF framework using the USACE P&G System of Accounts (Yoe and Orth 1996), which guides an evaluation of the effects of a project with respect to National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). Establishing the system of accounts 1) shows all effects important to decision-making, 2) explicitly shows the NED effects as the basis for establishing the economic feasibility of the plan, 3) offers a rational, organized framework for presenting the results of the MsCIP analysis, and 4) provides a means for comparing plan effects. The plans' effects presented in the system of accounts relate to the plans' contributions toward planning objectives. The effects of the plans are arranged such that the differences among the plans are easily discerned.

In recent history, USACE planners have been guided to select the NED plan (the one maximizing national economic development benefits) as the preferred alternative, while still meeting National Environmental Policy Act requirements. The Mobile District has received slightly different and more flexible guidance for the critical MsCIP project. Namely, choice is not constrained to an NED plan but rather more broadly to a cost-effective plan that best meets objectives across the NED, RED, EQ, and OSE accounts. Metrics proposed in the subsequent section for evaluating project effects in MsCIP are categorized according to these four accounts.

3.1.3 Outcome Metrics of Performance

Metrics to be used to guide the MsCIP evaluation are presented in Table 1A-1E. These metrics were used to score and then rank flood and storm damage reduction and environmental restoration measures and plans. In selecting this set of metrics, we strove to represent the best available information for evaluating alternatives in the MsCIP, keeping in mind the characteristics of effective metrics (see Roy, 1985; Seager et al. 2007, Graedel and Allenby 2002, Seager and Theis 2004; Yoe 2002). Effective metrics are:

- **Comprehensive and complete:** The metric set should capture the entire range of the decision maker's priorities. No relevant priorities should be unaccounted-for.
- **Preferentially independent:** Changes in one attribute or metric should not affect the decision maker's preferences for another attribute or metric.
- **Verifiable:** Two independent assessments yield similar results.
- **Cost-effective**: Evaluation of the metrics should be not require an intensive deployment of resources or unavailable technology.
- **Easy to communicate to a wide audience**: The public understands the scale and context of the metric and can interpret the metric with little additional explanation.
- **Changeable by human intervention**. The metric has a causal relationship between the state of the system and the variables that are under the decision-maker's control. Metrics that are independent of human action do not inform a management, policy-making, or design process.
- **Credible**: Stakeholders perceive that the metric accurately measures that which it is intended to measure.
- **Appropriate scale:** The metric is applicable at the spatial and temporal scales chosen for analysis.
- **Directed**: Metric scales whether they are qualitative or quantitative, are bi-directional polar scales,
- **Relevant**: The metric reflects stakeholder priorities and enhances the ability of managers and regulators to faithfully execute their stewardship responsibilities. There is no point assembling a metric no one cares about.
- **Sensitive:** enough to capture the minimum meaningful level of change or make the smallest distinctions that are still significant, and it would have uncertainty bounds that are easy to communicate.
- **Minimally redundant:** A smaller metric set is preferred to a larger metric set to avoid interactions or correlations with other metrics.
- **Transparent:** The metric should not be designed to serve a "hidden agenda."

It is important to acknowledge here that there will be "conflicts" among metrics, resulting in the need to make tradeoffs. For example, a tradeoff exists between achieving any significant benefit from a project and minimizing cost. The tradeoff concept is discussed in Step 5. As a consequence of such "conflicts", a given measure or alternative may not take clear precedence over other measures or alternatives in respect to every metric for evaluating performance. This may present a dilemma to decision-makers, who are trying to choose a single measure. It is important to place development of metrics prior to the development of measures because the "hard thinking" that goes into developing the metrics can create an improved set of measures; this in turn permits stakeholders to focus on thinking about the objectives rather than anchoring themselves to favored measures (Keeney and Raiffa 1976).

In the following sections and in Tables 3-1A thru 3-1E the metrics for the MsCIP are listed and described.

3.1.3.1 Environmental Quality (EQ) Metrics

Table 3-1A.
MsCIP Objectives and Metrics for Environmental Quality

Plan Performance Objectives for Risk Reduction		Metrics	(Units)	Description	Data Source
Environmental Quality	Restore and protect tidal and non-tidal habitats.	Tidal Habitat Restored	Functional units	This metric measures positive changes to the tidally-influenced wetlands that result from the implementation of a measure or plan.	Models
		Tidal Habitat Lost	Functional units	This metric measures adverse impacts to the tidally-influenced wetlands that result from the implementation of a measure or plan.	Models
		Non-tidal Habitat Restored	Functional units	This metric measures positive changes to the non-tidal ecosystem that result from the implementation of a measure or plan.	Models
		Non-tidal Habitat Lost	Functional units	This metric measures adverse impacts to the non-tidal ecosystem that result from the implementation of a measure or plan.	Models

1. Tidal Habitat Restored - This metric measures positive changes to the tidally-influenced wetlands that result from the implementation of a measure or plan. These are positive benefits from implementing a restoration plan or a combination of plans. Ecosystem components included in this metric are tidal wetlands (i.e., tidal fringes), associated threatened and endangered and other species associated with essential fish and other tidal habitats, and related losses that require mitigation due from implementation of structural plans. Units are in acres.

2. Tidal Habitat Lost - This metric measures adverse impacts to the tidally-influenced wetlands that result from the implementation of a measure or plan. Ecosystem components included in this metric are tidal wetlands (i.e., tidal fringes), associated threatened and endangered and other species associated with essential fish and other tidal habitats, and related losses that require mitigation from the implementation of structural plans. Units are in acres.

3. Non-tidal Habitat Restored - This metric measures positive changes to the non-tidal ecosystem that result from the implementation of a measure or plan. These are positive benefits from implementing a restoration plan or a combination of plans. Ecosystem components included in this metric are maritime forests, wetland pine savannah, beach and dune habitats, and associated threatened, endangered and other species in non-tidal habitats. Units for this metric are the percentage increase of quality fish and wildlife habitat in acres.

4. Non-tidal Habitat Lost- This metric measures adverse impacts to the non-tidal ecosystem that results from the implementation of a measure or plan. This has a negative impact of implementation of an array of alternatives as part of the comprehensive plan. Ecosystem components included in this metric are maritime forests, wetland pine savannah, beach and dunes, threatened, endangered and other species and their non-tidal habitats, and related losses that require mitigation due to implementation of structural plans. Units for this metric are the percentage decrease of quality fish and wildlife habitat in acres.

3.1.3.2 National Economic Development (NED) Metrics

Table 3-1B.
MsCIP Objectives and Metrics for National Economic Development

Plan Performance Objectives for Risk Reduction		Metrics	(Units)	Description	Data Source
National Economic Development	Reduce damages from catastrophic storm inundation.	Expected Annual Damages Avoided	$	The amount of storm damages reduced/avoided by a plan expressed as annualized dollars. Annualized dollars are calculated by comparing a future without a project in place versus a future with a project in place.	HEC-FDA Model
		Residual Damage	$	This metric describes what a plan does not account for (or what happens if a plan is exceeded). Residual damage is defined as the storm damage that is not prevented with the implemented plan in place (expressed as annualized dollars).	Model
		Cost of Implementation	$	The amount of money in dollars needed to implement the plan. This metric measures the cost in today's dollars to local and Federal governments to implement the recommended plan.	Empirical Data

1. Expected Annual Damages Avoided - The amount of storm damages reduced/avoided by a plan expressed as annualized dollars. Annualized dollars are calculated by comparing a future without a project in place versus a future with a project in place.

2. Residual Damage – This metric describes what a plan does not account for (or what happens if a plan is exceeded). Residual damage is defined as the storm damage that is not prevented with the implemented plan in place (expressed as annualized dollars).

3. Cost to Implement Plan – The amount of money in dollars needed to implement the plan. This metric measures the cost in today's dollars to local and Federal governments to implement the recommended plan.

3.1.3.3 Other Social Effects (OSE) Metrics

These OSE metrics focus on the preservation of people's quality of life. OSE metrics were developed addressing impacts to cultural heritage and preservation of historical structures, disruptions to public service and infrastructure and impacts to personal effects.

Table 3-1C.
MsCIP Objectives and Metrics for Other Social Effects

Plan Performance Objectives for Risk Reduction		Metrics	(Units)	Description	Data Source
Other Social Effects	Protect public health and safety from catastrophic storm inundation.	Cultural and Historical Heritage Impacts	Unitless	This metric addresses impacts to social groups, church congregations and groups with common heritages. This metric also includes impacts to aesthetics and the destruction of the human-created landscape such as historical structures.	Expert Judgment
		Public Service and Infrastructure Disruptions	Unitless	This metric includes post-flood event disruptions to schools, fire and police service, access to hospitals, libraries and community centers, and use of roads, bridges, and utilities.	Expert Judgment
		Personal Impacts	Unitless	This metric includes loss of family possessions, photographs, and impacts to people's emotional and mental health.	Expert Judgment

1. Cultural and historical heritage impacts – This metric addresses impacts to social groups, church congregations and groups with common heritages. This metric also includes impacts to aesthetics and the destruction of the human-created landscape such as historical structures. Units are a unitless quantitative scale where a score of 10 is best, 1 is worst. (i.e., 10 is least impacts to structures, 1 is most impacts).

2. Public service and infrastructure disruptions – This metric includes post-flood event disruptions to schools, fire and police service, access to hospitals, libraries and community centers, and use of roads, bridges, and utilities. Units are a unitless quantitative scale where a score of 10 is best, 1 is worst (i.e., 10 is least disruption, 1 is most disruption).

3. Personal impacts – This metric includes loss of family possessions, photographs, and impacts to people's emotional and mental health. Units are a unitless quantitative scale where a score of 10 is best, 1 is worst. (i.e., 10 is least impacts to people, 1 is most impacts).

3.1.3.4 Regional Economic Development (RED) Metrics

The RED metrics measure both positive and negative impacts to the regional economy. Positive impacts are captured by impacts to sales volume, personal income and employment and negative impacts by local cost burdens. Sales volume, income and employment will be sub-metrics under RED, and will be equally weighted. This metric is termed Positive regional economic benefits and will combine these 3 sub-metrics. The local cost burdens metric is also a sub-metric under RED and will receive a weight equal to combined weighting of the positive metrics under regional economic benefits.

Table 3-1D.
MsCIP Objectives and Metrics Regional Economic Development

Plan Performance Objectives for Risk Reduction		Metrics	(Units)	Description	Data Source
Regional Economic Development	Reduce damages from catastrophic storm inundation.	Local Cost Burden	Unitless	This metric assesses the costs that will be born locally. This includes the local cost-share with the Federal government to implement the alternative and local costs for ongoing operations and maintenance (O&M) related to the alternative. It also accounts economic impacts on the gross sales volume, personal income, and number of individuals employed in the workforce. These measures are incorporated into unitless scale.	Model/Expert Judgment
		Positive Regional Economic Benefits	Unitless	Economic benefits to the region with regards to sales volume, income and employment. This metric assesses the potential impacts of sales volume change and personal income in dollars and regional employment change in number of jobs to the local economy.	Expert Judgment

1. Local Cost Burdens – This metric represents costs born locally. This includes cost-sharing with the Federal government to implement the recommended plan and local costs for ongoing operations and maintenance (O&M) related to the implemented plan. The local cost burdens may include costs associated with maintenance workers needed to maintain infrastructure of the recommended plan. Units are a unitless quantitative scale where a score of 10 is best, 1 is worst.

2. Positive regional economic benefits – Economic benefits to the region with regards to sales volume, income and employment. This metric assesses the potential impacts of sales volume change and personal income in dollars and regional employment change in number of jobs to the local economy. Units are a unitless quantitative scale where a score of 10 is best, 1 is worst.

3.1.3.5 Comprehensive Risk Metrics

The following risk metrics serve as additional information to decision makers. They are a way to address extreme cases of uncertainty.

Table 3-1E.
MsCIP Objectives and Metrics for Comprehensive Risk

Plan Performance Objectives for Risk Reduction		Metrics	(Units)	Description	Data Source
Comprehensive Risk	Reduce plan risk.	Long-term Sustainability of Plan	Unitless	The risk that features associated with the recommended plan will not perform as intended (over time) due to factors such as cost, human behavior, technical level of maintenance required, political concerns, resource availability, local funding per year, and operational reliability.	Expert Judgment
		Residual Risk	Unitless	This metric describes what a plan does not account for (or what happens if a plan is exceeded). Residual risk is defined as the storm damage risk that remains with the implemented plan in place (expressed as annualized dollars).	Empirical Data/Expert Judgment
		Consequences of Plan Failing	Unitless	This metric describes what happens if a plan does not work as intended. It describes consequences to humans and the environment due to a catastrophic failure of an implemented plan under design conditions or other sets of circumstances from a storm event.	Expert Judgment

1. Long-term Sustainability of Plan – The risk that features associated with the recommended plan will not perform as intended (over time) due to factors such as cost, human behavior, technical level of maintenance required, political concerns, resource availability, local funding per year, and operational reliability. Units are a unitless quantitative scale where a score of 10 is best, 1 is worst (i.e., 10 is least risk, 1 is most risk).

2. Residual Risk – This metric describes what a plan does not account for (or what happens if a plan is exceeded). Residual risk is defined as the storm damage risk that remains with the implemented plan in place (expressed as annualized dollars). It accounts for the following factors: erosion, wildlife species, wildlife habitat, salt water intrusion, surge damages, drainage, wind, maximum probable intensity (MPI) plan (accounts for more intense storm), cultural heritage, and infrastructure. Units are a unitless quantitative scale where a score of 10 is best, 1 is worst.

3. Consequences of Plan Failing – This metric describes what happens if a plan does not work as intended. In other words, it describes consequences to humans and the environment due to a catastrophic failure of an implemented plan under design conditions or other sets of circumstances from a storm event. The greatest risk is risk of failure to structural measures, such as levees, flood gates, etc. Consequences and likelihood of failure vary depending on the line of defense. For example, risk of Line 2 failure is more likely, but consequences are relatively low; risk of Line 4 failure is highly unlikely, but consequences are very high. It includes the following factors: injuries to population, loss of infrastructure, loss of habitat, and loss of wildlife species. Units are a unitless quantitative scale where a score of 10 is best, 1 is worst.

3.2. Step 2: Inventory and Forecast to Establish Baseline Conditions

In this step of the planning process, models and tools are selected to simulate decision outcomes in terms of the selected performance metrics. There is often uncertainty in projecting decision outcomes and, when planning horizons are long, a considerable amount of uncertainty may be unavoidable. Nominal forecasts of decision outcomes, those forecasts made assuming baseline conditions or "business as usual" conditions, should therefore be qualified by considering what implications uncertainty in these assumptions may have for the decision recommendations. Uncertainty is a lack of knowledge that originates from an incomplete understanding of the structure and function of natural or manmade systems (*e.g.*, coastal hydraulics at the mouth of the Mississippi).[1] Uncertainty is often classified as either model uncertainty or parameter uncertainty. Model uncertainty is a lack of knowledge about the proper structure of a model (*e.g.*, choice of a two vs. a three dimensional model to simulate hydrodynamics). Parameter uncertainty is the lack of knowledge about the best value to use as an input parameter value for the chosen model.

One of the advantages of decision analysis is its ability to assist decision makers to make rational decisions in the face of uncertainty. A full uncertainty analysis of the decision would culminate in a probability distribution over the utility of decision outcomes. However, considerable effort may be needed to reach such a conclusion. Often, a sensitivity analysis that considers how the decision recommendations might change under different assumptions may be adequate. Neither sensitivity nor uncertainty analysis of this decision were undertaken for MsCIP at this point.

1 Although the mathematics used to describe variability and uncertainty is essentially similar, uncertainty is widely recognized as being distinct from natural variability. Variability describes the heterogeneity in an inherently random value. For example, the heterogeneity of some size attribute within a population. This variability is, in principle, not reducible (Morgan and Henrion 1990). In contrast, uncertainty can be thought of as a lack of knowledge about what parameter value to use in a model or how to represent a process in a mechanistic model. This lack of knowledge might in principle be reduced, although reducing some uncertainties can often be difficult in practice.

3.3 Step 3: Formulate alternative plans

3.3.1 Plan Formulation

Plan formulation is the process of building plans that meet planning objectives and avoid planning constraints. It requires the knowledge, experience, and judgments from many professional disciplines, as well as the views of stakeholders, other agencies and non-governmental organizations (NGOs), and the public. Plan formulation capitalizes on imagination and creativity wherever it is found, across technical backgrounds and group affiliations. Formulating plans includes developing management measures (e.g., structural and non-structural), identifying planning units, conducting screening of measures, and combining measures into alternative plans. Plans include abilities to be modified into the future within the adaptive management framework. For more details on the formulation of plans and planning units for MsCIP, refer to the Main Report.

3.4 Step 4: Evaluate effects of alternative plans

Once the plans have been formulated, the performance of each plan with respect to each metric is estimated for each decision alternative and scenario. The SAM Technical Team accomplished this step using mechanistic or empirical models of physical, economic, and social systems where available and expert judgment where such models were not available. Sources of metric data are presented in Tables 3-1A thru 3-1E.

3.5 Step 5: Compare alternative plans

In this step, the objective is to rank the decision alternatives (plans) using an abstract utility measure that integrates information about anticipated performance outcomes and stakeholder interests. The MCDA approach used for MsCIP is multi-attribute utility theory (MAUT) (Keeney and Raiffa 1976). With respect to its applications in MCDA, the advantage of MAUT is that it converts a multi-objective decision with competing objectives to a single objective problem for which the objective is to maximize utility given information about the decision maker's preferences. The purpose of this section is to provide an overview of the approach. Sub-section 3.5.1 describes how information on stakeholder preferences is brought into the decision making process. Sub-section 3.5.2 describes the calculation of a multi-attribute utility score, the ranking of decision alternatives, and decision analysis. Sub-section 3.5.3 describes how sensitivity and uncertainty analysis can be used in conjunction with MCDA specifically to support risk-informed decision making. Specific details about this application of RIDF are provided in Section 4.0.

3.5.1 Stakeholder Preferences

The first step toward developing a multi-attribute utility function is to collect information on stakeholder preferences by finding out how much importance stakeholders place on the various decision objectives. Information about stakeholder preferences is obtained through workshops during which stakeholders participate in a series of assessments designed to obtain information on their preferences. These preferences are expressed as relative weights on decision objectives. These weights are subsequently incorporated into a multi-attribute utility function that is then used to

calculate the utility score by which decision alternatives are ranked. This process gives stakeholders an active role in the decision making process because, if stakeholder weights are used in the utility function, the ranking of plans is then tied directly to their preferences.

Since stakeholders can exhibit a diverse set of preference patterns, it is important to consider how this diversity of preference will be treated in the decision analysis. If there are many stakeholders, their sheer number may make it very difficult to consider each ones preferences individually. In addition, there would be much redundancy in such an approach because most stakeholders appear to have some recognizable preference patterns. On the other hand, aggregating stakeholders into a single group and averaging their weights to represent an amalgamated public interest is also not a good strategy, particularly if diverse values have been expressed in the stakeholder population. An averaged set of weights would tend to converge on an equal distribution of weights across the decision objectives and/or a set of weights that is not likely to represent anybody's interests in particular.

The approach used in this analysis is to analyze the sets of weights obtained from individual stakeholders and then classify them based on their expressions of common preference patterns. For classification purposes, we rely on a set of multivariate statistical techniques known as cluster analysis to identify distinct preference patterns that exist within the stakeholder population. Once stakeholders have been segregated based on their preferences, the patterns of preference that are characteristic of each group can be represented by averaging their weights on decision objectives. At this time, no particular consideration is given to the prevalence of each preference pattern in the MsCIP project area. The primary concern is to understand what patterns of preference exist in the project area and what affect these different patterns of preference might have on the choice of a risk-reduction plan.

3.5.2 Multi-attribute Utility and MCDA

The multi-attribute utility function transforms the metrics for the several objectives to a single, aggregate measure of utility. The utility function is compensatory in the sense that it allows progress on one objective to substitute for lack of progress on another objective. The rate of compensation depends upon the relative weight on each objective, which depends upon the preferences of the decision maker. Multi-attribute utility (*U*) is the weighted sum of *L* outcome measures of performance,

$$V(m_{jkl}) : U_{jk} = \sum_{l} w_l V(m_{jkl}) .$$

Outcome measures of performance are evaluated through modeling studies for

$$j = \{1,2,3,..., J\}$$

decision alternatives and

$$k = \{1,2,3,..., K\}$$

planning scenarios. Planning scenarios represent the range of possible futures under which plan performance may be realized. A set of weights (*w*) that reflects the relative importance of each decision objective is elicited from the decision maker and/or stakeholders using a direct weighting

procedure (see Section 3.5.1). Weights may take any value between zero and one, but must sum exactly to one. Value scores are then calculated from a linear utility function for each metric,

$$V(m_{jkl}),$$

that is either increasing or decreasing with that metric, m_{jkl}. For an economic "good" (*i.e.*, more is better):

$$V(m_{jkl}) = \frac{m_{jkl} - \underset{jk}{MIN}(m_{jkl})}{\underset{jk}{MAX}(m_{jkl}) - \underset{jk}{MIN}(m_{jkl})}$$

and for an economic "bad":

$$V(m_{jkl}) = 1 - \frac{m_{jkl} - \underset{jk}{MIN}(m_{jkl})}{\underset{jk}{MAX}(m_{jkl}) - \underset{jk}{MIN}(m_{jkl})},$$

where the *MIN* and *MAX* functions are over all decision alternatives and scenarios. Each scenario is represented by a set of possible values for uncertain variables in hydrologic and economic models used to simulate outcome measures of performance. Value and utility scores, which are bounded by 0 and 1 so that scores closer to 0 indicate less desirable outcomes, are calculated for the outcome of each alternative and scenario, including a "No Action" alternative.

In MCDA without uncertainty, the objective is to maximize the multi-attribute utility function for a set of stakeholder preferences by choosing the "best" decision alternative. Results of the analysis can also be presented more comprehensively by ranking the alternatives by their utility score. This is useful because much can be learned about the alternatives themselves by observing how the utility score varies from one alternative to another. For example, it is possible that some alternatives may yield as much utility as the preferred alternative, but do so because they accentuate performance on a different set of objectives. Just as results of a decision analysis are conditioned on the assumptions used to simulate performance outcomes, the results of the decision analysis and plan rankings also depend in part upon what set of stakeholder weights are used in the multi-attribute utility function. Thus, it is also useful to examine the sensitivity of plan rankings to the weights on decision objectives. If plan rankings are not sensitive to the weights, this may suggest that the alternative may have a broad base of support among stakeholders.

3.6 Step 6: Select recommended plan

Analysis of the project selection decision using the risk-informed decision process should provide a basis for recommending a risk-reduction plan for each planning unit. This recommendation will be based on all of the information assembled during the planning process including information on stakeholder preferences, performance outcomes, and both risk and uncertainty. An advantage of the RIDF is that the process of plan selection is a transparent and rational one. Decision makers should be able to rely on the results of RIDF analysis as long as all of the factors, issues, and concerns of relevance have been accounted for among the decision objectives. Care should be taken to minimize the number of factors germane to a decision that remain outside the formal

scoring and ranking process. In other words, the decision model implemented using MAUT should include as many of the concerns, objectives, and factors that are relevant to decision-making as possible. Given the large number of parties relevant to the decisions under consideration (The Corps, other Federal agencies, Congress, state, counties, cities, stakeholders, the public), great care must be taken to ensure that the planning process is comprehensive in its approach to the interests and values of these parties.

4. APPLICATION OF RIDF TO MSCIP PROJECT SELECTION

4.1 Stakeholder Workshops Activities Summary

The purpose of the weight elicitation workshop held on 10-11 September 2007 was to develop a transparent process to provide decision makers with key stakeholder group perspectives (traditional process used mainly NED and RED criteria to select a plan). We wanted to capture stakeholder value information that guides the ranking of plans and recommendations. We also wanted to document differences among stakeholders so that we can identify consensus areas and potential compromises. This makes it easier to find common ground in selecting a plan. We documented these differences by comparing the performance of different plans by looking at different metrics for each plan. A common set of metrics was used to facilitate negotiation. Stakeholders were actively engaged in weighting the metrics during the workshop.

The workshop involved using questionnaires (survey instruments) to elicit weights of individuals from key stakeholder groups. The objective of the workshop was to conduct sessions with key stakeholders where their weights were elicited and their weight judgments summarized. Both the direct score and swing weight methods were used to elicit these weights. The workshop was held in Biloxi, MS at the Mississippi Department of Marine Resources building, Room 205.

Stakeholder groups were selected for participation in this effort based on their participation in previous MsCIP stakeholder meetings. These groups and individuals were selected by the MsCIP team in advance to ensure diversity of opinions. Key stakeholder groups included individuals from government (Federal, state, and local), non-governmental organizations (NGOs), and individuals representing various environmental, business, development, and academic institutions. The Corps (MsCIP technical team and the ERDC) also submitted weights.

To kick off the stakeholder session, the MsCIP technical team and ERDC described the background and purpose of the workshop and answered questions or concerns that arose. We discussed the metric set, its importance and clarified metric definitions as appropriate. We also described through specific hypothetical examples the swing weight process and how stakeholder weights will be generated using this method. Draft data for the set of 15 metrics were included in the matrix. Weights were obtained for the final set of 15 metrics (see Tables 4-1). We elicited and received input from each of the stakeholder groups on the metric set and its completeness.

A series of “polls” were conducted. In the first of these, participants were asked to provide an ordinal ranking of the 15 individual metrics from most to least important, where each participant was asked

to “wear the hat” of their job within their organization. The results were shared and discussed briefly. Next, the stakeholders were asked to allocate points to each metric, thus providing finer distinction of the relative importance of metrics. Allocation was done with three rules. First, no individual metric could be given more than 70 points. Second, 100 points was available for the sum total of points given to all metrics. Third, all 100 points must be used. The same process was used of first ranking and then allocating points to the “categorical” metrics (NED, RED, OSE, and EQ). Thus, each of the stakeholder sessions progressed according to the following weight elicitation activities:

- Round 1: ranks were obtained for the list of 15 metrics.
- Round 2: rate (allocate) 15 metrics using 0-100 scale.
- Round 3: rank 15 metrics from 1-15.
- Round 4: rate (allocate) these metrics using 0-100 scale.

An intranet-based system was used to gather weight data from participants. Each participant accessed a dedicated PC to rank metrics. These results were compiled real-time and shared with the group so that weights could be discussed.

The RIDF and SAM Technical Team members attended to answer technical questions that arose and to document the process. Group Solutions, a Corps contractor, facilitated each session and electronically elicited the weights from each of the stakeholder groups. Group Solutions compiled the resultant weights and submitted all results electronically to ERDC for analysis and reporting.

Following the workshops, input values for metrics were combined with information about values and weighting functions for the various metrics to generate an overall score for each plan being considered. These scores will allow for direct comparisons to be made across all measures/plans and to rank plans in relation to each other in terms of the degree to which they satisfy the objectives the MsCIP metrics represent. Such scores can be used to evaluate measures or plans against the without project condition, as well as to compare the performance of individual measures or plans (see more detailed discussion below).

Session Participants and Organizations

Tables A1-1 to A1-6 in Annex 1 list in alphabetical order the people (and corresponding affiliation) who participated in the MsCIP stakeholder sessions. Some of those listed in the tables collaborated while others started but did not complete the weighting process.

4.2 Stakeholder Weightings

The MsCIP weight elicitation sessions yielded 45 complete sets of weights on fifteen metrics. We used a cluster analysis, an exploratory data reduction technique, to classify stakeholders with similar preference patterns expressed through their allocation of weights to metrics. These results enable us to identify and characterize patterns of preferences that exist in the project area.

Several different clustering techniques are available and applications of these methods would lead to alternative cluster solutions. The standard for evaluating solutions is whether or not the resulting solutions can be explained and are meaningful in the context of their purpose. In this case, the

objective of the analysis is to identify and document the existence of distinct patterns of preferences within the subject population and characterize preference patterns. Characteristic preference patterns are then used to analyze the sensitivity of the decision to stakeholder preferences. This enables the sensitivity analysis to focus only on those preference patterns that have been observed, while excluding from the analysis those that have not been observed. The data reduction also eliminates the duplication of effort associated with carrying out sensitivity analysis for preference patterns that are essentially similar.

A number of clustering techniques were tested to evaluate the sensitivity of clusters to the choice of clustering method. The selected method employs a hierarchical agglomerative clustering technique called Ward's minimum variance method. In this method, an initial cluster of two individuals is formed by considering all possible clusters of size two and combining those individuals that produce the least impairment in an objective function. In the subsequent stage, all possible combinations of two individuals and all possible combinations of three individuals that include the initial cluster are formed and the cluster that results in least impairment of the objective function is accepted. At each level of the hierarchy, the objective function is minimized over all partitions of the data (Dillon and Goldstein 1984, SAS 2004). Although slightly different methods might produce clusters consisting of somewhat different individuals, we found that different methods identified a set of clusters that differed in similar ways.

Clusters were tested using two versions of the weight data. We used the raw weights that were allocated through direct weight elicitation to the fifteen metrics and we also used an aggregate weight statistic in which the fifteen metrics were aggregated into four metrics that correspond to the USACE system of accounts. Aggregate weights by planning objective are the sum of weights allocated to individual metrics associated with National Economic Objectives (NED), Regional Economic Objectives (RED), Environmental Objectives (EQ), and Other Social Effects (OSE). When the weights are aggregated this way, the data have fewer dimensions and the clusters are more clearly delineated. For this analysis, the comprehensive risk metrics that were identified in Section 3.1.3.5 were subsumed into one of the system of accounts. Long-term sustainability (Metric 13) and consequences of plan failing (Metric 14) are subsumed into the RED account. Residual risk (Metric 15) was subsumed into the NED account.

4.2.1 Analysis of Stakeholder Weights

The MsCIP weight elicitation sessions yielded 45 complete sets of stakeholder weights on the set of fifteen metrics (Annex 2). Four clusters emerged from the weight elicitation results. Mean weights are summarized in Table 4-1 for each metric and in Table 4-2 for each aggregation of weights by planning objective. The smallest cluster, D, contains six individuals and the largest cluster, B, contains 15 individuals. The formation of each cluster explains at least five percent of the variation in respondent's allocation of weights to the aggregate planning objectives. Five respondents were classified as outliers and therefore are not included in any particular cluster. Figure 4-1 shows the mean weight for each aggregate planning objective and each cluster. This graph can be used to help develop explanations for why the different clusters emerged. For example, group A places the highest weight on RED and Group D places the highest weight on EQ.

Table 4-1.
Mean Weight for each Metric by Cluster

Metric Description			Cluster			
		Category	A	B	C	D
1	Tidal Habitat Restored	EQ	0.02	0.07	0.12	0.21
2	Tidal Habitat Lost	EQ	0.02	0.09	0.17	0.18
3	Non-Tidal Habitat Restored	EQ	0.02	0.05	0.09	0.13
4	Non Tidal Habitat Lost	EQ	0.02	0.06	0.12	0.18
5	Damage Reduced/Avoided	NED	0.14	0.11	0.05	0.04
6	Residual Damages	NED	0.06	0.07	0.03	0.04
7	Cost to Implement Plan	NED	0.10	0.09	0.06	0.02
8	Local Cost Burden	RED	0.12	0.07	0.05	0.02
9	Regional Economic Benefits	RED	0.08	0.06	0.03	0.02
10	Cultural and Historical Heritage	OSE	0.05	0.04	0.05	0.02
11	Public Service Disruptions	OSE	0.08	0.06	0.04	0.02
12	Personal Impacts	OSE	0.05	0.05	0.03	0.02
13	Long-Term Sustainability	RED	0.13	0.08	0.09	0.05
14	Consequences of Plan Failure	RED	0.08	0.07	0.06	0.03
15	Residual Risk	NED	0.04	0.06	0.02	0.03

Table 4-2.
Mean Weight for each Aggregate Planning Objective by Cluster

Cluster	Respondents (Number)	Aggregate Planning Objective			
		NED	RED	EQ	OSE
A	9	0.34	0.42	0.07	0.17
B	15	0.32	0.27	0.27	0.15
C	10	0.17	0.24	0.48	0.12
D	6	0.12	0.12	0.70	0.06

(5 respondents are outliers)

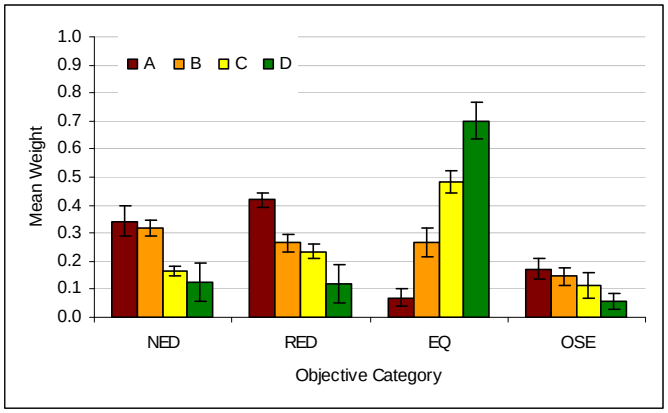
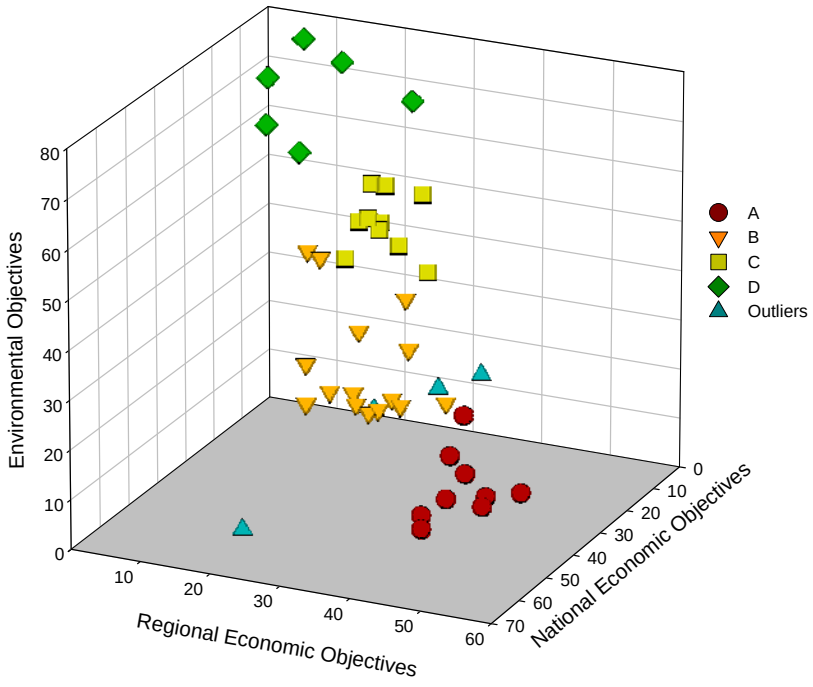


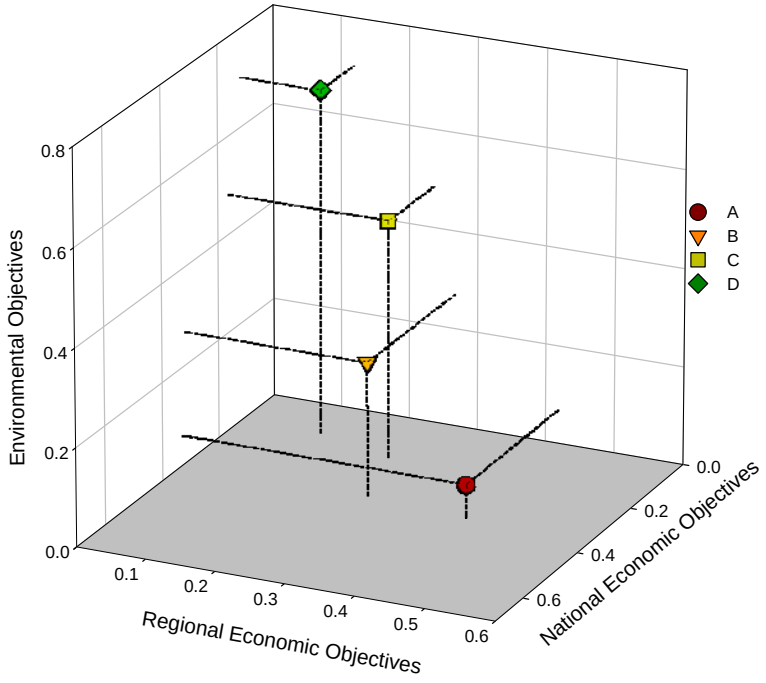
Figure 4-1. Mean weights by aggregate planning objective for four clusters, A through D. Uncertainty bounds represent 95% confidence limits on the estimated mean weight.

Differences among the clusters are further illustrated in Figures 4-2(a) and 4-2(b) which show the individual respondent weights arrayed in three-dimensional space. These results are not displayed in the OSE dimension because of relatively small differences in that dimension.

Performing the cluster analysis in this manner identifies distinct stakeholder group preferences across the Mississippi coast. These four groups represent differing stakeholder values and each will be used to rank alternative plans. This will permit us to document differences among stakeholders and identify areas for consensus and potential compromise. This information guides the ranking of plans and recommendations, as described below.



(a)



(b)

Figure 4-2: Weight allocation arrayed in three dimensions showing four clusters (a) and mean weight allocation for each cluster (b)

4.2.2 Cluster Groups

The cluster analysis identified four (4) distinct groups (or clusters) of stakeholders using stakeholder's allocation of weights across the fifteen metrics. Each group is described below relative to each of the four system of accounts, or objective categories on a 0-1 scale (see Table 4-2 and Figure 4-1).

- Cluster A: This group's focus was on economic development at both the regional and national levels. It had the highest NED weighting of 0.42 and the highest RED weighting of 0.34. This group also had the highest OSE weight (0.17) and the lowest weight for EQ (0.07).
- Cluster B: This group was intermediate (not highest or lowest weight for any category), allocating at least a weight of 0.15 to each category. It was unique in that it provided the second-highest weights for three categories: NED (0.32), RED (0.27) and OSE (0.15).
- Cluster C: While this group focused on EQ, giving it the second-highest weight (0.48), this group also weighted (balanced) each of the other categories with at least a 0.12 weighting, which sets it apart from Cluster D.
- Cluster D: This group is the most focused on the EQ category, showing the highest EQ weight of 0.70. This high EQ weighting comes at the expense of the other 3 categories, yielding the lowest weights for RED (0.12), NED (0.12) and OSE (0.06).

4.3 Plan Rankings by Multi-attribute Utility (MAU) Score

In this analysis, an MAU score is calculated and plans are ranked by the MAU score. Plans with higher MAU scores are preferred, but these ranks assume a particular set of stakeholder preferences and planning assumptions.

4.3.1 Ranking of Measures

MAU scores were calculated for each of the measures and the no-action alternative using a full set of fifteen weights and metrics. The alternatives are then ranked by MAU score, with the alternative having the highest MAU score being most preferred given the preferences under consideration. However, these ranks should be interpreted with more caution than this because there are many uncertainties that have not been fully addressed in this analysis. Therefore, rather than focusing on identifying the top-ranked plan and choosing this as the "best" alternative, it may be more useful to consider other types of questions. For example:

- How much do the MAU scores vary across the alternatives?
- Is there a group of plans at the top that have MAU scores that are relatively close to one another? What are the similarities and differences of the plans that form this "top tier?"
- How sensitive are plan rankings to planning assumptions and stakeholder preferences?
- Do stakeholders with different preference patterns prefer one particular plan but for different reasons?

Results of the analysis are presented in the form of numerous tables and graphs that summarize the results for each planning unit so that they can be used to support these types of deliberations among decision makers and stakeholders.

4.3.2 Summary of Results

Results of the MCDA are summarized in Table 4-3 for each cluster group of preference pattern. An independent MCDA was completed in each of the nine subdivisions. Stakeholder preferences are assumed to be consistent across subdivisions and the preferred plan in one subdivision is assumed to be independent of choices in every other subdivision or project alternatives (see Chapter 5 of Main Report for discussion of alternatives). Therefore, when aggregated, the combination of preferred plans in Table 4-3 represents a comprehensive suite of projects for each preference pattern. For example, stakeholders with preferences consistent with those of preference pattern A are best-served by a plan that consists of a suite of projects including the Barrier Islands Comprehensive Plan, Option K in LOD2, Bayou Cumbest Acquisition, Forrest Heights Plan 2, the High-risk Homeowner's plan. These stakeholders prefer no action in Turkey Creek, Admiral Island, Dantzler, and Franklin Creek subdivisions. Although Table 4-3 suggests that, in some cases, some stakeholders would prefer the no action alternative in some subdivisions, each subdivision has at least one preference pattern for which an action plan is preferred by at least one preference pattern.

Table 4-3.
Summary of Decision Analysis Results by Preference Pattern and Subdivision

Subdivision	Preference Pattern			
	A	**B**	**C**	**D**
Barrier Islands	Comprehensive Plan	Comprehensive Plan	Option A	Option A
LOD2	Option K	Option K	Option K	Option K
Turkey Creek	No Action	No Action	No Action	Ecosystem Plan 1
Bayou Cumbest	Acquisition	Acquisition	Acquisition	Ecosystem Plan 1
Admiral Island	No Action	No Action	No Action	Ecosystem Plan 1
Dantzler	No Action	No Action	No Action	Ecosystem Plan 1
Franklin Creek	No Action	No Action	No Action	Ecosystem Plan 1
Forrest Heights	Plan 2	Plan 2	No Action	No Action
Non-Structural	High Risk HARP	Long-term HARP	High Risk HARP	Long-term HARP

HARP = Homeowner's Relocation and Assistance Plan

The calculation of the MAU score is summarized for each of the four preference patterns in Annex 3. In most subdivisions, at least one of the fifteen metrics did not vary across the decision alternatives. If a metric did not vary, it was dropped from the calculation of MAU and the weights for all preference patterns in that subdivision were re-scaled to sum to one. The consequence of this re-scaling is that MAU scores cannot be compared across subdivisions. For example, the Barrier Island Comprehensive Plan has an MAU score of 0.7393 for preference pattern A. This score should not be compared to an MAU score in Dantzler or any other subdivision. There are fifteen outcome metrics of performance associated with each decision outcome. If none of the decision alternatives being considered in a subdivision would have any impact on an outcome measure of performance, that outcome measure is irrelevant to the decision because it cannot affect the choice. Moreover, if the maximum value of an outcome metric for a set of alternatives is the same as the maximum value of that outcome metric (the case of non-varying metrics), it is impossible to calculate a value score

using the equations on lines 6 and 8 on page 41 and a multi-attribute utility score cannot be calculated. Therefore, non-varying metrics are dropped. Dropping these metrics will have no effect on the decision (*i.e.,* which alternative is chosen) because there is a linear utility function.

Figures 4-3 through 4-11 illustrate project rankings and show the relative contribution of each metric to the overall multi-attribute utility (MAU) score. This is illustrated by the color banding of the vertical bar in each figure. A larger color band for a metric indicates that metric contributes more to multi-attribute utility than metrics with smaller bands. One of the results of this study is that in some subdivisions, stakeholders with different preference patterns may prefer similar measures for different reasons. For example, in Figure 4-4, LOD2 Option K is associated with the highest MAU for all preference patterns. It is sometimes the case that stakeholders with different preference patterns prefer the same plan, but they prefer the plan for different reasons. In these cases, MCDA can serve as a way to recognize these situations, help focus the debate and discussion on only the issues that matter, and promote consensus within a diverse group.

In the Barrier Islands (Figure 4-3), the Comprehensive Plan and Plan A are preferred by all preference patterns, but their ordering depends upon preferences. In LOD2 (Figure 4-4), Option K is preferred by all preference patterns. In Turkey Creek (Figure 4-5), the No Action plan is preferred by preference patterns A, B, and C. Preference pattern D prefers Plan 1. In Bayou Cumbest (Figure 4-6), Acquisition is the preferred alternative for preference patterns A, B, and C with the No Action plan coming in ahead of the other plans for preference patterns A and C. For preference pattern B, the No Action plan is least preferred. For preference pattern D, the preferred plan in Bayou Cumbest is Plan 1. For Admiral Island (Figure 4-7), Dantzler (Figure 4-8), and Franklin Creek (Figure 4-9), the No Action plan is preferred for preference patterns A, B, and C. Plan 1 is preferred for preference pattern D. In Forrest Heights (Figure 4-10), Plan 2 is preferred by preference patterns A and B. The No Action plan is preferred by preference patterns C and D. Among the Non-structural program alternatives (Figure 4-11), the High-risk Homeowner's Plan is preferred by preference patterns A and C and Long-term Homeowner's Plan is preferred by preference pattern B and D.

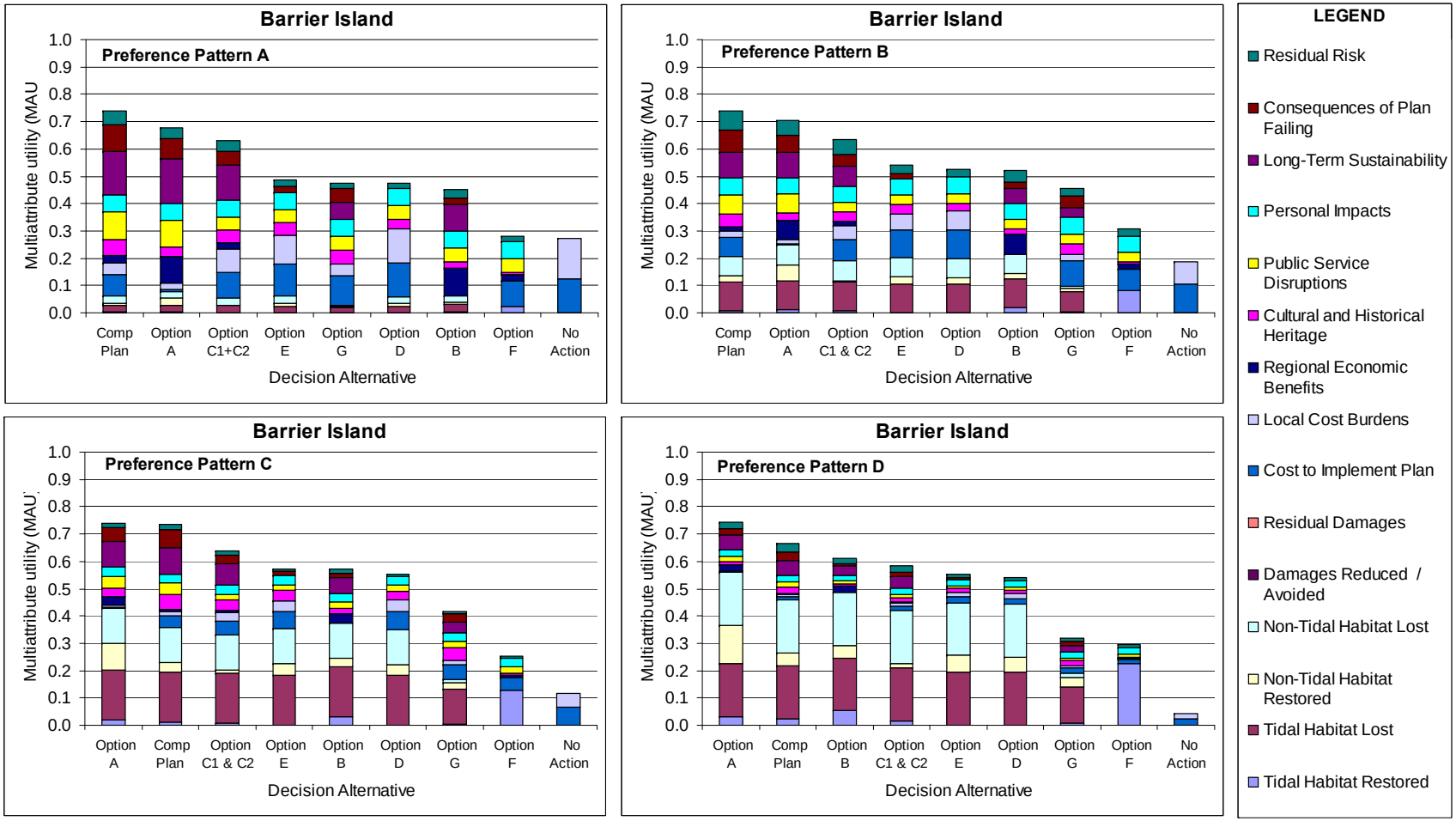


Figure 4-3: Contributions of the Metrics to Multi-attribute Utility Scores for Barrier Islands Ecosystem Restoration

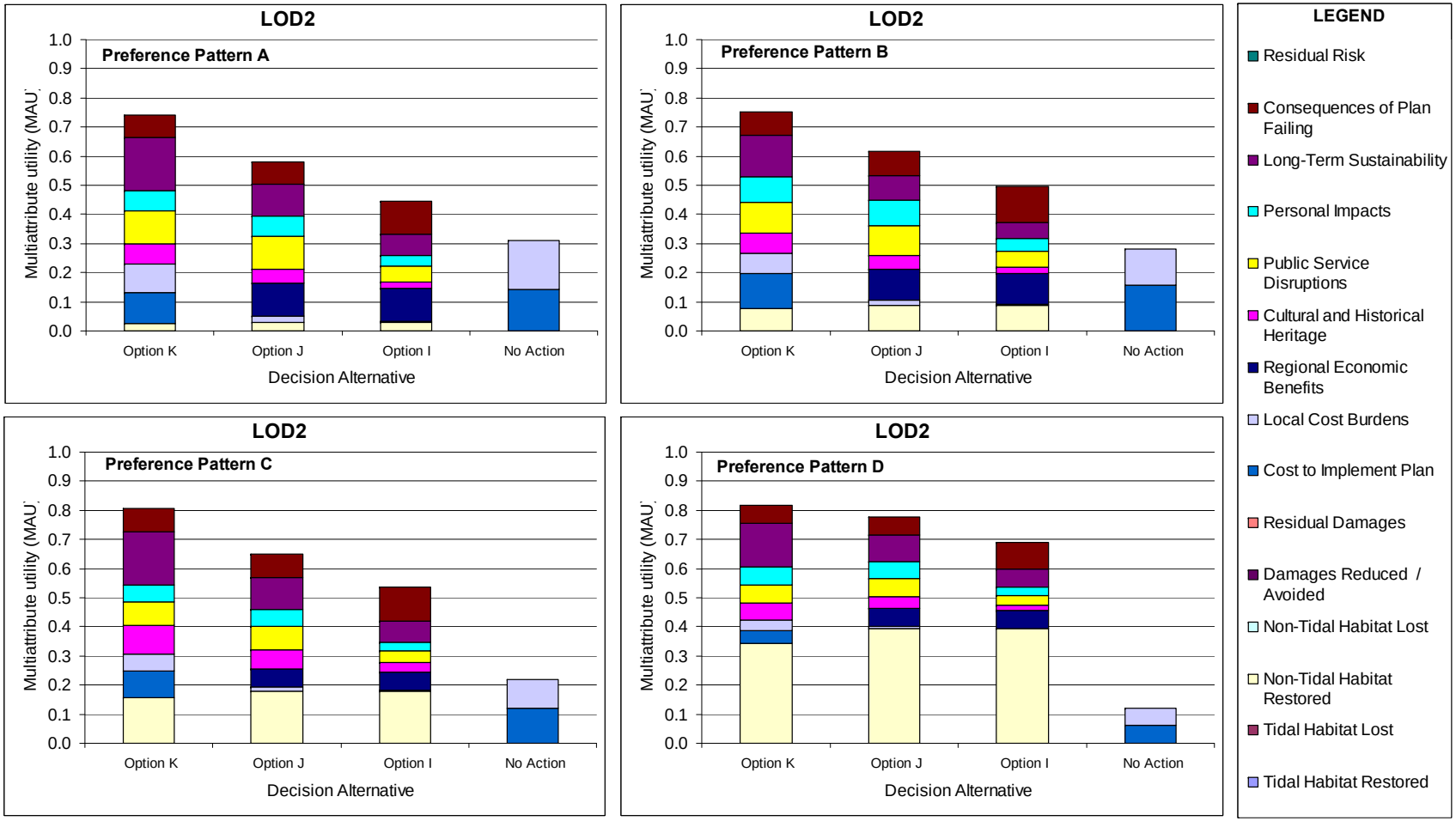


Figure 4-4: Contributions of the Metrics to Multi-attribute Utility Scores for LOD2, Beach and Dune Restoration

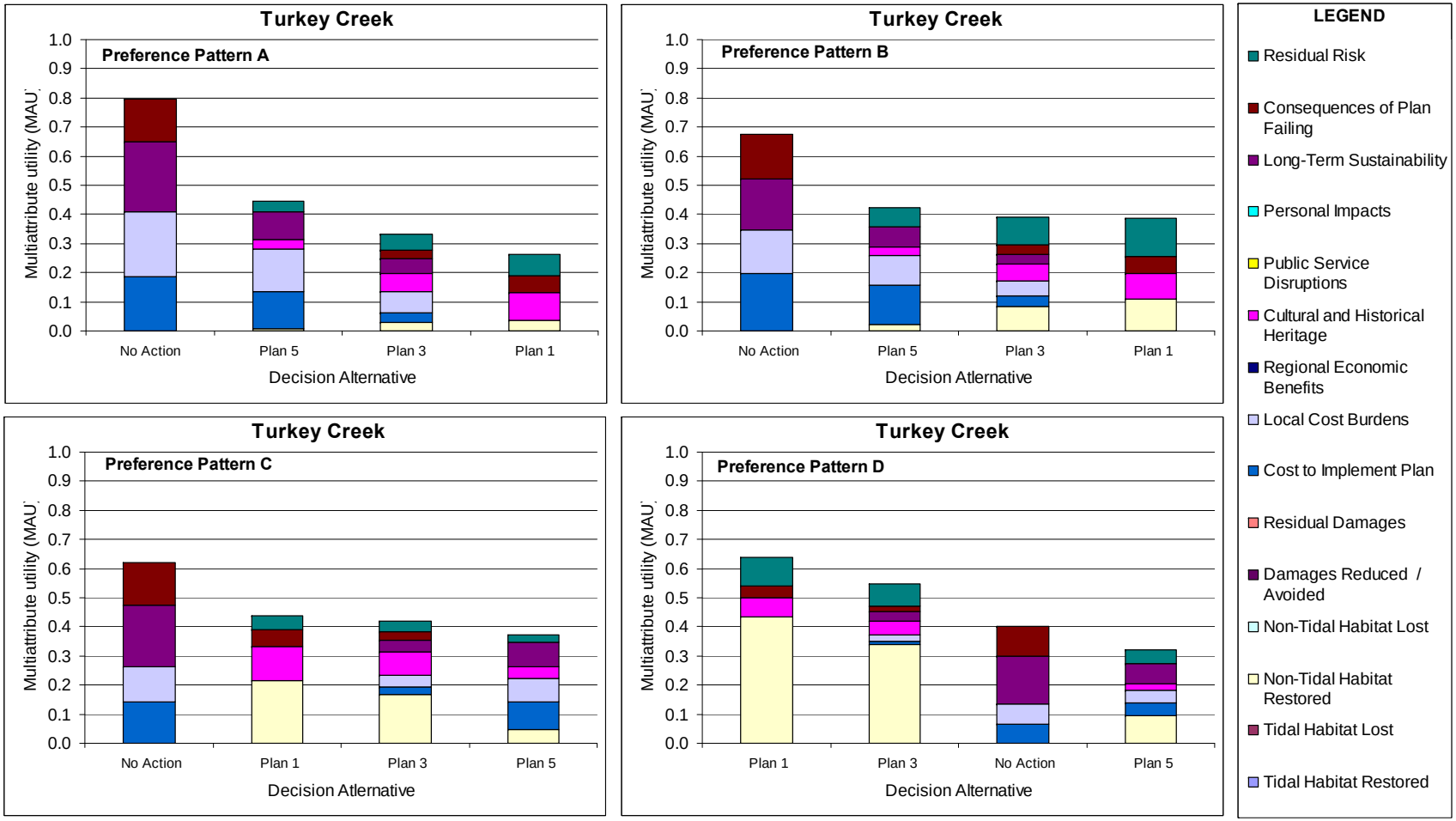


Figure 4-5: Contributions of the Metrics to Multi-attribute Utility Scores for Turkey Creek Ecosystem Restoration

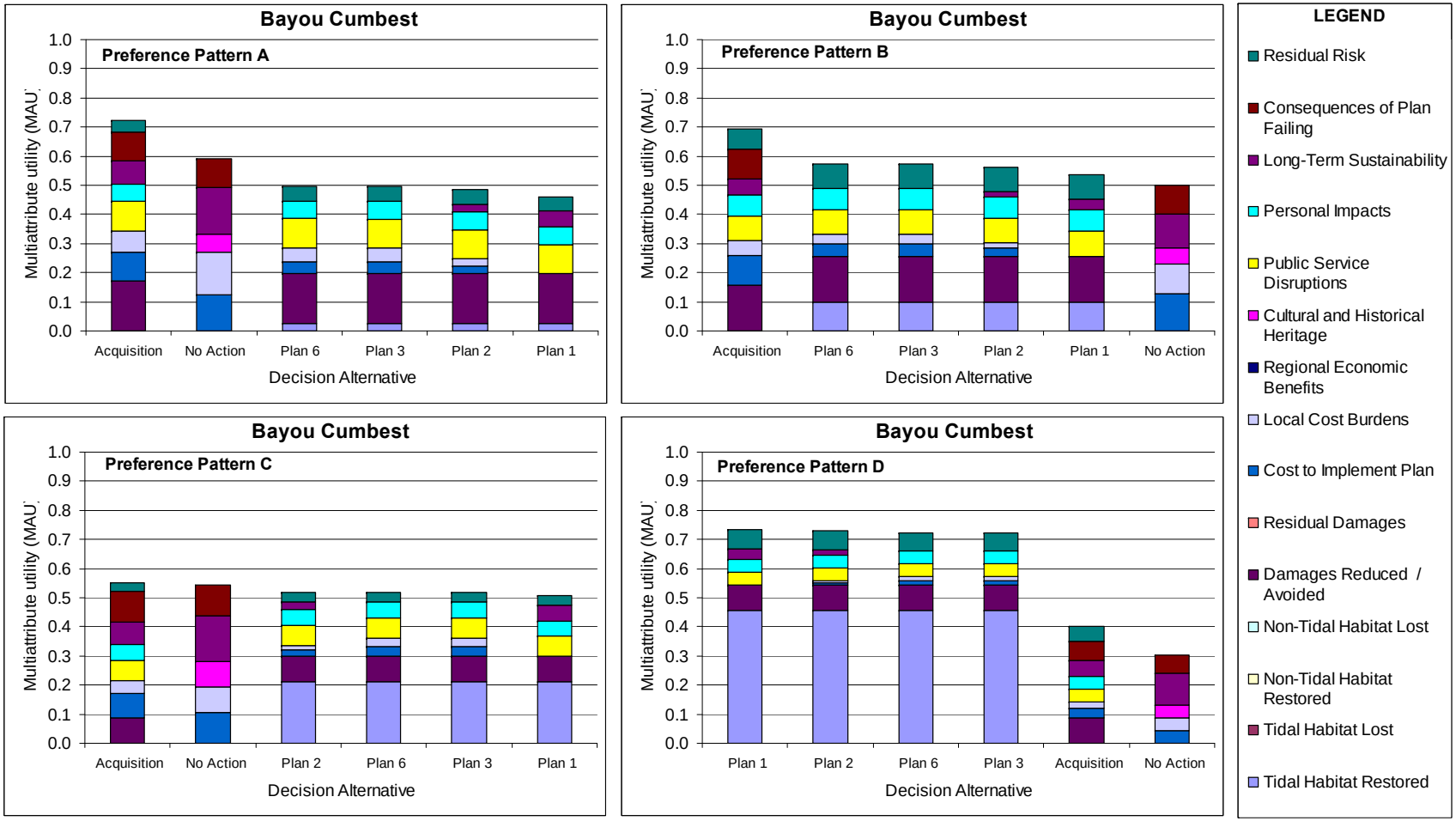


Figure 4-6: Contributions of the Metrics to Multi-attribute Utility Scores for Bayou Cumbest Ecosystem Restoration

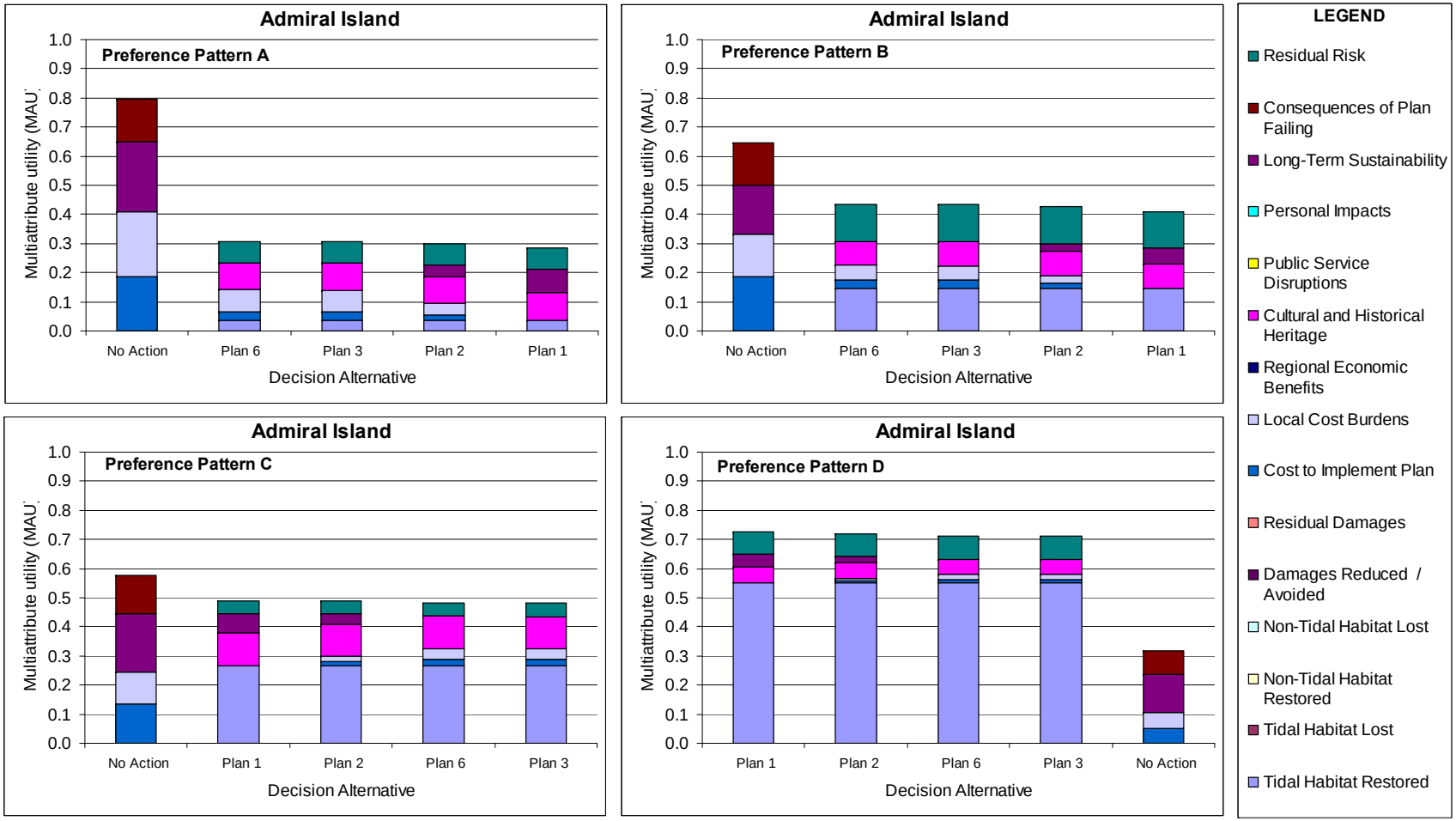


Figure 4-7: Contributions of the Metrics to Multi-attribute Utility Scores for Admiral Island Ecosystem Restoration

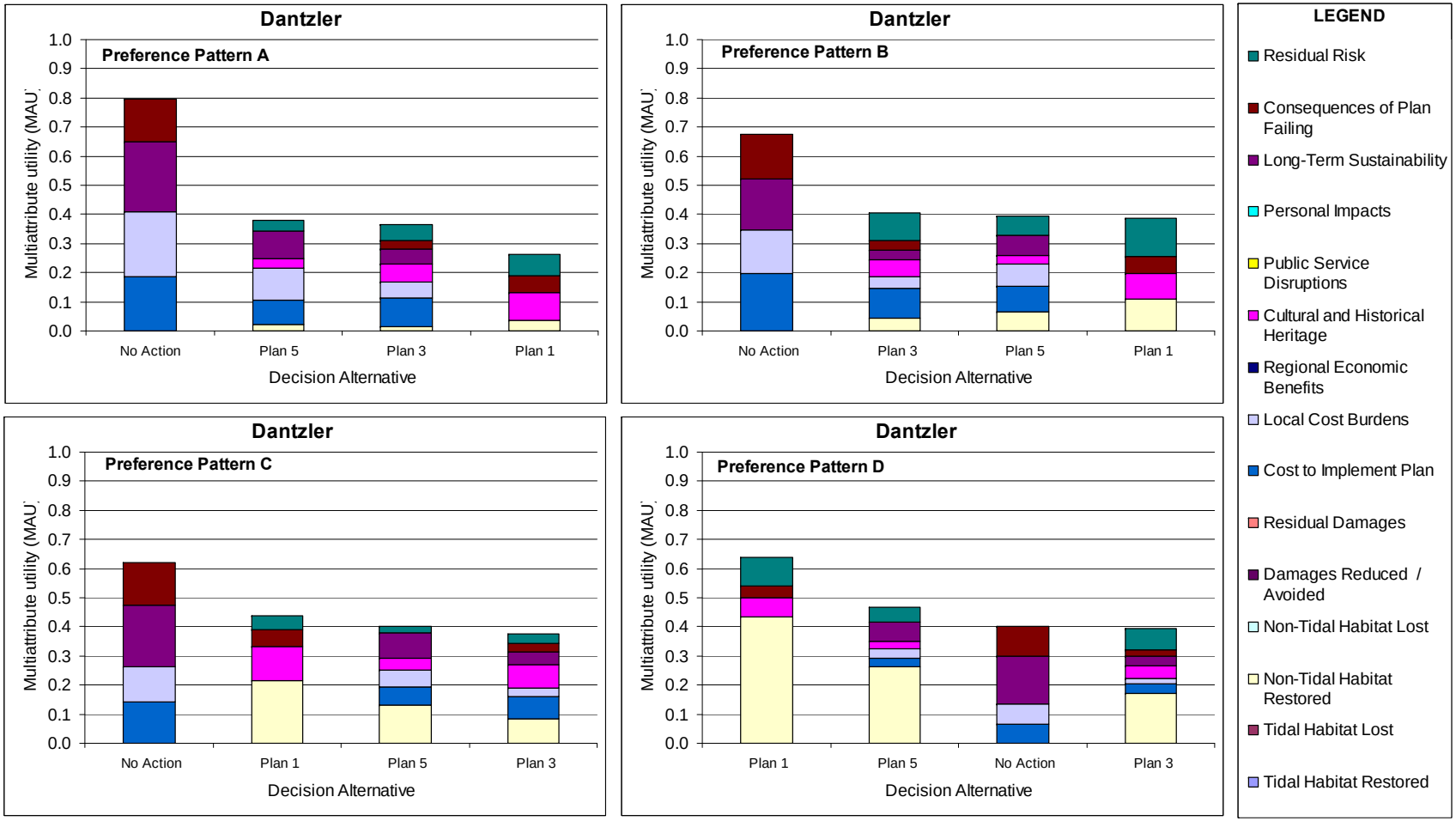


Figure 4-8: Contributions of the Metrics to Multi-attribute Utility Scores for Dantzler Ecosystem Restoration

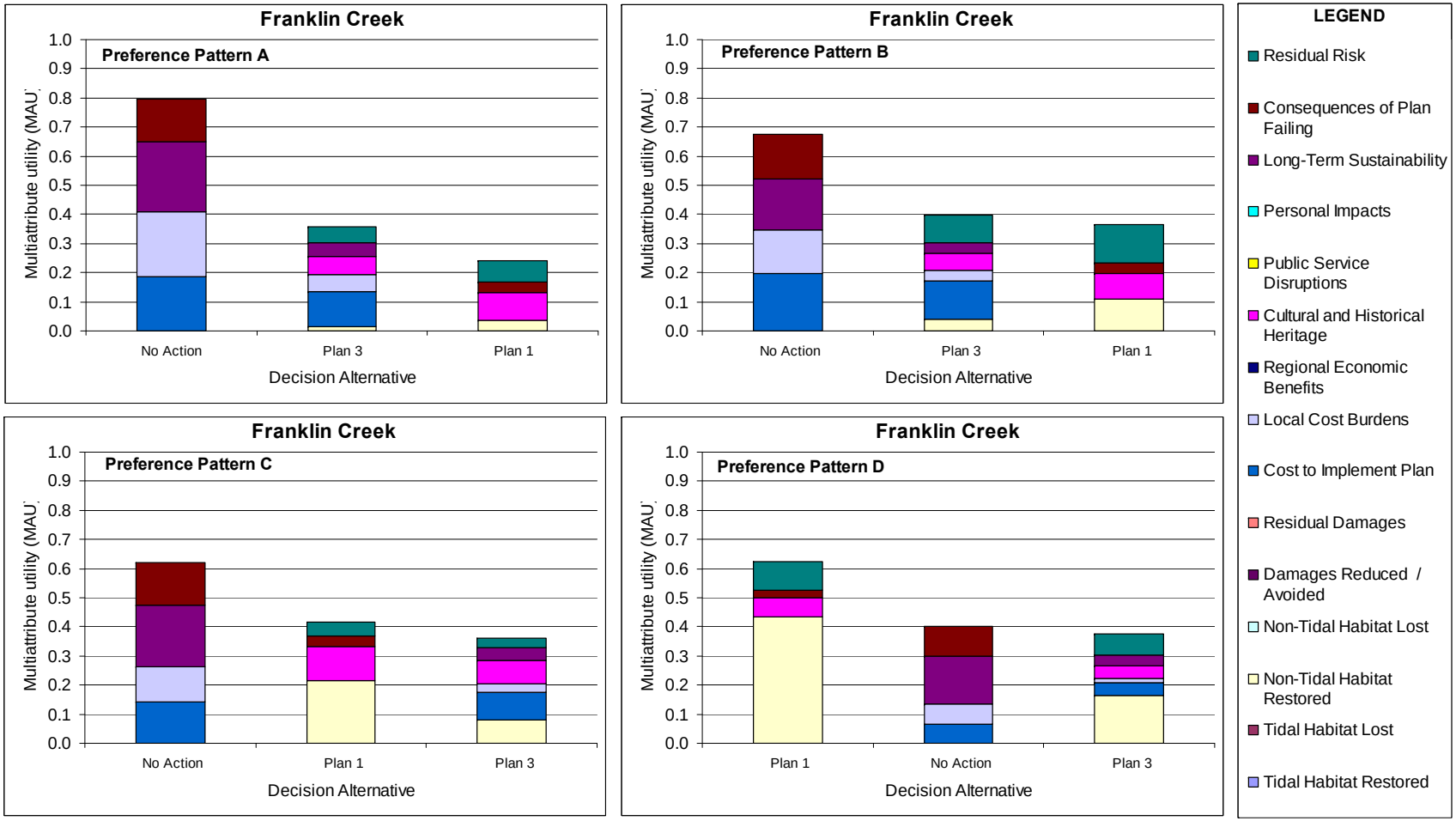


Figure 4-9: Contributions of the Metrics to Multi-attribute Utility Scores for Franklin Creek Ecosystem Restoration

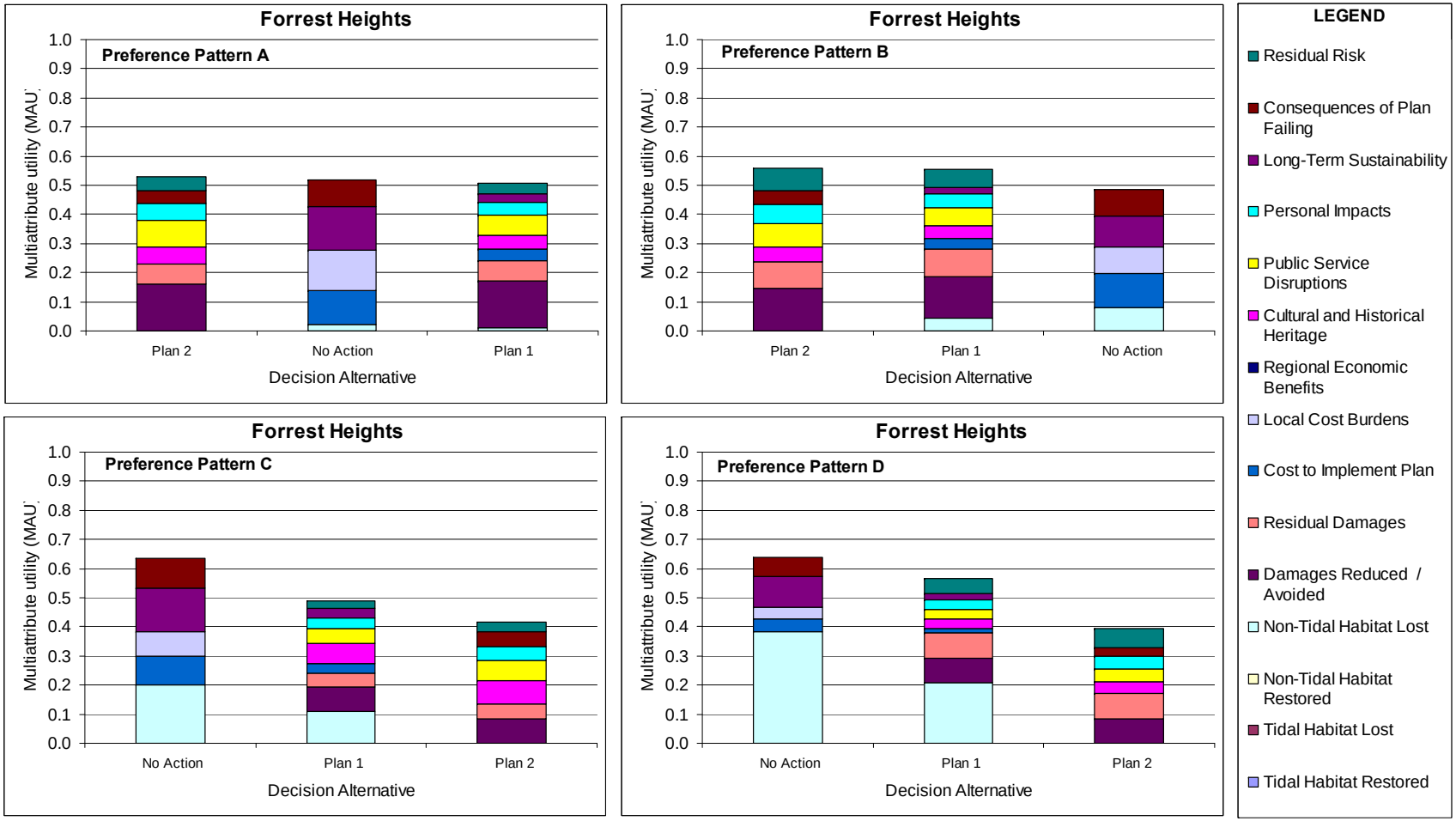


Figure 4-10: Contributions of the Metrics to Multi-attribute Utility Scores for Forrest Heights Hurricane and Storm Damage Reduction

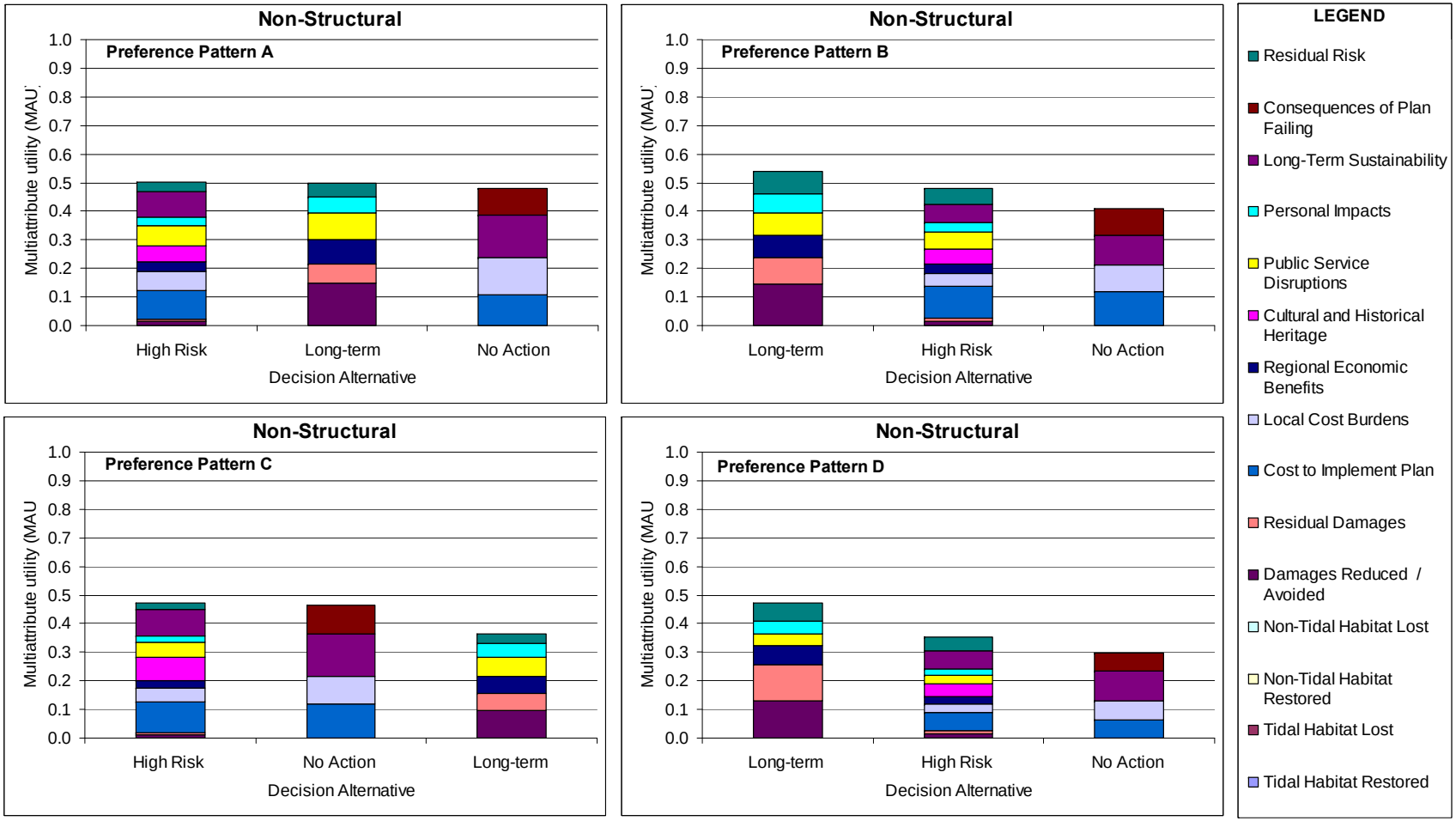


Figure 4-11: Contributions of the Metrics to Multi-attribute Utility Scores for Non-Structural Hurricane and Storm Damage Reduction

5. DISCUSSION

This application of RIDF has focused on developing an objectives hierarchy for MsCIP measures selection, identifying a set of metrics to model performance outcomes, and developing a multi-attribute utility function to rate the relative performance of project alternatives. In the analysis of results, MsCIP measures alternatives are ranked by MAU score using four different sets of attribute weights. Each set of weights characterizes a pattern of preference that is represented by a group of individuals, or cluster, within the stakeholder community. Plans are ranked by MAU score and, in the absence of uncertainty in the assumptions used to model plan outcomes, the preferred measure for each cluster is the measure with the highest MAU score. However, most decisions with long-range planning horizons involve a considerable amount of uncertainty and MsCIP is no exception.

In addition to enhancing the Corps' six-step P&G guidelines by providing a means to consider multiple objectives in the decision process, RIDF also offers a mechanism by which to engage stakeholders more actively in the Corps' planning process. For example, these MCDA procedures help decision makers and stakeholders: 1) systematically structure the decision process; 2) assess tradeoffs among decision objectives; 3) reflect upon, articulate, and apply explicit value judgments concerning conflicting decision criteria; 4) make more consistent and rational evaluations of risks and uncertainties; and 5) facilitate negotiation (Hobbs and Meier 2000). In addition to improving the quality of decisions, RIDF helps decision makers engage stakeholders. Stakeholders assist decision makers to develop an objectives hierarchy and to assess the relative importance of those decision objectives. An obvious benefit of engaging stakeholders during the planning process is that this is likely to engender greater trust and confidence on the part of stakeholders and may enhance the sense of legitimacy of the decision or final outcome. The objectives hierarchy is described in Section 3.1.3 and the stakeholder weight elicitation sessions are described in Section 4.1.

Results of the stakeholder weight elicitation sessions are analyzed using cluster analysis to identify characteristic patterns of preference in the stakeholder population. The rationale for this method is that it provides an objective approach to classifying stakeholders based on psychometric data obtained directly from them. Four characteristic patterns of preference emerged from the results of weight elicitation. These preference patterns can be differentiated by the aggregate weight on EQ objectives, which is the sum of relative weights on individual EQ sub-objectives. The aggregate weight on EQ objectives is negatively correlated with the aggregate weight on each of the remaining higher level objectives: NED, RED, and OSE. Preference pattern A places the greatest emphasis on NED and RED objectives while preference pattern D places the greatest emphasis on EQ objectives. OSE objectives are consistently rated low relative to the other objectives, but preference pattern A gives slightly more emphasis to OSE objectives than EQ objectives.

This study describes why the outcomes associated with some alternatives are preferred by various stakeholders to others. Utility provides a relative measure with which to compare decision outcomes given a set of objectives and the preferences of a subject. The contribution of an attribute to utility is determined by the relative importance placed on a performance objective and the relative performance of the alternative with respect to that decision objective. Plan rankings will tend to be more strongly influenced by those decision attributes that have both a high weight and a large amount of variability in performance outcomes across plans. If relative performance does not vary much across the alternatives, then these metrics should have little impact on the decision. Similarly,

an objective that is unimportant (receives a low weight) should also have little impact on the decision, even if the corresponding metric varies a lot from one alternative to another. Metrics that do not vary much do not affect the plan rankings. For MsCIP, at least one metric in each subdivision was eliminated because it exhibited no variation across decision alternatives. Weights on decision objectives were scaled in each sub-division to accommodate the elimination of metrics.

Results of the MCDA are summarized in Table 4-3 and in the ensuing figures. A great deal can be learned by analyzing the MCDA for these four distinctly different patterns of preference. For the Barrier Islands Ecosystem Restoration, Option A and the Comprehensive Plan form a top tier of decision alternatives (Figure 4-3). These plans outrank the seven other plans for each preference pattern. Although preference patterns A and B prefer the Comprehensive Plan and preference patterns C and D prefer Option A, the differences in the MAU scores between these two plans appears relatively small for each preference pattern. This suggests that, while the different preference patterns express wildly different values and priorities, stakeholders could reach consensus around one of these two plans. Each preference pattern prefers the similar decision alternatives, but for different reasons. A similar result is observed in the LOD2 subdivision, where Option K is preferred to other alternatives for all preference patterns (Figure 4-4).

Results in other subdivisions are slightly more complicated. In Turkey Creek (Figure 4-5), Admiral Island (Figure 4-7), Dantzler (Figure 4-8), and Franklin Creek (Figure 4-9), preference patterns A, B, and C all prefer the No Action alternative while preference pattern D, which has a high weight on environmental objectives, prefers Ecosystem Plan 1. A similar pattern is observed in Bayou Cumbest (Figure 4-6) where preference patterns A, B, and C all prefer Acquisition while preference pattern D prefers Ecosystem Plan 1. It is worth pointing out that, in each case, the MAU score for the preferred alternative stands out as apparently higher than the MAU score for the other alternatives. In Forrest Heights (Figure 4-10), Plan 2 has the highest MAU score for preference patterns A and B while the No Action alternative ranks highest for preference patterns C and D. Among the Non-structural alternatives (Figure 4-11), the High Risk Homeowners Assistance Plan has the highest MAU score for preference patterns A and C while the Long-term Homeowners Assistance Plan has the highest MAU score for preference patterns B and D.

One of the benefits of subjecting policy decisions such as those being considered in MsCIP to a multi-attribute decision analysis and stakeholder involvement is that it helps decision makers to identify where common interests exist. It is possible to analyze the results to identify where and how bridges might be built to unite stakeholders who hold competing views, and where more work may be needed to evaluate decision alternatives. The results of this analysis suggest that, given the information that is available at this time, stakeholder consensus is a real possibility in the Barrier Islands and LOD2 subdivisions. For Turkey Creek, Bayou Cumbest, Admiral Island, Dantzler, and Franklin Creek, there is a modal preference for the No Action alternative among the preference patterns considered in this report. More work may be needed differentiate among the alternatives will be needed to develop recommendations for the Forrest Heights and Non-structural subdivisions.

Although a plan may have a high rank over a large number of preference patterns, the utility of that plan for one or more of those preference types may be substantially lower than for others. In this case, consideration should be given to how large these differences in utility are, whether or not these differences represent an inequity, and to what extent this outcome may be the product of having considered only a limited scope of decision alternatives.

6. LESSONS LEARNED FROM IMPLEMENTATION OF THE RIDF

Stakeholder input is being used by US Army Corps of Engineers to inform itself about the interests and values of the stakeholders who will be affected by the planning process. However, the ultimate responsibility for this project selection decision rests solely with the US Army Corps of Engineers. The agency is legally bound to act only within the mission and authority that it was given by Congress.

A number of lessons were learned in this application of RIDF that suggest recommendations for future planning studies that use this method. For example, it is important that sufficient attention be given to developing the objectives hierarchy and selecting the metrics. The time spent structuring an objectives hierarchy will assist in helping the decision maker to clarify his objectives and the use of poorly structured hierarchies can result in recommendations that lead to sub-optimal outcomes. All of the relevant interests of the decision maker should be included in the hierarchy and the lower level objectives should be associated with metrics that clearly represent the extent to which that objective is achieved by a decision outcome.

Ideally, metrics should be quantitative and measurable. Some of the metrics adopted for this study were qualitative because time and resource constraints limited the ability to evaluate the metrics quantitatively through modeling studies or other forms of analysis. Metrics should also be meaningful for the stakeholders who are participating in the weight elicitation session. For example, a decision objective to minimize project cost could be represented by a metric that is an estimate of an individual's additional tax burden rather than an estimate of the total project cost, which may hold less meaning for most stakeholders.

All objectives and metrics should be clearly defined. If definitions are long, complicated, or ambiguous, they will lack clarity. Clarity is needed to avoid confusion in the weight elicitation process and divergent views about what a particular metric represents. Such circumstances could undermine the ability to compare weights elicited from stakeholders.

Many different patterns of preference will commonly exist in populations affected by large planning projects. Therefore, it is important that the group of stakeholders who participate in the weight elicitation sessions provide a representative cross-section of the population. If participants are drawn from too narrow a subset of the population, the interests of the population will not be accurately represented.

Preference assessment is a difficult task and it is important that the level of effort needed to obtain valid results not be underestimated. While much effort went into obtaining information on stakeholder preferences for this project, some improvements in the approach are still possible. Stakeholder engagement sessions, such as those conducted for this project, should incorporate controls during the weight elicitation procedure to qualify the results using internal validity tests. For example, future weight elicitation sessions should include tests to help confirm that participants understand and are implementing the instructions properly. In addition, persons conducting the weight elicitation sessions should follow a script so that the procedures are consistently applied from one session to another and are well documented. It may also be useful to expand the scope of information collected from stakeholders. For example, a set of questions unrelated to the project at

hand could assist in developing a more meaningful interpretation of the clusters. This will also provide the ground work for formalizing the MCDA technique and making it more generally applicable to other Corps decision processes.

Finally, there are many uncertainties that can influence a project selection decision. For example, the rate of change in sea-level rise over the life of the project is an obvious and relevant factor to consider in evaluating decision alternatives. Decision analysis assists decision makers in choosing among alternatives despite these uncertainties. Failure to account for uncertainty in the decision can lead to suboptimal outcomes. Therefore, future applications of the RIDF should assess the most important sources of uncertainty and fully analyze their impacts on the decision.

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ANNEX 1. – STAKEHOLDER WORKSHOP PARTICIPANTS

Table A1-1.
State Government Participants 10 September. 15 survey participants

Name	Organization
Margaret Bretz	Secretary of State
Mike Buchanan	MS Dept of Marine Resources
Sonia Carr	MEMA Long-Term Recovery
Kerwin Cuevas	MS Dept of Marine Resources
Dale Diaz	MS Dept of Marine Resources
Ashley Edwards	Governor's Office
Tom Mann	MS Museum Natural Science/MDWFP
David McNeel	MS State Port Authority
Jamie Miller	Governor's Office
Ken P'Pool	MS Dept of Archives and History
George Ramseut, Jr.	MS Dept of Marine Resources
David Seyfarth	MS Dept of Transportation
Kathy Shelton	MS Museum Natural Science/MDWFP
R. Chad Wallace	MDOT, Environmental Division
Nick Winstead	MS Museum Natural Science/MDWFP

Table A1-2.
Federal Government Participants 10 September. 11 survey participants

Name	Organization
Valerie Anderson	FEMA Biloxi
Sabrina Chandler	USFWS Jackson
Tyree Harrington	USDA-NRCS
Ntale Kajumba	USEPA Region 4
Rob Lowe	FEMA Region 4
C. Baxter Mann	FEMA-DELO
Bruce McCraney	National Park Service
Jim Murphy	MARAD
Mickey Plunkett	USGS (MS)
Chris Recceston	FEMA
Mark Thompson	National Marine Fisheries Service (Habitat)

Table A1-3.
Local Government Participants 10 September. 8 survey participants

Name	Organization
Patrick Bonck	Harrison County Zoning
Harrietta Eaton	City of Pascagoula
Les Fillingame	City of Bay St. Louis
Liz Ford	City of Pascagoula
Aneice Liddell	City of Moss Point
Gordon Quesenberry	City of Gautier
Jaclyn Turner	City of Pascagoula
Daphne Viverette	City of Moss Point

Table A1-4.
Business/Developer Participants 11 September. 5 survey participants

Name	Organization
Laura Brown	Gulf Coast Investment Dev (GCID)
Willie Davis	City of Pass Christian
Jim Kelly	Eco-Logic Restoration
Shelby Stevenson	CSX Transportation
Stuart Williamson	Association of Floodplain Managers of Mississippi

Table A1-5.
NGO/Scientist Participants 11 September. 5 survey participants

Name	Organization
Jeff Grimes	Gulf Restoration Network
Buck Lawrence	STEPs Coalition/North Gulfport Commission Land Trust
Mike Murphy	The Nature Conservancy
Stephanie Powell	STEPs Coalition Environmental Justice & Sustainability Piller
Judy Steckler	Land Trust

Table A1-6.
Corps MsCIP and ERDC Participants 11 September: 5 survey participants

Name	Organization
Cynthia Banks	ERDC
Todd Boatman	SAM
Barry Payne	ERDC
Susan Rees	SAM
Burton Suedel	ERDC

ANNEX 2. STAKEHOLDER RANKINGS

Table A2-1.
Allocation of 100 Points to 15 MsCIP Metrics (See Table 1-1 for Definitions of Metrics)

Cluster	Elicitation Session	Metrics														
		Tidal Habitat Restored	Tidal Habitat Lost	Non-Tidal Habitat Restored	Non-Tidal Habitat Lost	Damage Reduced/Avoided	Residual Damages	Cost to Implement Plan	Local Cost Burden	Regional Economic Benefits	Cultural and Historical Heritage	Public Service Disruptions	Personal Impacts	Long-Term Sustainability	Consequences of Plan Failure	Residual Risk
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
A	Business	1	1	1	1	35	3	5	5	5	4	2	2	15	16	4
A	Business	5	3	5	3	5	4	9	10	10	6	8	8	15	3	6
A	Federal	2	1	2	1	20	4	10	4	10	1	10	4	17	10	4
A	Local	2	2	2	2	7	7	12	24	10	5	10	5	5	2	5
A	Local	1	1	1	1	3	3	25	25	10	10	5	1	7	3	4
A	Local	1	2	1	2	13	8	1	12	13	1	8	5	12	12	9
A	Local	3	4	1	2	15	5	5	3	4	3	12	8	18	13	4
A	Local	1	1	1	1	20	8	12	9	10	6	7	2	15	5	2
A	Local	1	1	1	1	10	10	10	16	3	7	7	7	15	10	1
B	Business	8	6	6	2	15	6	10	8	8	8	5	7	4	3	4
B	Business	10	8	1	1	7	10	10	12	5	3	8	5	9	6	5
B	USACE	12	12	10	10	12	7	2	2	2	5	5	2	7	7	5
B	USACE	10	12	10	14	10	9	8	5	7	3	2	4	2	3	1
B	USACE	5	5	5	5	10	5	10	10	5	5	5	5	7	15	3
B	Federal	6	6	5	5	20	6	6	4	7	4	5	3	9	8	6
B	Federal	5	5	5	5	10	10	10	5	5	5	5	5	10	10	5
B	Federal	10	10	5	5	10	1	10	7	5	1	5	1	5	5	20
B	Local	1	10	1	10	10	12	18	1	8	4	8	3	1	12	1
B	Local	15	9	5	2	8	5	6	8	3	8	5	5	8	5	8
B	NGO	5	10	5	10	17	1	10	5	2	3	3	3	18	7	1
B	State	5	5	5	5	10	10	10	10	10	5	10	5	10	0	0
B	State	7	12	7	12	6	3	11	6	3	3	2	2	16	5	5
B	State	5	4	5	3	9	5	5	7	6	5	10	10	8	6	12
B	State	3	15	2	2	8	10	8	8	7	1	5	12	5	6	8
C	Business	8	30	1	1	5	1	10	10	9	5	5	3	10	1	1
C	USACE	11	12	11	12	5	7	6	6	4	2	3	2	9	8	2
C	Federal	12	12	12	12	5	5	3	3	2	5	5	5	10	5	4

Cluster	Elicitation Session	Metrics														
		Tidal Habitat Restored	Tidal Habitat Lost	Non-Tidal Habitat Restored	Non-Tidal Habitat Lost	Damage Reduced/Avoided	Residual Damages	Cost to Implement Plan	Local Cost Burden	Regional Economic Benefits	Cultural and Historical Heritage	Public Service Disruptions	Personal Impacts	Long-Term Sustainability	Consequences of Plan Failure	Residual Risk
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C	Federal	10	10	12	15	4	4	1	1	1	15	1	1	5	15	5
C	NGO	16	16	11	11	4	3	3	1	1	2	1	1	18	8	4
C	NGO	10	20	5	20	6	3	5	3	5	2	5	2	5	8	1
C	State	12	14	11	13	9	1	10	9	2	2	1	2	10	2	1
C	State	8	15	8	16	5	5	5	10	2	5	4	4	8	3	2
C	State	15	20	10	10	5	0	10	0	3	2	3	2	10	10	0
C	State	15	15	5	5	5	5	5	5	5	5	10	10	4	4	2
D	Federal	15	20	15	15	10	5	1	2	3	4	2	4	1	1	2
D	Federal	30	25	12	8	1	1	1	1	1	1	1	1	77	5	5
D	Federal	50	1	20	2	6	5	2	2	1	2	2	2	2	1	2
D	NGO	14	20	14	20	1	1	1	3	7	2	1	1	5	88	2
D	NGO	14	25	15	24	2	1	3	2	1	2	2	3	2	3	1
D	State	5	15	2	40	1	10	5	1	1	2	1	1	10	1	5

ANNEX 3. - CALCULATION OF MULTI-ATTRIBUTE UTILITY SCORES BY PREFERENCE PATTERN.

Table A3-1.
Calculation of Multi-attribute Utility Scores for Preference Pattern A

CLUSTER A

Metric:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	MAU
Overall Weights:	0.02	0.02	0.02	0.02	0.14	0.06	0.1	0.12	0.08	0.05	0.08	0.05	0.13	0.08	0.04	
Barrier Island Scaled Weights	0.0247	0.0247	0.0247	0.0247			0.1235	0.1481	0.0988	0.0617	0.0988	0.0617	0.1605	0.0988	0.0494	
Barrier Island Comp Plan	0.0026	0.0247	0.0084	0.0247			0.0811	0.0423	0.0247	0.0617	0.0988	0.0617	0.1605	0.0988	0.0494	0.7393
Barrier Island Option A	0.0036	0.0247	0.0247	0.0247			0.0087	0.0212	0.0988	0.0353	0.0988	0.0617	0.1605	0.0741	0.0395	0.6762
Barrier Island Option C1 & C2	0.0018	0.0247	0.0026	0.0247			0.0951	0.0847	0.0247	0.0441	0.0494	0.0617	0.1284	0.0494	0.0395	0.6308
Barrier Island Option E	0.0000	0.0247	0.0110	0.0247			0.1187	0.1058	0.0000	0.0441	0.0494	0.0617	0.0000	0.0247	0.0198	0.4845
Barrier Island Option G	0.0007	0.0172	0.0058	0.0023			0.1096	0.0423	0.0000	0.0529	0.0494	0.0617	0.0642	0.0494	0.0198	0.4753
Barrier Island Option D	0.0000	0.0247	0.0099	0.0247			0.1217	0.1270	0.0000	0.0353	0.0494	0.0617	0.0000	0.0000	0.0198	0.4742
Barrier Island Option B	0.0058	0.0247	0.0083	0.0247			0.0000	0.0000	0.0988	0.0265	0.0494	0.0617	0.0963	0.0247	0.0296	0.4504
Barrier Island Option F	0.0247	0.0000	0.0000	0.0000			0.0912	0.0000	0.0247	0.0088	0.0494	0.0617	0.0000	0.0000	0.0198	0.2803
Barrier Island No Action	0.0000	0.0000	0.0000	0.0000			0.1235	0.1481	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2716
LOD2 Scaled Weights			0.0282				0.1408	0.1690	0.1127	0.0704	0.1127	0.0704	0.1831	0.1127		
LOD2 Option K			0.0244				0.1077	0.0966	0.0000	0.0704	0.1127	0.0704	0.1831	0.0751		0.7404
LOD2 Option J			0.0282				0.0000	0.0241	0.1127	0.0469	0.1127	0.0704	0.1099	0.0751		0.5800
LOD2 Option I			0.0282				0.0034	0.0000	0.1127	0.0235	0.0563	0.0352	0.0732	0.1127		0.4452
LOD2 No Action			0.0000				0.1408	0.1690	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.3099
Turkey Creek Scaled Weights			0.0370				0.1852	0.2222		0.0926			0.2407	0.1481	0.0741	
Turkey Creek No Action			0.0000				0.1852	0.2222		0.0000			0.2407	0.1481	0.0000	0.7963
Turkey Creek Ecosystem Plan 5			0.0080				0.1260	0.1481		0.0309			0.0963	0.0000	0.0370	0.4464
Turkey Creek Ecosystem Plan 3			0.0290				0.0334	0.0741		0.0617			0.0481	0.0296	0.0556	0.3316
Turkey Creek Ecosystem Plan 1			0.0370				0.0000	0.0000		0.0926			0.0000	0.0593	0.0741	0.2630
Bayou Cumbest Scaled Weights	0.0247				0.1728		0.1235	0.1481		0.0617	0.0988	0.0617	0.1605	0.0988	0.0494	
Bayou Cumbest Acquisition	0.0000				0.1728		0.0978	0.0741		0.0000	0.0988	0.0617	0.0802	0.0988	0.0395	0.7237
Bayou Cumbest No Action	0.0000				0.0000		0.1235	0.1481		0.0617	0.0000	0.0000	0.1605	0.0988	0.0000	0.5926
Bayou Cumbest Ecosystem Plan 6	0.0247				0.1728		0.0394	0.0494		0.0000	0.0988	0.0617	0.0000	0.0000	0.0494	0.4962
Bayou Cumbest Ecosystem Plan 3	0.0247				0.1728		0.0393	0.0494		0.0000	0.0988	0.0617	0.0000	0.0000	0.0494	0.4961
Bayou Cumbest Ecosystem Plan 2	0.0247				0.1728		0.0263	0.0247		0.0000	0.0988	0.0617	0.0267	0.0000	0.0494	0.4851
Bayou Cumbest Ecosystem Plan 1	0.0247				0.1728		0.0000	0.0000		0.0000	0.0988	0.0617	0.0535	0.0000	0.0494	0.4609
Admiral Island Scaled Weights	0.0370						0.1852	0.2222		0.0926			0.2407	0.1481	0.0741	
Admiral Island No Action	0.0000						0.1852	0.2222		0.0000			0.2407	0.1481	0.0000	0.7963
Admiral Island Ecosystem Plan 6	0.0370						0.0298	0.0741		0.0926			0.0000	0.0000	0.0741	0.3076
Admiral Island Ecosystem Plan 3	0.0370						0.0294	0.0741		0.0926			0.0000	0.0000	0.0741	0.3071
Admiral Island Ecosystem Plan 2	0.0370						0.0194	0.0370		0.0926			0.0401	0.0000	0.0741	0.3003
Admiral Island Ecosystem Plan 1	0.0370						0.0000	0.0000		0.0926			0.0802	0.0000	0.0741	0.2840
Dantzler Scaled Weights			0.0370				0.1852	0.2222		0.0926			0.2407	0.1481	0.0741	
Dantzler No Action			0.0000				0.1852	0.2222		0.0000			0.2407	0.1481	0.0000	0.7963
Dantzler Ecosystem Plan 5			0.0225				0.0827	0.1111		0.0309			0.0963	0.0000	0.0370	0.3806
Dantzler Ecosystem Plan 3			0.0145				0.0995	0.0556		0.0617			0.0481	0.0296	0.0556	0.3646
Dantzler Ecosystem Plan 1			0.0370				0.0000	0.0000		0.0926			0.0000	0.0593	0.0741	0.2630
Franklin Creek Scaled Weights			0.0370				0.1852	0.2222		0.0926			0.2407	0.1481	0.0741	
Franklin Creek No Action			0.0000				0.1852	0.2222		0.0000			0.2407	0.1481	0.0000	0.7963
Franklin Creek Ecosystem Plan 3			0.0139				0.1227	0.0556		0.0617			0.0481	0.0000	0.0556	0.3576
Franklin Creek Ecosystem Plan 1			0.0370				0.0000	0.0000		0.0926			0.0000	0.0370	0.0741	0.2407
Forrest Heights Scaled Weights				0.0230	0.1609	0.0690	0.1149	0.1379		0.0575	0.0920	0.0575	0.1494	0.0920	0.0460	
Forrest Heights Plan 2				0.0000	0.1609	0.0690	0.0000	0.0000		0.0575	0.0920	0.0575	0.0000	0.0460	0.0460	0.5287
Forrest Heights No Action				0.0230	0.0000	0.0000	0.1149	0.1379		0.0000	0.0000	0.0000	0.1494	0.0920	0.0000	0.5172
Forrest Heights Plan 1				0.0125	0.1607	0.0689	0.0383	0.0000		0.0479	0.0690	0.0431	0.0299	0.0000	0.0368	0.5070
Nonstructural Scaled Weights					0.1505	0.0645	0.1075	0.1290	0.0860	0.0538	0.0860	0.0538	0.1398	0.0860	0.0430	
High Risk Homeowners Assistance Plan					0.0161	0.0069	0.1010	0.0645	0.0344	0.0575	0.0690	0.0287	0.0897	0.0000	0.0345	0.5022
Long-term Homeowners Assistance Plan					0.1505	0.0645	0.0000	0.0000	0.0860	0.0000	0.0920	0.0575	0.0000	0.0000	0.0460	0.4965
No Action Homeowners Assistance Plan					0.0000	0.0000	0.1075	0.1290	0.0000	0.0000	0.0000	0.0000	0.1494	0.0920	0.0000	0.4779

Table A3-2.
Calculation of Multi-attribute Utility Scores for Preference Pattern B

CLUSTER B

Metric:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	MAU
Overall Weights:	0.07	0.09	0.05	0.06	0.11	0.07	0.09	0.07	0.06	0.04	0.06	0.05	0.08	0.07	0.06	
Barrier Island Scaled Weights	0.0824	0.1059	0.0588	0.0706			0.1059	0.0824	0.0706	0.0471	0.0706	0.0588	0.0941	0.0824	0.0706	
Barrier Island Comp Plan	0.0085	0.1059	0.0201	0.0706			0.0695	0.0235	0.0176	0.0471	0.0706	0.0588	0.0941	0.0824	0.0706	0.7393
Barrier Island Option A	0.0121	0.1059	0.0588	0.0706			0.0075	0.0118	0.0706	0.0269	0.0706	0.0588	0.0941	0.0618	0.0565	0.7058
Barrier Island Option C1 & C2	0.0061	0.1059	0.0063	0.0706			0.0816	0.0471	0.0176	0.0336	0.0353	0.0588	0.0753	0.0412	0.0565	0.6358
Barrier Island Option E	0.0000	0.1059	0.0262	0.0706			0.1018	0.0588	0.0000	0.0336	0.0353	0.0588	0.0000	0.0206	0.0282	0.5398
Barrier Island Option D	0.0000	0.1059	0.0237	0.0706			0.1044	0.0706	0.0000	0.0269	0.0353	0.0588	0.0000	0.0000	0.0282	0.5244
Barrier Island Option B	0.0193	0.1059	0.0198	0.0706			0.0000	0.0000	0.0706	0.0202	0.0353	0.0588	0.0565	0.0206	0.0424	0.5198
Barrier Island Option G	0.0024	0.0739	0.0138	0.0066			0.0940	0.0235	0.0000	0.0403	0.0353	0.0588	0.0376	0.0412	0.0282	0.4557
Barrier Island Option F	0.0824	0.0000	0.0000	0.0000			0.0783	0.0000	0.0176	0.0067	0.0353	0.0588	0.0000	0.0000	0.0282	0.3073
Barrier Island No Action	0.0000	0.0000	0.0000	0.0000			0.1059	0.0824	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1882
LOD2 Scaled Weights			0.0877				0.1579	0.1228	0.1053	0.0702	0.1053	0.0877	0.1404	0.1228		
LOD2 Option K			0.0761				0.1207	0.0702	0.0000	0.0702	0.1053	0.0877	0.1404	0.0819		0.7523
LOD2 Option J			0.0877				0.0000	0.0175	0.1053	0.0468	0.1053	0.0877	0.0842	0.0819		0.6164
LOD2 Option I			0.0877				0.0039	0.0000	0.1053	0.0234	0.0526	0.0439	0.0561	0.1228		0.4957
LOD2 No Action			0.0000				0.1579	0.1228	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.2807
Turkey Creek Scaled Weights			0.1087				0.1957	0.1522		0.0870			0.1739	0.1522	0.1304	
Turkey Creek No Action			0.0000				0.1957	0.1522		0.0000			0.1739	0.1522	0.0000	0.6739
Turkey Creek Ecosystem Plan 5			0.0235				0.1332	0.1014		0.0290			0.0696	0.0000	0.0652	0.4219
Turkey Creek Ecosystem Plan 3			0.0852				0.0353	0.0507		0.0580			0.0348	0.0304	0.0978	0.3923
Turkey Creek Ecosystem Plan 1			0.1087				0.0000	0.0000		0.0870			0.0000	0.0609	0.1304	0.3870
Bayou Cumbest Scaled Weights	0.1000				0.1571		0.1286	0.1000		0.0571	0.0857	0.0714	0.1143	0.1000	0.0857	
Bayou Cumbest Acquisition	0.0000				0.1571		0.1019	0.0500		0.0000	0.0857	0.0714	0.0571	0.1000	0.0686	0.6919
Bayou Cumbest Ecosystem Plan 6	0.1000				0.1571		0.0411	0.0333		0.0000	0.0857	0.0714	0.0000	0.0000	0.0857	0.5744
Bayou Cumbest Ecosystem Plan 3	0.1000				0.1571		0.0410	0.0333		0.0000	0.0857	0.0714	0.0000	0.0000	0.0857	0.5743
Bayou Cumbest Ecosystem Plan 2	0.1000				0.1571		0.0274	0.0167		0.0000	0.0857	0.0714	0.0190	0.0000	0.0857	0.5631
Bayou Cumbest Ecosystem Plan 1	0.1000				0.1571		0.0000	0.0000		0.0000	0.0857	0.0714	0.0381	0.0000	0.0857	0.5381
Bayou Cumbest No Action	0.0000				0.0000		0.1286	0.1000		0.0571	0.0000	0.0000	0.1143	0.1000	0.0000	0.5000
Admiral Island Scaled Weights	0.1458						0.1875	0.1458		0.0833			0.1667	0.1458	0.1250	
Admiral Island No Action	0.0000						0.1875	0.1458		0.0000			0.1667	0.1458	0.0000	0.6458
Admiral Island Ecosystem Plan 6	0.1458						0.0302	0.0486		0.0833			0.0000	0.0000	0.1250	0.4329
Admiral Island Ecosystem Plan 3	0.1458						0.0297	0.0486		0.0833			0.0000	0.0000	0.1250	0.4325
Admiral Island Ecosystem Plan 2	0.1458						0.0197	0.0243		0.0833			0.0278	0.0000	0.1250	0.4259
Admiral Island Ecosystem Plan 1	0.1458						0.0000	0.0000		0.0833			0.0556	0.0000	0.1250	0.4097
Dantzler Scaled Weights			0.1087				0.1957	0.1522		0.0870			0.1739	0.1522	0.1304	
Dantzler No Action			0.0000				0.1957	0.1522		0.0000			0.1739	0.1522	0.0000	0.6739
Dantzler Ecosystem Plan 3			0.0426				0.1051	0.0380		0.0580			0.0348	0.0304	0.0978	0.4068
Dantzler Ecosystem Plan 5			0.0661				0.0874	0.0761		0.0290			0.0696	0.0000	0.0652	0.3933
Dantzler Ecosystem Plan 1			0.1087				0.0000	0.0000		0.0870			0.0000	0.0609	0.1304	0.3870
Franklin Creek Scaled Weights			0.1087				0.1957	0.1522		0.0870			0.1739	0.1522	0.1304	
Franklin Creek No Action			0.0000				0.1957	0.1522		0.0000			0.1739	0.1522	0.0000	0.6739
Franklin Creek Ecosystem Plan 3			0.0409				0.1296	0.0380		0.0580			0.0348	0.0000	0.0978	0.3991
Franklin Creek Ecosystem Plan 1			0.1087				0.0000	0.0000		0.0870			0.0000	0.0380	0.1304	0.3641
Forrest Heights Scaled Weights				0.0789	0.1447	0.0921	0.1184	0.0921		0.0526	0.0789	0.0658	0.1053	0.0921	0.0789	
Forrest Heights Plan 2				0.0000	0.1447	0.0921	0.0000	0.0000		0.0526	0.0789	0.0658	0.0000	0.0461	0.0789	0.5592
Forrest Heights Plan 1				0.0429	0.1445	0.0920	0.0395	0.0000		0.0439	0.0592	0.0493	0.0211	0.0000	0.0632	0.5556
Forrest Heights No Action				0.0789	0.0000	0.0000	0.1184	0.0921		0.0000	0.0000	0.0000	0.1053	0.0921	0.0000	0.4868
Nonstructural Scaled Weights					0.1447	0.0921	0.1184	0.0921	0.0789	0.0526	0.0789	0.0658	0.1053	0.0921	0.0789	
Long-term Homeowners Assistance Plan					0.1447	0.0921	0.0000	0.0000	0.0789	0.0000	0.0789	0.0658	0.0000	0.0000	0.0789	0.5395
High Risk Homeowners Assistance Plan					0.0154	0.0098	0.1113	0.0461	0.0316	0.0526	0.0592	0.0329	0.0632	0.0000	0.0592	0.4813
No Action Homeowners Assistance Plan					0.0000	0.0000	0.1184	0.0921	0.0000	0.0000	0.0000	0.0000	0.1053	0.0921	0.0000	0.4079

Table A3-3.
Calculation of Multi-attribute Utility Scores for Preference Pattern C

CLUSTER C

Metric:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	MAU
Overall Weights:	0.12	0.17	0.09	0.12	0.05	0.03	0.06	0.05	0.03	0.05	0.04	0.03	0.09	0.06	0.02	
Barrier Island Scaled Weights	0.1290	0.1828	0.0968	0.1290			0.0645	0.0538	0.0323	0.0538	0.0430	0.0323	0.0968	0.0645	0.0215	
Barrier Island Option A	0.0189	0.1828	0.0968	0.1290			0.0046	0.0077	0.0323	0.0307	0.0430	0.0323	0.0968	0.0484	0.0172	0.7403
Barrier Island Comp Plan	0.0134	0.1828	0.0330	0.1290			0.0424	0.0154	0.0081	0.0538	0.0430	0.0323	0.0968	0.0645	0.0215	0.7358
Barrier Island Option C1 & C2	0.0096	0.1828	0.0103	0.1290			0.0497	0.0307	0.0081	0.0384	0.0215	0.0323	0.0774	0.0323	0.0172	0.6392
Barrier Island Option E	0.0000	0.1828	0.0431	0.1290			0.0620	0.0384	0.0000	0.0384	0.0215	0.0323	0.0000	0.0161	0.0086	0.5723
Barrier Island Option B	0.0302	0.1828	0.0326	0.1290			0.0000	0.0000	0.0323	0.0230	0.0215	0.0323	0.0581	0.0161	0.0129	0.5707
Barrier Island Option D	0.0000	0.1828	0.0390	0.1290			0.0636	0.0461	0.0000	0.0307	0.0215	0.0323	0.0000	0.0000	0.0086	0.5536
Barrier Island Option G	0.0038	0.1275	0.0227	0.0120			0.0573	0.0154	0.0000	0.0461	0.0215	0.0323	0.0387	0.0323	0.0086	0.4181
Barrier Island Option F	0.1290	0.0000	0.0000	0.0000			0.0477	0.0000	0.0081	0.0077	0.0215	0.0323	0.0000	0.0000	0.0086	0.2548
Barrier Island No Action	0.0000	0.0000	0.0000	0.0000			0.0645	0.0538	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1183
LOD2 Scaled Weights			0.1800				0.1200	0.1000	0.0600	0.1000	0.0800	0.0600	0.1800	0.1200		
LOD2 Option K			0.1561				0.0917	0.0571	0.0000	0.1000	0.0800	0.0600	0.1800	0.0800		0.8050
LOD2 Option J			0.1800				0.0000	0.0143	0.0600	0.0667	0.0800	0.0600	0.1080	0.0800		0.6490
LOD2 Option I			0.1800				0.0029	0.0000	0.0600	0.0333	0.0400	0.0300	0.0720	0.1200		0.5383
LOD2 No Action			0.0000				0.1200	0.1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.2200
Turkey Creek Scaled Weights			0.2143				0.1429	0.1190		0.1190			0.2143	0.1429	0.0476	
Turkey Creek No Action			0.0000				0.1429	0.1190		0.0000			0.2143	0.1429	0.0000	0.6190
Turkey Creek Ecosystem Plan 1			0.2143				0.0000	0.0000		0.1190			0.0000	0.0571	0.0476	0.4381
Turkey Creek Ecosystem Plan 3			0.1680				0.0258	0.0397		0.0794			0.0429	0.0286	0.0357	0.4200
Turkey Creek Ecosystem Plan 5			0.0463				0.0972	0.0794		0.0397			0.0857	0.0000	0.0238	0.3721
Bayou Cumbest Scaled Weights	0.2105				0.0877		0.1053	0.0877		0.0877	0.0702	0.0526	0.1579	0.1053	0.0351	
Bayou Cumbest Acquisition	0.0000				0.0877		0.0834	0.0439		0.0000	0.0702	0.0526	0.0789	0.1053	0.0281	0.5501
Bayou Cumbest No Action	0.0000				0.0000		0.1053	0.0877		0.0877	0.0000	0.0000	0.1579	0.1053	0.0000	0.5439
Bayou Cumbest Ecosystem Plan 2	0.2105				0.0877		0.0224	0.0146		0.0000	0.0702	0.0526	0.0263	0.0000	0.0351	0.5195
Bayou Cumbest Ecosystem Plan 6	0.2105				0.0877		0.0336	0.0292		0.0000	0.0702	0.0526	0.0000	0.0000	0.0351	0.5190
Bayou Cumbest Ecosystem Plan 3	0.2105				0.0877		0.0335	0.0292		0.0000	0.0702	0.0526	0.0000	0.0000	0.0351	0.5189
Bayou Cumbest Ecosystem Plan 1	0.2105				0.0877		0.0000	0.0000		0.0000	0.0702	0.0526	0.0526	0.0000	0.0351	0.5088
Admiral Island Scaled Weights	0.2667						0.1333	0.1111		0.1111			0.2000	0.1333	0.0444	
Admiral Island No Action	0.0000						0.1333	0.1111		0.0000			0.2000	0.1333	0.0000	0.5778
Admiral Island Ecosystem Plan 1	0.2667						0.0000	0.0000		0.1111			0.0667	0.0000	0.0444	0.4889
Admiral Island Ecosystem Plan 2	0.2667						0.0140	0.0185		0.1111			0.0333	0.0000	0.0444	0.4881
Admiral Island Ecosystem Plan 6	0.2667						0.0214	0.0370		0.1111			0.0000	0.0000	0.0444	0.4807
Admiral Island Ecosystem Plan 3	0.2667						0.0211	0.0370		0.1111			0.0000	0.0000	0.0444	0.4804
Dantzler Scaled Weights			0.2143				0.1429	0.1190		0.1190			0.2143	0.1429	0.0476	
Dantzler No Action			0.0000				0.1429	0.1190		0.0000			0.2143	0.1429	0.0000	0.6190
Dantzler Ecosystem Plan 1			0.2143				0.0000	0.0000		0.1190			0.0000	0.0571	0.0476	0.4381
Dantzler Ecosystem Plan 5			0.1302				0.0638	0.0595		0.0397			0.0857	0.0000	0.0238	0.4028
Dantzler Ecosystem Plan 3			0.0840				0.0767	0.0298		0.0794			0.0429	0.0286	0.0357	0.3771
Franklin Creek Scaled Weights			0.2143				0.1429	0.1190		0.1190			0.2143	0.1429	0.0476	
Franklin Creek No Action			0.0000				0.1429	0.1190		0.0000			0.2143	0.1429	0.0000	0.6190
Franklin Creek Ecosystem Plan 1			0.2143				0.0000	0.0000		0.1190			0.0000	0.0357	0.0476	0.4167
Franklin Creek Ecosystem Plan 3			0.0805				0.0947	0.0298		0.0794			0.0429	0.0000	0.0357	0.3629
Forrest Heights Scaled Weights				0.2000	0.0833	0.0500	0.1000	0.0833		0.0833	0.0667	0.0500	0.1500	0.1000	0.0333	
Forrest Heights No Action				0.2000	0.0000	0.0000	0.1000	0.0833		0.0000	0.0000	0.0000	0.1500	0.1000	0.0000	0.6333
Forrest Heights Plan 1				0.1087	0.0832	0.0500	0.0333	0.0000		0.0694	0.0500	0.0375	0.0300	0.0000	0.0267	0.4888
Forrest Heights Plan 2				0.0000	0.0833	0.0500	0.0000	0.0000		0.0833	0.0667	0.0500	0.0000	0.0500	0.0333	0.4167
Nonstructural Scaled Weights					0.0980	0.0588	0.1176	0.0980	0.0588	0.0980	0.0784	0.0588	0.1765	0.1176	0.0392	
High Risk Homeowners Assistance Plan					0.0105	0.0063	0.1106	0.0490	0.0235	0.0833	0.0500	0.0250	0.0900	0.0000	0.0250	0.4732
No Action Homeowners Assistance Plan					0.0000	0.0000	0.1176	0.0980	0.0000	0.0000	0.0000	0.0000	0.1500	0.1000	0.0000	0.4657
Long-term Homeowners Assistance Plan					0.0980	0.0588	0.0000	0.0000	0.0588	0.0000	0.0667	0.0500	0.0000	0.0000	0.0333	0.3657

Table A3-4
Calculation of Multi-attribute Utility Scores for Preference Pattern D

CLUSTER D

Metric:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	MAU
Overall Weights:	0.21	0.18	0.13	0.18	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.03	0.03	
Barrier Island Scaled Weights	0.2258	0.1935	0.1398	0.1935			0.0215	0.0215	0.0215	0.0215	0.0215	0.0215	0.0538	0.0323	0.0323	
Barrier Island Option A	0.0330	0.1935	0.1398	0.1935			0.0015	0.0031	0.0215	0.0123	0.0215	0.0215	0.0538	0.0242	0.0258	0.7451
Barrier Island Comp Plan	0.0234	0.1935	0.0476	0.1935			0.0141	0.0061	0.0054	0.0215	0.0215	0.0215	0.0538	0.0323	0.0323	0.6666
Barrier Island Option B	0.0528	0.1935	0.0471	0.1935			0.0000	0.0000	0.0215	0.0092	0.0108	0.0215	0.0323	0.0081	0.0194	0.6096
Barrier Island Option C1 & C2	0.0167	0.1935	0.0149	0.1935			0.0166	0.0123	0.0054	0.0154	0.0108	0.0215	0.0430	0.0161	0.0258	0.5855
Barrier Island Option E	0.0000	0.1935	0.0623	0.1935			0.0207	0.0154	0.0000	0.0154	0.0108	0.0215	0.0000	0.0081	0.0129	0.5540
Barrier Island Option D	0.0000	0.1935	0.0563	0.1935			0.0212	0.0184	0.0000	0.0123	0.0108	0.0215	0.0000	0.0000	0.0129	0.5405
Barrier Island Option G	0.0067	0.1350	0.0327	0.0180			0.0191	0.0061	0.0000	0.0184	0.0108	0.0215	0.0215	0.0161	0.0129	0.3190
Barrier Island Option F	0.2258	0.0000	0.0000	0.0000			0.0159	0.0000	0.0054	0.0031	0.0108	0.0215	0.0000	0.0000	0.0129	0.2953
Barrier Island No Action	0.0000	0.0000	0.0000	0.0000			0.0215	0.0215	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0430
LOD2 Scaled Weights			0.3939				0.0606	0.0606	0.0606	0.0606	0.0606	0.0606	0.1515	0.0909		
LOD2 Option K			0.3417				0.0463	0.0346	0.0000	0.0606	0.0606	0.0606	0.1515	0.0606		0.8166
LOD2 Option J			0.3939				0.0000	0.0087	0.0606	0.0404	0.0606	0.0606	0.0909	0.0606		0.7763
LOD2 Option I			0.3939				0.0015	0.0000	0.0606	0.0202	0.0303	0.0303	0.0606	0.0909		0.6883
LOD2 No Action			0.0000				0.0606	0.0606	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.1212
Turkey Creek Scaled Weights			0.4333				0.0667	0.0667		0.0667			0.1667	0.1000	0.1000	
Turkey Creek Ecosystem Plan 1			0.4333				0.0000	0.0000		0.0667			0.0000	0.0400	0.1000	0.6400
Turkey Creek Ecosystem Plan 3			0.3397				0.0120	0.0222		0.0444			0.0333	0.0200	0.0750	0.5467
Turkey Creek No Action			0.0000				0.0667	0.0667		0.0000			0.1667	0.1000	0.0000	0.4000
Turkey Creek Ecosystem Plan 5			0.0937				0.0454	0.0444		0.0222			0.0667	0.0000	0.0500	0.3224
Bayou Cumbest Scaled Weights	0.4565				0.0870		0.0435	0.0435		0.0435	0.0435	0.0435	0.1087	0.0652	0.0652	
Bayou Cumbest Ecosystem Plan 1	0.4565				0.0870		0.0000	0.0000		0.0000	0.0435	0.0435	0.0362	0.0000	0.0652	0.7319
Bayou Cumbest Ecosystem Plan 2	0.4565				0.0870		0.0093	0.0072		0.0000	0.0435	0.0435	0.0181	0.0000	0.0652	0.7303
Bayou Cumbest Ecosystem Plan 6	0.4565				0.0870		0.0139	0.0145		0.0000	0.0435	0.0435	0.0000	0.0000	0.0652	0.7240
Bayou Cumbest Ecosystem Plan 3	0.4565				0.0870		0.0139	0.0145		0.0000	0.0435	0.0435	0.0000	0.0000	0.0652	0.7240
Bayou Cumbest Acquisition	0.0000				0.0870		0.0344	0.0217		0.0000	0.0435	0.0435	0.0543	0.0652	0.0522	0.4018
Bayou Cumbest No Action	0.0000				0.0000		0.0435	0.0435		0.0435	0.0000	0.0000	0.1087	0.0652	0.0000	0.3043
Admiral Island Scaled Weights	0.5526						0.0526	0.0526		0.0526			0.1316	0.0789	0.0789	
Admiral Island Ecosystem Plan 1	0.5526						0.0000	0.0000		0.0526			0.0439	0.0000	0.0789	0.7281
Admiral Island Ecosystem Plan 2	0.5526						0.0055	0.0088		0.0526			0.0219	0.0000	0.0789	0.7204
Admiral Island Ecosystem Plan 6	0.5526						0.0085	0.0175		0.0526			0.0000	0.0000	0.0789	0.7102
Admiral Island Ecosystem Plan 3	0.5526						0.0083	0.0175		0.0526			0.0000	0.0000	0.0789	0.7101
Admiral Island No Action	0.0000						0.0526	0.0526		0.0000			0.1316	0.0789	0.0000	0.3158
Dantzler Scaled Weights			0.4333				0.0667	0.0667		0.0667			0.1667	0.1000	0.1000	
Dantzler Ecosystem Plan 1			0.4333				0.0000	0.0000		0.0667			0.0000	0.0400	0.1000	0.6400
Dantzler Ecosystem Plan 5			0.2634				0.0298	0.0333		0.0222			0.0667	0.0000	0.0500	0.4654
Dantzler No Action			0.0000				0.0667	0.0667		0.0000			0.1667	0.1000	0.0000	0.4000
Dantzler Ecosystem Plan 3			0.1700				0.0358	0.0167		0.0444			0.0333	0.0200	0.0750	0.3952
Franklin Creek Scaled Weights			0.4333				0.0667	0.0667		0.0667			0.1667	0.1000	0.1000	
Franklin Creek Ecosystem Plan 1			0.4333				0.0000	0.0000		0.0667			0.0000	0.0250	0.1000	0.6250
Franklin Creek No Action			0.0000				0.0667	0.0667		0.0000			0.1667	0.1000	0.0000	0.4000
Franklin Creek Ecosystem Plan 3			0.1629				0.0442	0.0167		0.0444			0.0333	0.0000	0.0750	0.3765
Forrest Heights Scaled Weights				0.3830	0.0851	0.0851	0.0426	0.0426		0.0426	0.0426	0.0426	0.1064	0.0638	0.0638	
Forrest Heights No Action				0.3830	0.0000	0.0000	0.0426	0.0426		0.0000	0.0000	0.0000	0.1064	0.0638	0.0000	0.6383
Forrest Heights Plan 1				0.2082	0.0850	0.0850	0.0142	0.0000		0.0355	0.0319	0.0319	0.0213	0.0000	0.0511	0.5640
Forrest Heights Plan 2				0.0000	0.0851	0.0851	0.0000	0.0000		0.0426	0.0426	0.0426	0.0000	0.0319	0.0638	0.3936
Nonstructural Scaled Weights					0.1290	0.1290	0.0645	0.0645	0.0645	0.0645	0.0645	0.0645	0.1613	0.0968	0.0968	
Long-term Homeowners Assistance Plan					0.1290	0.1290	0.0000	0.0000	0.0645	0.0000	0.0426	0.0426	0.0000	0.0000	0.0638	0.4715
High Risk Homeowners Assistance Plan					0.0138	0.0138	0.0606	0.0323	0.0258	0.0426	0.0319	0.0213	0.0638	0.0000	0.0479	0.3537
No Action Homeowners Assistance Plan					0.0000	0.0000	0.0645	0.0645	0.0000	0.0000	0.0000	0.0000	0.1064	0.0638	0.0000	0.2992

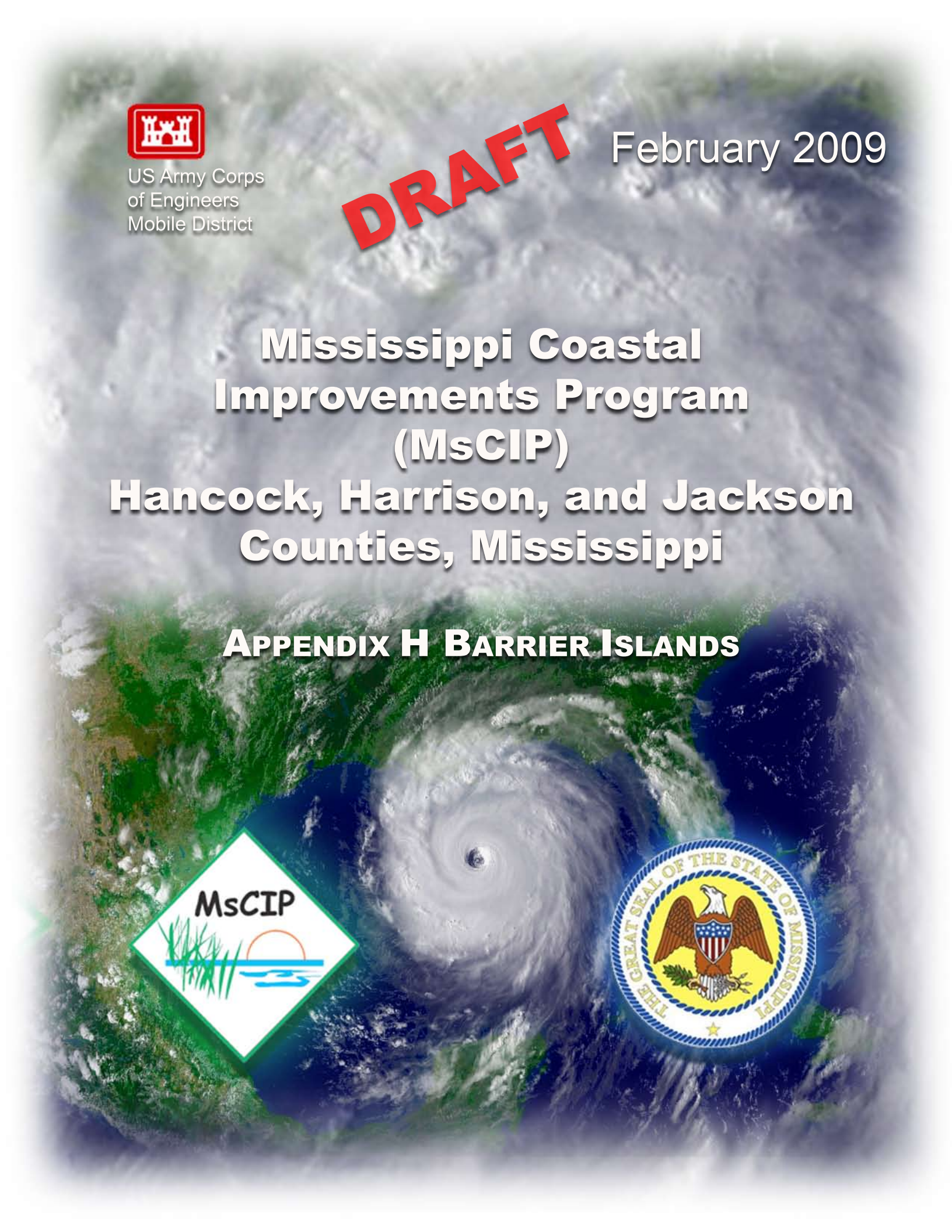
US Army Corps
of Engineers
Mobile District

DRAFT

February 2009

Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

Appendix H Barrier Islands



FOREWORD

This document is one of a number of technical appendices to the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Feasibility Report and Environmental Impact Statement.

The Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Integrated Feasibility Report and Environmental Impact Statement provides systems-based solutions and recommendations that address: hurricane and storm damage reduction, ecosystem restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion. The recommendations contained in the Main Report/EIS also provide measures that aid in: greater coastal environmental and societal resiliency, regional economic re-development, and measures to reduce long-term risk to the public and property, as a consequence of hurricanes and coastal storms. The recommendations cover a comprehensive package of projects and activities, that treat the environment, wildlife, and people, as an integrated system that requires a multi-tiered and phased approach to recovery and risk reduction, irrespective of implementation authority or agency.



The MsCIP Study Area

The purpose of the Comprehensive Plan Report is to present, to the Congress of the United States, the second of two packages of recommendations (i.e., the first being the “interim” recommendations funded in May 2007, and this “final” response, as directed by the Congress), directed at recovery of vital water and related land resources damaged by the hurricanes of 2005, and development of recommendations for long-term risk reduction and community and environmental resiliency, within the three-county, approximately 70 mile-long coastal zone, including Mississippi Sound and its barrier islands, of the State of Mississippi.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and an External Peer Review (EPR). Both review processes will have been conducted in accordance with the Corps "Peer Review of Decision Documents" process, has been reviewed by Corps staff outside the originating office, conducted by a Regional and national team of experts in the field, and coordinated by the National Center of Expertise in Hurricane and Storm Damage Protection, North Atlantic Division, U.S. Army Corps of Engineers.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing recommendations directed at assisting the people of the State of Mississippi in recovery, recommended actions and projects that would assist in the recovery of the physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

This appendix contains detailed technical information used in the analysis of existing and future without-project conditions, in the development of problem-solving measures, and in the analysis, evaluation, comparison, screening, and selection of alternative plans, currently presented as tentatively-selected recommendations contained in the Main Report/EIS.

Each appendix functions as a complete technical document, but is meant to support one particular aspect of the feasibility study process. However, because of the complexity of the plan formulation process used in this planning study, the information contained herein should not be used without parallel consideration and integration of all other appendices, and the Main Report/EIS that summarizes all findings and recommendations.

This appendix, The Comprehensive Barrier Island Restoration Plan Appendix, contains detailed supporting data and technical information on the engineering and environmental options that were configured to meet the goals of the Comprehensive Plan. The Comprehensive Barrier Island Restoration Plan was developed through a joint effort of many Federal agencies including the National park Service who has jurisdiction over most of Mississippi's barrier islands as part of the Gulf Islands National Seashore.

EXECUTIVE SUMMARY

Soon after Hurricane Katrina, the notion became widely accepted by the public that if the Mississippi barrier islands had been in a “pre-Hurricane Camille” condition, there would have been much less storm damage during Katrina. During Hurricane Camille, there was extensive land loss on the islands and little natural recovery had occurred since then. Also during Camille, Ship Island was breached and this breach has remained open and is now known as Camille Cut. This massive restoration of the barrier islands was included in the State’s Hurricane Recovery Program which was published soon after Katrina. During completion of the Mississippi Coastal Improvements Program Report, the Mississippi Barrier Islands were subject to several different design concepts for storm damage reduction including total restoration to the pre-Camille condition. These plans are fully described in the Engineering Appendix. Subsequent computer modeling of storm damage reduction benefits from any engineered changes reveal that storm surge reduction was not large, but other benefits would be obtained from simply maintaining the existence of the islands. These benefits include reduction of wave damage to the mainland coast and many important environmental benefits associated with maintaining Mississippi Sound as an estuary formed by the islands. Coordination with the National Park Service (NPS) who has ownership of most of the islands and other agencies has resulted in a plan that will provide continuing existence for the islands that have been badly eroded by storms. Ship Island received sufficient storm damage to endanger it’s survival in the future. This plan, the Comprehensive Barrier Island Restoration Plan, was coordinated with he NPS and includes direct sand placement in the breach of Ship Island with plantings of dune grasses, additional sand placed into the local littoral zone, changes in the Regional Sediment Management Practice, and additional studies of Cat Island where little data is available. The program also has the potential to make beneficial use of dredged material that has been deposited in both inland and offshore areas if quality objectives are clearly demonstrated. After implementation, a long term monitoring program will be established to monitor the project. This data will be extremely valuable in future programs such as this and can provide the NPS with information that they can use to better manage their coastal resources.

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CHAPTER 1 BACKGROUND AND GENERAL INFORMATION

The Barrier Island Restoration Plan consists of a comprehensive, all-inclusive plan to construct the best combination of the various options that have been developed for the Mississippi Barrier Islands. The State Plan to "restore the barrier islands to a pre-Camille footprint" offered many different ideas to accomplish this goal. An important factor that was not forgotten during this study was that the Mississippi Barrier Islands are owned within the National Park Service as the "Gulf Islands National Seashore". Coordination with many agencies has resulted in a plan that will provide many benefits including economic, environmental and storm damage reduction. The loss of land mass on the barrier islands has been documented and the continued loss will result in a change in the ecology of the Mississippi Sound that is formed by the island chain. The best method to accomplish any restoration requires that the different options be integrated to maximize benefits and prevent any adverse environmental impacts, modeled to predict the best benefits from any sand placement, and to bring consensus to the many agencies that would be involved in this type of plan. The options discussed in the Engineering Appendix that have been based on three basic concepts for island restoration and identified to include:

- Adding additional land mass to the existing islands by using sand dredged and transported from an off-shore location. The new land mass would be shaped into dunes and marshes and planted with native marsh, maritime forest and dune vegetation or simply planted with these types of vegetation and allowing the effects of nature to create the land forms. The anticipated source of the sand is the St. Bernard Shoals, but this needs further investigation to verify the quantity and quality of the sand.

- Adding sand into the littoral zone at specific locations between the islands based on additional sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system. This option would obtain the sand from the beneficial use of dredged material from an inland river source or from offshore borrow areas.

- Planting native vegetation to help provide environmental restoration of the existing islands where the vegetation was destroyed by Katrina. These options may also consist of shaping existing sand into low dunes on the beaches or adding sand from an offshore source to create dunes several feet above the existing beach. These dunes would be planted with sea oats to help in the re-establishment of the dunes on the beaches. This would be along with planting of maritime forests in the inland's interior where they were mostly destroyed by Hurricane Katrina. This plan was completed during the fall of 2007 and combined two of the engineering options described in the Engineering Appendix, incorporated some additional studies at Cat Island and recommended changes in the current practices under the Regional Sediment Management Plan. In compiling this plan, several documents were used. In the order included in this appendix is the "National Park Service Vision Statement for the Mississippi Barrier Islands", results of the "Sediment Transport Modeling and Sediment Budget", studies of "Inland River Sand Sources for Use at Barrier Islands", an "Overview of All Barrier Island Options (Line of Defense-1) from Engineering Appendix", and the "Multi-agency Mississippi Barrier Island Restoration Recommendation". The resulting plan is included in Chapter 7 as "The Comprehensive Barrier Island Restoration Plan". After completion of sand placement and planting vegetation, the project will be subject to an 11 year monitoring program described in Chapter 7.

CHAPTER 2 NATIONAL PARK SERVICE VISION STATEMENT

During the study phase for the Barrier Islands, the National Park Service (NPS) issued a Vision Statement for the Mississippi Barrier Islands. As a tool for the planners and engineers, this document set forth the details of any modifications that might be conceived for the barrier islands during this study that would carry the endorsement of the NPS. A copy of this document is included below.

United States Department of the Interior

NATIONAL PARK SERVICE
Southeast Regional Office
Atlanta Federal Center
1924 Building
100 Alabama St., SW.
Atlanta, Georgia 30303

IN REPLY REFER TO:
SER-SNRM

JUN 22 2007

Brigadier General Joseph Schrodel
Commander, South Atlantic Division
U. S. Army Corps of Engineers
60 Forsyth Street, Room 9M15
Atlanta, GA 30303-8801

Dear General Schroedel:

As requested by the Mississippi Coastal Improvements Program (MsCIP) Planning Team Program Manager, Dr. Susan Rees, in January 2007, the National Park Service has prepared and is enclosing its "Vision Statement for the Management of the Mississippi Barrier Islands, Gulf Islands National Seashore, National Park Service, June 22, 2007." This document is being copied to the MsCIP Project Delivery Team – Mobile, for incorporation into the draft Comprehensive Plan (MsCIP), which will be released in the fall of 2007 for agency and public reviews fall of 2007.

We appreciate the opportunity to participate in and provide feedback for this important planning process, and we look forward to a continued cooperative relationship with the U.S. Army Corps of Engineers Mississippi Coastal Improvements Program. Please let us know if we can provide additional information.

Sincerely,

Kat Fredrick

Patricia A. Hooks
Regional Director
Southeast Region

For

Enclosure

cc: Colonel Peter F. Taylor, Jr., COE w/ enclosure
cc: Dr. Susan Rees, COE w/ enclosure

TAKE PRIDE IN AMERICA

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cc: Mississippi Coastal Improvements Program, COE w/ enclosure
cc: Jerry Eubanks, Superintendent, NPS – GUIS
cc: Sam D. Hamilton, Southeast Regional Director, USFWS
cc: Ray Aycock, USFWS - ES/MS
cc: Suzette Kimball, Eastern Regional Director, USGS
cc: Jack Kindinger, Deputy Director for Science / St. Petersburg, USGS
cc: S. Jeffress Williams, Coastal Marine Geologist / Woods Hole, USGS

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Vision Statement for the
Management of the Mississippi Barrier Islands
Gulf Islands National Seashore
National Park Service

June 2007

Executive Summary

The National Park Service (NPS) has a direct interest in the barrier island components of the Mississippi Coastal Improvements Program (MsCIP), since Horn, Petit Bois, East and West Ship Islands, and portions of Cat Island are within Gulf Islands National Seashore (Seashore). The Seashore's purpose is to preserve, protect, and interpret its Gulf Coast barrier island and bayou ecosystem and its system of coastal defense fortifications, while providing for public use and enjoyment. Undeveloped natural resource areas protected by the NPS provide habitat for several endangered species, stop-over habitat for migratory birds, and critical nursery habitat for marine flora and fauna, and serve as an enclave for complex terrestrial and aquatic plant and animal communities that characterize the northern Gulf Coast. The Seashore also contains one of the most complete collections of publicly accessible seacoast defense structures in the United States, from early French and Spanish exploration and colonization through World War II.

Barrier islands are dynamic coastal landforms that act as the interface between ocean and land, and bear the full impact of atmospheric and oceanic energy. Hurricanes, variations in sediment supply, and sea level rise anticipated from global warming will drive changes in island location and morphology. Effective barrier island management requires adaptation to their dynamics.

Based on federal statutes such as the National Park Service Organic Act and the park's enabling legislation, NPS Management Policies, and the Seashore's management plans, the NPS is mandated to preserve natural conditions and processes, and to preserve cultural resources. If peer-reviewed scientific studies indicate that human activities have altered or interfered with natural conditions or processes of the Mississippi barrier islands, such as the natural sediment supply and transport rate and direction, the NPS would consider actions that would attempt to restore those natural processes. Restoration of natural processes would help to re-establish a more natural biological and geological condition within park boundaries.

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Restoration actions that NPS may consider acceptable and consistent within its legal mandates and authorities are:

Immediate measures (1 year or less)

- Sediment dredged from Ship Island Pass channel should be placed on the beach along the north (sound) shoreline near Fort Massachusetts on West Ship Island. The fort is a listed classified structure on the National Register of Historic Places. Renourishment would better protect the structural integrity of the fort, which currently is threatened by shoreline erosion, migration, and encroachment. Beach renourishment near the documented French Warehouse archaeological site on East Ship Island should also be undertaken, as this site is also currently exposed and threatened by erosion.
- Placement of sand fencing on the upper beach areas of East and West Ship Islands would assist natural dune formation and enhance wildlife habitat. Similar actions would not be appropriate on Horn and Petit Bois Islands given their designation as wilderness areas.
- Planting of sea oats and other native beach grasses and vegetation on East and West Ship Islands would aid the process of natural dune formation.

Long term measures

- Sand dredged from adjacent navigational/shipping channels should be re-deposited within the littoral system of the barrier islands. The additional sand supply would assist the island's natural recovery from recent storm events, and partially offset prior disruption to sediment transport and deposition from past human intervention. The sand must be free from contaminants and compatible in grain size, composition, and color with the existing beach and nearshore sediments.
- A Quality Assurance/Quality Control plan should be developed that includes adaptive management steps to halt, modify or mitigate the effects of activities with negative or adverse impacts to natural or cultural resources.

In order to make informed management decisions, and before beginning long-term measures, the NPS recommends additional scientific study to ensure that actions are effectively targeted and will not harm park resources.

1. Measure bathymetry to 40-ft depth from Dauphin Island to Cat Island, to help develop an improved sediment budget from 1917/20 (the most recent data set with complete bathymetric coverage) to the present.
2. Develop models to predict future location and geometry of the barrier islands at specific time intervals, perhaps 25, 50 and 100 years or longer into the future. Models should include forecasts of sea-level rise linked to global climate change.
3. Assess the quantity of sediment that has entered the Mississippi barrier island system through time from Mobile Pass and the Mobile ebb tidal delta, the primary source of sediment to the barrier islands.
4. Examine barrier island morphologic changes since the 2005 hurricane season to determine the extent of post-storm recovery.

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I. Introduction

The National Park Service (NPS) has a direct interest in the barrier island components of the Mississippi Coastal Improvements Program (MsCIP). These barrier islands -- Horn, Petit Bois, East and West Ship Islands, and portions of Cat Island -- are all situated within Gulf Islands National Seashore, a unit of the National Park System. NPS also administers the 401-acre Davis Bayou area on the mainland near Ocean Springs, MS.

Gulf Islands National Seashore includes outstanding natural, cultural, and recreational resources along the Northern Gulf of Florida and Mississippi. These include several coastal defense forts spanning more than two centuries of military activity, archeological values, pristine examples of intact Mississippi coastal barrier islands, salt marshes, bayous and submerged seagrass beds, complex terrestrial communities, emerald green water, and white sand beaches.

The barrier islands within the Seashore are nationally significant for several reasons. Specifically, these islands:

1. Contain one of the most complete collections of publicly accessible seacoast defense structures in the United States, representing a continuum of development from early French and Spanish exploration and colonization through World War II.
2. Provide the public with recreational opportunities on natural and scenic island, beach, dune and water areas which possess the rare combination of remaining undeveloped and in a wilderness state, yet are located in close proximity to major population centers.
3. Provide habitat for several endangered species in diverse ecosystems, stop-over habitat for migratory birds, and critical nursery habitat for marine flora and fauna, and serve as an enclave for complex terrestrial and aquatic plant and animal communities that characterize the northern Gulf Coast and fully illustrate the natural processes which shape these unique areas.
4. Contain land and marine archeological resources which represent a continuum of human occupation in a coastal environment and are important in enhancing the knowledge of the past including interactions between the earliest settlers and original inhabitants of this area of the Gulf Coast.
5. Provide a benchmark to compare conditions in developed areas of the Gulf Coast to natural areas within the park.

The NPS manages the Gulf Coast barrier island system in accordance with the various federal laws which govern the National Park System and Gulf Islands National Seashore, NPS national management policies, and park-specific planning and management documents. The NPS management vision for the barrier islands, and several restoration actions potentially consistent with that vision, are explained in Section II. The legal, policy, and administrative authorities which form the foundation of the NPS's vision are explained in Section III. NPS management questions involving further scientific studies

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are presented in Section IV. The geomorphic origin and history of the island chain are explained in Appendix A.

II. NPS's Vision for the Mississippi Barrier Islands

The NPS's vision for management of the Mississippi barrier islands includes the preservation of natural biological and geological marine and terrestrial conditions and processes, and the preservation of cultural resources, consistent with peer-reviewed and documented scientific study.

Horn and Petit Bois Islands, which are designated wilderness areas, receive an even higher level of protection. In these areas, the NPS vision and management focuses on providing park visitors with an undisturbed environment, a pristine and unencumbered viewshed, an atmosphere of solitude, an opportunity for primitive, unconfined recreation, and negligible evidence of resource impairment. The NPS implements this vision by controlling nonconforming uses, preventing unnecessary or undue reduction of wilderness values, and applying the "minimum requirement" concept of the 1964 Wilderness Act to all proposed projects involving these islands.

The NPS's vision for the Mississippi barrier islands reflects an appreciation for the islands' geomorphic origin and history (see Appendix A). Studies indicate that hurricanes have historically segmented these barriers. A hurricane in 1740 split Isle Dauphin into Petit Bois and Dauphin Islands, while the July 1916 storm cut the Isle of Caprice in two. Furthermore, in 1969, Hurricane Camille split Ship Island into West Ship and East Ship Islands. Hurricanes, variations in sediment supply, and sea level rise anticipated from global warming will drive changes in island location and morphology. Effective barrier island management requires adaptation to their dynamics.

Nonetheless, if peer-reviewed studies provide evidence that human activities have altered or interfered with the natural condition or processes of the Mississippi barrier islands, such as the natural sediment supply and transport rate and direction, the NPS would consider actions that would attempt to restore these natural processes. Restoration of natural processes would, in turn, help to reestablish a more natural biological and geological marine and terrestrial condition within park boundaries, which NPS is charged to promote. Adaptive management principles would govern restoration actions, facilitated by continuing analysis of monitoring data to assess project effectiveness.

The following are restoration actions and associated specifications that NPS may consider acceptable and consistent with the legal mandates and other authorities listed above. NPS restoration actions identified below are contingent upon dedicated funding support for materials and staffing being provided as a component or line item cost incorporated into the MsCIP, as current NPS base funding is insufficient to cover these expenditures.

Immediate measures (1 year or less)

- Sediment dredged from Ship Island Pass channel should be placed on the beach along the north (sound) shoreline near Fort Massachusetts on West Ship Island. The fort is a listed classified structure on the National Register of Historic Places. Renourishment would better protect the structural integrity of the fort, which currently is threatened by active shoreline processes, including erosion, migration, and encroachment. Similarly, beach renourishment near the documented French Warehouse archeological site (GUIS-98, 22Hr-638) on East Ship Island would also be undertaken, as this site is also currently exposed and threatened by erosion due to active shoreline processes.

- Placement of sand fencing behind the upper beach area on both East Ship and West Ship Islands to assist in the process of natural dune formation and enhance wildlife habitat. Specific length and placement design of fencing will be determined in cooperation with park staff. Similar actions on Horn and Petit Bois islands are not feasible considering their designation as wilderness areas, and the coinciding higher conservation standards, and non-manipulative management objectives applying to these areas, as stipulated in Section III, C of this document.

- Planting of sea oats and other native beach grasses and vegetation on East and West Ship Islands as deemed appropriate by park science and natural resources management staff. The native vegetation could also aid in the process of natural dune formation.

Long term measures

- Sediment (sand) dredged from any of the adjacent navigational/shipping channels should be re-deposited within the littoral system of the barrier islands. Sand would be placed to mimic to the greatest extent possible natural sediment depositional processes, including within the surf zones, or as otherwise prescribed based on analysis of the longshore transport system. Sand placement would supplement the supply to the island where it has been significantly diminished or eliminated by dredging of shipping channels, with an estimated withdrawal of ~72 mcy of sand from the system over the last 100+ years. The additional sand supply would assist the island's natural recovery from recent storm events, and partially offset prior disruption to sediment transport and deposition from human-caused intervention.

- Any placement of dredged sediment within the park boundaries, whether on a barrier island beach or within the littoral system, would be contingent upon tests that show that the sediments are free from contaminants and are compatible in grain size, composition, and color with the existing beach and nearshore sediments. Dredging and sediment disposal, which have a significant potential to

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impact many of the animal communities on and around the islands, should be timed to avoid periods of high or seasonal animal activity. Limiting sediment dredging and disposal actions to certain months would reduce or minimize impacts to several threatened and endangered species that spend at least a portion of the year within the barrier island area, as well as non-listed species such as migratory shorebirds which may be particularly sensitive to on-island and nearshore disturbances.

- A Quality Assurance/Quality Control (QA/QC) plan should be developed, possibly as part of the NEPA or environmental compliance process, to monitor both adverse and beneficial impacts of any activities undertaken within the boundaries of GUIS as part of the MSCIP. The QA/QC plan should include monitoring during construction activities to measure immediate or short-term impacts, as well as for a specified time period after construction activities are completed to measure long-term or cumulative impacts. The plan should also include adaptive management steps to halt or modify activities, or to mitigate the effects of activities, should negative or adverse impacts to natural or cultural resources be noted during monitoring. The QA/QC plan would be developed through coordination between the US Army Corps of Engineers, National Park Service, the US Fish and Wildlife Service and the National Marine Fisheries Service.

III. Statutory, Policy, and Administrative Foundation of the NPS Vision for the Mississippi Barrier Islands

The NPS vision for managing the Mississippi barrier islands is derived directly from the federal laws which govern the National Park System and Gulf Islands National Seashore. Because Horn and Petit Bois Islands are also designated wilderness areas, the NPS's vision for these islands is additionally derived from the law which established the National Wilderness Preservation System.

A. Statutory Basis for NPS Management of the Mississippi Barrier Islands

In the **National Park Service Organic Act of 1916** (16 U.S.C. § 1), Congress stated that "There is hereby created in the Department of the Interior a service to be called the National Park Service, which shall be under the charge of a director....The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified, except such as are under the jurisdiction of the Secretary of the Army, as provided by law, by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

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Subsequently, in the **National Park System General Authorities Act of 1970**, Congress clarified that national park areas are to be "preserved and managed for the benefit and inspiration of all of the people of the United States, in light of the high public value and integrity of the National Park System" (16 U.S.C. § 1a-1). In the **National Parks Omnibus Management Act of 1998,** Congress instructed the NPS to integrate the results of scientific research into its management decisions (16 U.S.C. § 5936).

In the **enabling legislation which established Gulf Islands National Seashore**, Congress instructed the NPS to preserve for public use and enjoyment the outstanding natural, historic, and recreational values of the area, including wildlife natural resources and the military forts within the park (16 U.S.C.§ 459h). Congress further stipulated that "[t]he Secretary of the Interior and the Secretary of the Army may cooperate in the study and formulation of plans for beach erosion control and hurricane protection of the Seashore. Any such protective works or spoil deposit activities undertaken by the Chief of Engineers, Department of the Army, shall be carried out within the seashore in accordance with a plan that is acceptable to the Secretary of the Interior and that is consistent with the purposes of sections 459h to 459 h-10 of this title."

As required by the **Endangered Species Act of 1973** (16 U.S.C. § 1531 et seq.), the NPS also strives to conserve threatened and endangered species at Gulf Islands National Seashore, ensuring that its authorization, funding, or implementation of activities will not jeopardize the existence of any endangered or threatened species of plant or animal (including fish) or result in the destruction or deterioration of critical habitat of such species.

The Mississippi barrier islands also contain a number of sites of historic/archaeological value, including Fort Massachusetts on West Ship Island, which is a listed classified structure on the National Register of Historic Places. The NPS preserves these cultural resources and landscapes as required by the **National Historic Preservation Act** (16 U.S.C. § 470 et seq.).

Additionally, Horn and Petit Bois islands are designated wilderness areas and are therefore subject to the provisions of the **Wilderness Act of 1964** (16 U.S.C. §§ 1131, 1133), which directs federal land management agencies to preserve the wilderness character of the areas, including the preservation of natural conditions with the imprint of man's work substantially unnoticeable.

B. Policy Basis for NPS Management of the Mississippi Barrier Islands

The NPS's management vision for the Mississippi barrier islands is additionally derived from the Service-wide NPS Management Policies. Updated in 2006 after extensive review and comment from the general public, the scientific community, and agency employees, the NPS Management Policies are mandatory for all NPS employees unless specifically waived or modified in writing by the Secretary of the Interior, the Assistant Secretary of the Interior, or the Director of the National Park Service.

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The sections of the NPS Management Policies most relevant to NPS management of the Mississippi barrier islands are quoted here. The policies are available in their entirety at www.nps.gov/policy/mp/policies.html or www.nps.gov/policy/MP2006.pdf.

(1) Section 4.4.2.4: Management of Natural Landscapes

"Natural landscapes disturbed by natural phenomena, such as landslides, earthquakes, floods, hurricanes, tornadoes, and fires, will be allowed to recover naturally unless manipulation is necessary to (1) mitigate for excessive disturbance caused by past human effects, (2) reserve cultural and historic resources as appropriate based on park planning documents, or (3) protect park developments or the safety of people. Landscape and vegetation conditions altered by human activity may be manipulated where the park management plan provides for restoring the lands to a natural condition."

(2) Section 4.8.1.1: Shorelines and Barrier Islands

"Natural shoreline processes (such as erosion, deposition, dune formation, overwash, inlet formation, and shoreline migration) will be allowed to continue without interference. Where human activities or structures have altered the nature or rate of natural shoreline processes, the Service will, in consultation with appropriate state and federal agencies, investigate alternatives for mitigating the effects of such activities or structures and for restoring natural conditions…Any shoreline manipulation measures proposed to protect cultural resources may be approved only after an analysis of the degree to which such measures would impact natural resources and processes, so that an informed decision can be made through an assessment of alternatives. Where erosion control is required by law, or where present developments must be protected in the short run to achieve park management objectives, including high-density visitor use, the Service will use the most effective method feasible to achieve the natural resource management objectives while minimizing impacts outside the target area."

(3) Section 4.1.5: Restoration of Natural Systems

"The Service will reestablish natural functions and processes in parks unless otherwise directed by Congress. Landscapes disturbed by natural phenomena, such as landslides, earthquakes, floods, hurricanes, tornadoes, and fires, will be allowed to recover naturally unless manipulation is necessary to protect other park resources, developments, or employee and public safety. Impacts on natural systems resulting from human disturbances include the introduction of exotic species; the contamination of air, water, and soil; changes to hydrologic patterns and sediment transport; the acceleration of erosion and sedimentation; and the disruption of natural processes. The Service will seek to return such disturbed areas to the natural conditions and processes characteristic of the ecological zone in which the damaged resources are situated. The Service will use the best available technology, within available resources, to restore the biological and physical components of these systems, accelerating both their recovery and the recovery of landscape and biological community structure and function."

(4) Section 4.4.1: General Principles for Managing Biological Resources

"The National Park Service will maintain as parts of the natural ecosystems of parks all plants and animals native to park ecosystems….by

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- preserving and restoring the natural abundances, diversities, dynamics, distributions, habitats, and behaviors of native plant and animal populations and the communities and ecosystems in which they occur; …. and
- minimizing human impacts on native plants, animals, populations, communities, and ecosystems, and the processes that sustain them."

(5) Section 4.4.2.3: Management of Threatened or Endangered Plants & Animals

"The Service will survey for, protect, and strive to recover all species native to national park system units that are listed under the Endangered Species Act. The Service will fully meet its obligations under the NPS Organic Act and the Endangered Species Act to both proactively conserve listed species and prevent detrimental effects on these species."

(6) Section 4.6.4: Floodplains

"In managing floodplains on park lands, the National Park Service will (1) manage for the preservation of floodplain values; (2) minimize potentially hazardous conditions associated with flooding; and (3) comply with the NPS Organic Act and all other federal laws and executive orders related to the management of activities in flood-prone areas, including Executive Order 11988 (Floodplain Management), the National Environmental Policy Act, applicable provisions of the Clean Water Act, and the Rivers and Harbors Appropriation Act of 1899."

(7) Section 4.6.5: Wetlands

"The Service will manage wetlands in compliance with NPS mandates and the requirements of Executive Order 11990 (Protection of Wetlands), the Clean Water Act, the Rivers and Harbors Appropriation Act of 1899, and the procedures described in Director's Order 77-1 (Wetland Protection). The Service will (1) provide leadership and take action to prevent the destruction, loss, or degradation of wetlands; (2) preserve and enhance the natural and beneficial values of wetlands; and (3) avoid direct and indirect support of new construction in wetlands unless there are no practicable alternatives and the proposed action includes all practicable measures to minimize harm to wetlands."

(8) Sections 6.1, 6.3.3, 6.3.5, & 6.3.7: Wilderness Management

These sections direct the National Park Service to manage wilderness areas for the use and enjoyment of the American people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness. They further charge the NPS to (1) administer designated wilderness lands consistently among agencies but in no way diminish any established NPS wilderness standards and values.; (2) keep human-caused intrusions within wilderness to an absolute minimum; (3) ensure proposed actions are narrow in scope and the least required to effectively preserve wilderness character; and (4) apply science-based decision making in all NPS wilderness areas.

(9) Sections 5.3.5, 5.3.5.1, 5.3.5.1.1-4: Cultural Resources

Recognizing that the NPS is the steward of many of America's most important cultural resources, including archeological sites, as well as historic and prehistoric structures, the NPS Management Policies specify that park cultural resource management involves: (1)

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research to identify, evaluate, document, register, and establish basic information about cultural resources and traditionally associated peoples; (2) planning to ensure that management processes for making decisions and setting priorities integrate information about cultural resources and provide for consultation and collaboration with outside entities; and, (3) stewardship to ensure that cultural resources are preserved and protected, receive appropriate treatments to achieve desired conditions, and are made available for public understanding and enjoyment.

C. Administrative Planning Basis for NPS Management of the Mississippi Barrier Islands

In 1978, Gulf Islands National Seashore produced a General Management Plan (GMP) which provides long-term direction for administering the Seashore. Congress requires each park unit to have a GMP to guide park decisions about resource preservation, visitor use, and park management. GMPs are developed and adopted with much public review and input. Gulf Islands National Seashore is developing a new General Management Plan, which is anticipated to be completed in 2009-2010. Until then, the existing 1978 GMP, its 1983 amendment, and a 1995 updated Statement for Management will remain in effect.

As directed by the 1978 GMP, the NPS must manage the Mississippi barrier islands in the following ways:

- Keep development to a minimum, and manage Petit Bois and Horn Islands as wilderness areas emphasizing their primitive character and limited development.
- Promote diverse marine biota in Mississippi Sound, and the surrounding Gulf of Mexico waters and diverse estuarine biota at Davis Bayou, and assure that activities within the Seashore have the least possible effect on the population of fish, shellfish, and other marine and estuarine organisms.
- Minimize disturbance of natural landforms, vegetation, and wildlife by human-caused activities and restoring ecological conditions on lands adversely affected by such uses and activities in the past.
- Protect and perpetuate the Seashore's natural resources and managing them in ways that enhance natural, ecological, and geological processes and mitigate the adverse effects of human activities.
- Perpetuate suitable habitat conditions to support the Seashore's rich flora and fauna, with particular emphasis on Federally or State endangered or threatened species or, other species of management concern.
- Allow for the natural processes of storms and hurricanes related to barrier island development, by minimizing construction and development of facilities in areas prone to natural channelization and overwash, or otherwise dynamically active.

NPS management of Horn and Petit Bois Islands is also based on the Congressionally-mandated Wilderness Management Plan, completed in 2004. In accordance with this plan, the NPS objectives for these island wilderness areas are to (1) provide for solitude and primitive, unconfined recreation; (2) preserve the character of the wilderness, including a pristine, unencumbered viewshed; and (3) control nonconforming use and

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prevent unnecessary or undue reduction of wilderness values. The plan further establishes that the NPS's desired future condition for Horn and Petit Bois Islands is a wilderness area unaffected by the works and acts of humankind, where minimum tools or techniques are used in the completion of any project.

IV. Information Needs for NPS Management

The questions listed below were developed by NPS to highlight perceived scientific data needs and research gaps with respect to geomorphology issues to be addressed for NPS to make informed management decisions as to potential restoration alternatives for the barrier islands as part of the MsCIP. The study needs following the questions identify studies and research likely to yield data that could be used to address NPS management needs framed in the questions. The study needs should be regarded as only an initial list, and NPS would welcome the opportunity to work with the Army Corps of Engineers and the U.S. Geological Survey, as well as other agencies, to further refine these study needs.

A. NPS Scientific Data/Research Questions

1. To what extent have human-caused actions, principally from dredging of shipping channels in proximity to the MS barrier islands, altered the sediment transport and depositional processes of the islands?
2. Taking a modeling approach, what would the configuration/make-up of the MS barrier islands be today had sediment transport processes not been disrupted through human intervention, including reoccurring dredging to maintain adjacent shipping channels?
3. Taking a modeling approach, what is the projected future (25, 50, & 100-year intervals) configuration/make-up of the barrier islands given existing conditions vs. what the islands may otherwise look like if natural processes, including hurricane effects, were the only contributing factor to island migration historically and over time?
4. Factoring in the unpredictability of climate change and sea level rise, as well as hurricane frequency, what is the projected future location and configuration of the barrier islands (25, 50, & 100-year intervals)? The modeling studies should use both the long-term relative sea-level rise for the area, as well as one or more increased rates of sea-level rise as predicted with global climate warming data.
5. Given the present sediment transportation and depositional processes, where might additional sand be introduced into the active coastal system to most effectively maintain the MS barrier islands?

B. Further Study Needs

1. Measurement of the present-day bathymetry to a 40-ft depth for the Mississippi barrier island area from Dauphin Island to Cat Island. The most recent bathymetric data from 1960/1971 included only limited

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coverage offshore of the barrier islands. More extensive coverage of the present-day bathymetry could be used to formulate an improved historical sediment budget from 1917/20 (the most recent data set with complete bathymetric coverage) to the present. Measurement of the present-day bathymetry would allow the ongoing dredging and placement activities around Ship Island Pass and Horn Island Pass to be incorporated into the sediment budget.

2. Modeling studies to predict future location and geometry of the barrier islands at various scenarios of sea level rise. Existing information on historical shoreline change, bathymetric change, and dredging records, as well as any additional present-day bathymetric data that could be collected, may also be utilized in the studies that would predict future change in the barrier islands at specific time intervals (perhaps 25, 50, 100 years or longer) in the future. The modeling studies should use both the long-term relative sea-level rise for the area, as well as one or more increased rates of sea-level rise as predicted with global climate warming data.
3. Better understanding of the quantity of sediment that has entered the Mississippi barrier island system from Mobile Pass and the Mobile ebb tidal delta, the origin of the sediment supply to the barrier islands. A sediment budget should be developed for the Dauphin Island area that would quantify sediment transport from Mobile Pass and the Mobile Pass ebb tidal delta to Dauphin Island, and from Dauphin Island westward towards Petit Bois Island. A historical sediment budget could be developed based on existing bathymetric change, shoreline position change and dredging records. A hypothetical present-day sediment budget could also be developed based upon present-day bathymetric data and shoreline positions, incorporating dredging activities in and around Mobile Pass.
4. Studies to examine barrier island morphologic changes since the 2005 hurricane season to help determine the extent of storm recovery. Studies may use a combination of data sets, and include for example, the present-day bathymetry and hypothetical sediment budget. Full LiDAR (scanning airborne laser altimetry) and aerial video and photography coverage of the islands could be collected and compared with post-Katrina data collected in 2005 to quantify changes in elevation and shoreline position. Precise shoreline position and elevation data may also be collected in the field using high resolution GPS ground surveys to verify the laser altimetry data. These data sets may help identify the most effective locations and quantities of additional sediment to be introduced into the barrier island littoral system.

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Appendix A
Geomorphology of the Mississippi Barrier Islands

Barrier islands are extremely dynamic coastal landforms. They act as the interface between ocean and land, and bear the full impact of atmospheric and oceanographic energy. Composed primarily of sand and water, the features and habitats of the islands are constantly changing and evolving through time. The following excerpt from the Geologic Resource Evaluation Scoping Summary for Gulf Islands National Seashore (KellerLynn, 2007) briefly describes the origin and history of the Mississippi barrier islands located within the seashore.

The six barrier islands along the Mississippi Sound are parallel to the Pleistocene mainland coast (fig. 1). Dauphin Island, the only island not part of the national seashore, is at the mouth of Mobile Bay; westward are Petit Bois, Horn, East Ship, West Ship, and Cat islands. The sound behind the islands is very wide, more than 7 miles (11 km) on average, and deepens gradually from the mainland shore to the islands, with depths exceeding 20 feet (6.1 m) locally (Kwon, 1969).

As in Florida, the barrier islands in Mississippi formed from shoals (Otvos, 1979). Natural interactions between relative sea level, sediment supply, and meteorological-oceanographic conditions, and human-induced changes from dredging, sediment diversion, and habitat modifications resulted in the present configuration (Schmid, 2003). According to Otvos and Giardino (2004), the earliest barrier islands emerged between 5,700 and 5,000 years ago, when sea level was lower than present by 3.2 to 4.9 feet (1.0–1.5 m).

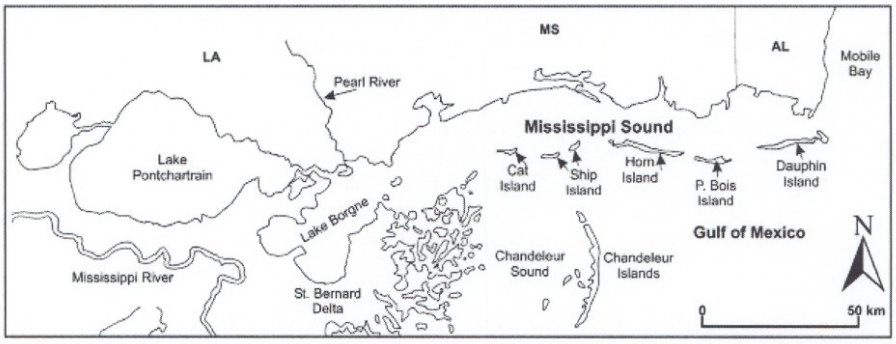


Figure 1. Index map of major landforms in the Mississippi Sound barrier island chain. *Source*: Otvos and Giardino (2004).

The islands formed against a background of decelerating late Holocene sea-level rise. At this time, eastern Dauphin Island represented a higher Pleistocene ground that was veneered by Holocene beach and dune deposits. Dauphin Island became the transmission site for large volumes of littoral sand. From this small island, the rest of Dauphin Island

aggraded and extended westward as a narrow, shore-parallel sandy shoal platform (Otvos and Giardino, 2004). By "capturing" the sand that arrived from the Alabama mainland shore through current and drift processes via the Mobile Bay ebb-tidal delta and steering it westward along its south shore, eastern Dauphin Island probably played an important role in originally determining the general offshore position of the whole barrier island chain, which extended well into southeastern Louisiana (Otvos and Giardino, 2004). Many new barrier sectors formed downdrift by gradual extension over adjacent shoal platform areas.

Historic trends indicate that island reduction by storm and fair-weather erosion to subtidal levels alternated with periods of platform aggradation above low-tide level. For instance, the earliest islands and beach ridges of still existing islands east of Cat Island were replaced by shoal areas or more recent islands (Otvos, 1981). Square Handkerchief Shoal west of and aligned with Cat Island probably represents the platform of an extinct barrier (Otvos and Giardino, 2004). Between 3,500 and 4,000 years ago, the St. Bernard delta of the Mississippi River (see fig. 1) prograded into the area west of the Mississippi barrier islands. Mainland extension and marsh development as a result of this progradation stranded the barrier islands and halted their westward migration. Sediments from the delta created shoals in present-day Mississippi Sound, which interrupted westward-directed littoral drift, diminished the impact of the Gulf wave regime, and deactivated Cat Island and the Square Handkerchief Shoal by approximately 2,400 years ago. Cat Island, its sand supply from the other islands cut off by surrounding shoal waters, kept eroding on its eastern end. Shore erosion, combined with subsidence, eliminated the oldest ridge sets off northern Cat Island long ago (Otovs, 1979). Another example of periodic erosion and aggradation is "Isle of Caprice," which existed between Horn and "Ship" islands between the early 1900s and 1940. This island and its neighboring group of islands ("Dog Keys") had a history of emergence, punctuated by episodes of these islets becoming shoals (Otvos, 1979; 1981).

The erosive history of the island chain suggests a relatively short life expectancy (Otvos and Giardino, 2004). French and British charts from the 18th century indicate that Dauphin and Petit Bois islands once formed a single entity ("Isle Dauphin") (Otvos, 1979). The oldest (eastern) part of Petit Bois Island formed the western sector of this ancient island that also incorporated present-day Dauphin Island. After Petit Bois and Dauphin were separated, Petit Bois gradually lost its narrow eastern sector. Widening to a record 5.3 miles (8.5 km) by 1957, Petit Bois Pass now overlaps with the former island area. Since the 1850s, Petit Bois has prograded westward, in downdrift direction (Otvos, 1979). While Petit Bois advanced approximately 3.1 miles (5.0 km) westward between 1850 and 1974, its 9.6-mile- (15.5 km) long eastern sector reverted to a shoal platform. Chart and survey data document a 26% area reduction in Ship, Horn, and Petit Bois islands, declining from a combined surface area of 15.5 square miles (40.2 km^2) in 1850 to 11.5 square miles (29.7 km^2) in 2000 (Otvos and Giardino, 2004).

Although episodic, hurricane destruction and segmentation have played an essential role in the evolution of all the Mississippi Sound barriers (Otvos, 1979) (see "Hurricane-generated Features" section). For instance, during the 1740 hurricane, Isle Dauphin was

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separated into Petit Bois and Dauphin islands (Otvos, 1979); Isle of Caprice was cut in two by the July 1916 hurricane (Otvos, 1979); and Ship Island was split into West Ship and East Ship islands during Hurricane Camille in 1969 (Falls, 2001). In 2005, Hurricane Katrina completely submerged the entire barrier island chain, segmenting several of the islands and causing significant erosion.

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CHAPTER 3 SEDIMENT TRANSPORT MODELING AND SEDIMENT BUDGET

3.1 Introduction and Purpose

In order to conceive any realistic plan for island restoration, it is necessary to understand the physical processes that move sand along the littoral drift zone off the coast of Mississippi. This littoral zone influences the character of the Mississippi barrier islands as they exist in an ever-changing cycle. To help in this understanding, a sediment transport model was conducted to establish a sediment budget for the islands. This study evaluated the existing regional sediment transport magnitudes and directions for the Mississippi and Alabama barrier islands fronting Mississippi Sound and the mainland coast, including an analysis of historical long-term barrier island migration. Based on analysis of previous studies, historical bathymetric and shoreline change, and numerical modeling, a suite of sediment budgets was developed. First, a conceptual sediment budget was developed through a review of existing studies; this budget formed the framework for the historical and calculated sediment budgets. Next, a historical sediment budget was developed through analysis of bathymetric and shoreline position change through time. Engineering activities and significant storm events were also documented. A calculated sediment budget was developed based on numerical modeling of regional waves and sediment transport, for the Gulf and Bay shorelines of the barrier islands as well as the mainland coast. The final sediment budget was formulated from all these intermediate budgets, and is presented herein along with a summary of information pertinent to the final budget. Details about the conceptual, historical, and calculated sediment budgets and further discussion of the entire study can be found in the draft Regional Sediment Budget for Mississippi Mainland and Barrier Island Coasts, Rosati et al. (2007) attached at the end of this appendix. Volume change and sediment budget calculations in the 2007 draft MsCIP sediment budget report will be updated during the advanced engineering and design phase using the Jan 2008 upgrade to ESRI's ArcGIS. This recent software upgrade allows more accurate procedures for quantifying volumetric change than were applied when the report was originally written in the spring of 2007. These changes are not likely to impact overall trends in the regional sediment transport system, but may change the magnitude of volumetric differences.

3.2 Mississippi Coast Physical Setting and Processes

The barrier islands in the project area, Cat, West and East Ship, Horn, Petit Bois, and Dauphin Islands, provide the offshore boundary for Mississippi Sound (Figure 3.2-1). These islands are the first line of defense for the mainland as tropical storms, hurricanes, and cold fronts pass the region. Table 3.2-1 summarizes the tropical storm and hurricane history for locations in and around the study area from 1871 (or 1872) through 2006. Because data were not provided for a city in Hancock County, New Orleans, Louisiana is shown in Table 3.2-1 to provide a western boundary to the study area. Locations in Hancock County are assumed to have storm occurrences similar to those presented for New Orleans and Gulfport.

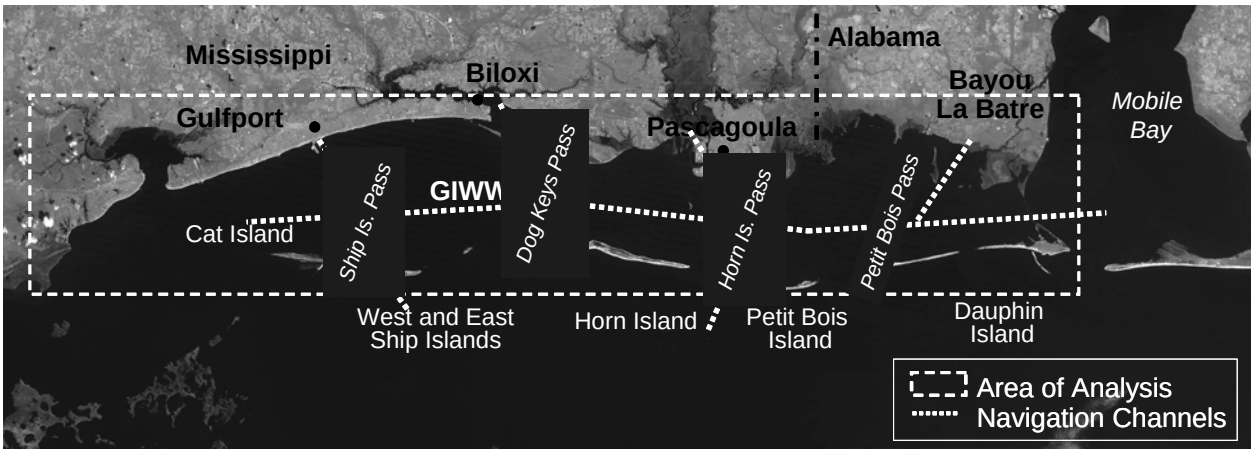


Figure 3.2-1. Mississippi Gulf Coast, showing barrier island system, navigation channels, and the area of study for the regional sediment budget (image courtesy NASA's Earth Observatory, dated 15 Sep 05)

Table 3.2-1.
Storms within 60 miles of selected Mississippi, Alabama, and Louisiana Cities west of Mobile Bay, 1871/2 through 2006[1]

Location (from west to east)	Year of Storm Occurrence t=tropical storm; b=brush; h=hurricane	Frequency of Occurrence (yr)	
		Brush or Hit	Direct Hit
New Orleans, LA	1879h, 1879t, 1887h, 1888b, 1897b, 1892t, 1893h, 1900tb, 1901h, 1905t, 1907t, 1909h, 1914t, 1915h, 1916b, 1932t, 1934tb, 1936t, 1944tb, 1947h, 1948h, 1949t, 1955t, 1964t, 1965h, 1969b, 1979h, 1985b, 1988t, 1992b, 1998t, 2002t(2), 2004tb, 2005t, 2005h	3.8	12.4
Gulfport, MS	1872t, 1879b, 1881b, 1885t, 1885tb, 1887t, 1892t, 1893h, 1895t, 1900t, 1901b, 1904tb, 1905tb, 1906h, 1907tb, 1912b, 1914tb, 1916h, 1923t, 1926t, 1932b, 1934tb, 1944t, 1947h, 1947t, 1955tb, 1960t, 1965b, 1969h, 1979b, 1985h, 1988b, 1998h, 2002tb, 2002t(2), 2004b, 2005t, 2005h	3.5	15.1
Biloxi, MS	1879b, 1880b, 1881t, 1885t, 1885tb, 1887t, 1892tb, 1893h, 1895h, 1900t, 1901h, 1906h, 1907tb, 1912h, 1916h, 1923t, 1926h, 1932h, 1934tb, 1947h, 1955tb, 1960t, 1969h, 1985h, 1997b, 1998h, 2002t, 2002tb, 2004b, 2005t, 2005h	4.4	11.3
Pascagoula, MS	1872b, 1881t, 1885t, 1885tb, 1887t, 1893h, 1893b, 1895t, 1900t, 1901h, 1902tb, 1904tb, 1906h, 1912h, 1914tb, 1916h, 1923tb, 1926h, 1932h, 1934tb, 1944tb, 1947b, 1950b, 1960b, 1969h, 1979h, 1985h, 1998h, 2002t, 2004h, 2005t, 2005h	3.8	9.7
Dauphin Island, AL	1880b, 1881t, 1882b, 1885, 1887t, 1893h, 1895tb, 1900t, 1901t, 1902t, 1904t, 1906h, 1910h, 1911b, 1912b, 1914tb, 1916b, 1919tb, 1922tb, 1923tb, 1926h, 1932h, 1934t, 1939t, 1944tb, 1947t, 1950h, 1956b, 1959t, 1960tb, 1979h, 1985h, 1985tb, 1995b, 1997h, 1998b, 2002t, 2004h, 2005(2)tb, 2005h	3.3	11.3

[1] http://www.hurricanecity.com/. This database does not have any locations in Hancock County, Mississippi; thus, data for New Orleans, Louisiana are included to provide a western boundary for the study area. Locations in Hancock County are assumed to have storm occurrences similar to those provided for New Orleans and Gulfport.

The frequency of direct landfall is approximately equal for Biloxi, Pascagoula, and Dauphin Island, with a direct hit every 10-11 years. The likelihood for a direct hit decreases to approximately once every 15 and 12 years for Gulfport and New Orleans, respectively. However, all locations listed in Table 3.2-1 have historically been brushed or hit with a tropical storm or hurricane approximately once every 3-4 years. Cold fronts, although less intense than tropical storms and hurricanes, occur more frequently at approximately 30 to 40 times per year (Stone et al. 1999).

The barrier islands protecting Mississippi Sound experience a low energy wave climate, with average significant wave height at National Data Buoy Center (NDBC) Buoy 42007 (22 nautical miles south-southeast of Biloxi, in 46 ft depth) averaging 2 ft and 1.3 ft in the winter and summer months, with associated average peak wave periods of 4 to 3.5 sec, respectively. Wave transformation modeling by Cipriani and Stone (2001) indicated that breaking wave heights on the barrier islands range from 1 to 2 ft. Waves in Mississippi Sound are fetch- and depth-limited. The Coastal Studies Institute's Wave-Current Surge Information System (WAVCIS[1]) gage CSI-13 located at Ship Island Pass (23 ft depth) from June 1998 through July 2005 measured an average significant wave height of 0.3 ft and associated average wave period of 2.5 sec.

Tides in Mississippi Sound are diurnal, with a tidal range of 1.5 ft and 1.8 ft for the mean and spring tides at Biloxi, Mississippi[2], respectively. However, the relatively shallow and large area of the Sound create strong currents in the tidal passes between the barrier islands, ranging from 1.63 to 3.3 ft/sec and 5.9 to 11.5 ft/sec on flood and ebb tides, respectively (Foxworth et al. 1962). In the winter months, winds from the same direction and of a sufficient magnitude are capable of lowering water surface elevations in the bays and nearshore from 1-2 ft (U.S. Army Corps of Engineers Mobile District 1984).

For the Gulf barrier island beaches, net longshore sediment transport is from east to west, although local reversals in the net transport occur adjacent to the tidal passes. The primary sources of sediment are longshore sediment transport from east to west, and, potentially, the offshore shelf (Otvos 1979, Cipriani and Stone 2001). Cipriani and Stone (2001) discussed that a well-defined cellular structure exists for each barrier island in which, over historic times, little sand transfer exists between islands. However, dredging records at Horn Island and Ship Island Passes (also called Pascagoula Bar Channel and Gulfport Bar Channel, respectively) suggest that infilling of sand from adjacent barrier islands occurs, indicating the potential for transport of sand between islands. Eastern Dauphin Island, with a Pleistocene core, is more stable than the other barriers although eastern Dauphin Island has been eroding in response to the dominant westerly-directed transport. Based on grain size analysis, Cipriani and Stone (2001) inferred that offshore sources may provide some sediment to central Petit Bois Island. The Mississippi Sound barrier islands range from very well vegetated, with maritime forests on east Dauphin Island, to low elevation barriers that are overwashed and breached during hurricanes. Long-term relative sea level rise for Dauphin Island, Alabama from 1966 to 1997 was 0.12 +/- 0.023 in/year[3].

On the mainland coast, beach change in Harrison County has been dominated by harbor construction, beach restoration and replenishment since 1951 (Byrnes et al. 1993a, 1993b). Cross-shore sediment transport processes dominate beach change, with wave-induced sediment transport processes of secondary importance, typically from east-to-west (Byrnes et al. 1993a, 1993b). Hancock County had beach nourishment in 1993-1994 between Waveland and Bay St Louis and again in 1996 for the Bay St Louis Downtown beach (Schmid 2002). Net longshore transport in Hancock County is generally from northeast to southwest. The bays, distributaries, and bayous of

[1] http://www.wavcis.lsu.edu/, dated 11 December 2006, accessed 11 December 2006.
[2] http://tidesandcurrents.noaa.gov/tides05/tab2ec4.html#107, dated 25 March 2005, accessed 11 December 2006.
[3] http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8735180, dated 10 February 2006, accessed 29 July 2006.

the remaining coast are typically bordered with marsh populated by *Spartina-Juncus* succession (Christmas 1973).

3.3 Review of Existing Studies and Dredging Database

Existing studies were reviewed for the project area to provide information about sediment transport processes of the barrier island and mainland coast. This knowledge gained was incorporated into the sediment budget as appropriate. For a full summary of each study that was reviewed, please see Rosati et al. (2007).

Dredging rates for navigation channels within Mississippi Sound were also evaluated in the study. As was shown in Figure 3.2-1, the study area is traversed by many navigation channels: two "bar" channels that extend through Horn Island Pass (also called Pascagoula Bar Channel) and Ship Island Pass (also called Gulfport Bar Channel); the Gulf Intercoastal Waterway (GIWW) that runs east-west through Mississippi Sound; and five Sound navigation channels that extend from Gulfport, Biloxi, Pascagoula, Bayou Cassotte, and Bayou La Batre. The SAM dredges these channels on a regular basis. The U.S. Army Corps of Engineers' Navigation Data Center[4] (NDC) has documented all Corps contract and non-contract dredging for all Districts for Fiscal Year (FY) 1990 through 2005. NDC's database for SAM's entire District dredging program is provided in Rosati et al. (2007).

Byrnes and Griffee (2007) culled historical dredging and placement information from published Corps reports and databases to develop annual dredging and placement rates for each of the bar channels. Sediment dredged from the GIWW and other channels extending through Mississippi Sound was side-cast or placed in disposal areas to either side of the channels, and is assumed to shoal primarily from fine sediment that is mobilized in the bay. Thus, these dredging and placement activities in the Sound do not change the sediment budget for the mainland and barrier islands. However, dredging and placement adjacent to the barrier islands (Ship Island Pass/Gulfport Bar Channel and Horn Island Pass/Pascagoula Bar Channel) must be considered in the sediment budget.

Dredging data provided by Byrnes and Griffee (2007) have been analyzed to provide estimated maintenance shoaling rates for each of the Bar Channels as a function of channel depth, width, and length (Table 3.3-1). Of particular interest is the maintenance dredging rate as a function of channel depth, as shown in Figure 3.3-1.

Table 3.3-1.
Summary of Dredging Rates for Navigation Channels Adjacent to Barrier Islands (modified from Byrnes and Griffee 2007)

Date	Description	New Work (cy)	Maintenance (cy)
Ship Island Pass/Gulfport Bar Channel (Data from 1881-2003)			
Mar 1899–Mar 1948	26-ft deep, 300-ft width, 0.76-mile long channel (1.9-mile length dredged in 1922)	163,401	2,115,576 (43,175 cy/yr) (33,028 cu m/yr)
Mar 1948–Jul 1992	32-ft deep, 300-ft wide, 8 miles long	3,679,044	21,111,495 (476,200 cy/yr) (364,292 cu m/yr)
Nov 1993–Apr 2003	38-ft, 300-ft wide, 8 miles long	9,695,988	5,456,817 (579,485 cy/yr) (443,306 cu m/yr)

[4] http://www.iwr.usace.army.mil/NDC/data/datadrg.htm , updated 25 July 2006, accessed 13 December 2006.

Table 3.3-1.
Summary of Dredging Rates for Navigation Channels Adjacent to Barrier Islands
(modified from Byrnes and Griffee 2007)

Date	Description	New Work (cy)	Maintenance (cy)
1899 to 2003	**Total Dredging**	**13,538,433**	**28,683,888 (275,807 cy/yr) (210,992 cu m/yr)**
Horn Island Pass/Pascagoula Bar Channel (Data from 1881-2005)			
Feb 1897–Mar1948	25-ft deep, 300-ft wide channel	896,748	1,735,817 (34,000 cy/yr) (26,010 cu m/yr)
Mar 1948–Jan 1965	38-ft deep, 325-ft wide, 2.8 mile length	2,910,835	2,711,925 (161,104 cy/yr (123,245 cu m/yr)
Jan 1965–Sep 1993	40-ft deep, 350-ft wide; Impoundment area along the western end of Petit Bois Island	1,305,589	14,772,517 (515,320 cy/yr) (394,220 cu m/yr)
Sep 1993–Nov 2005	44-ft deep, 550-ft wide; Impoundment area along the western end of Petit Bois Island	3,117,658	2,986,712 (245,483 cy/yr) (187,690 cu m/yr)
1897 to 2005	**Total Dredging**	**8,230,830**	**22,206,971 (205,600 cy/yr) (157,284 cu m/yr)**

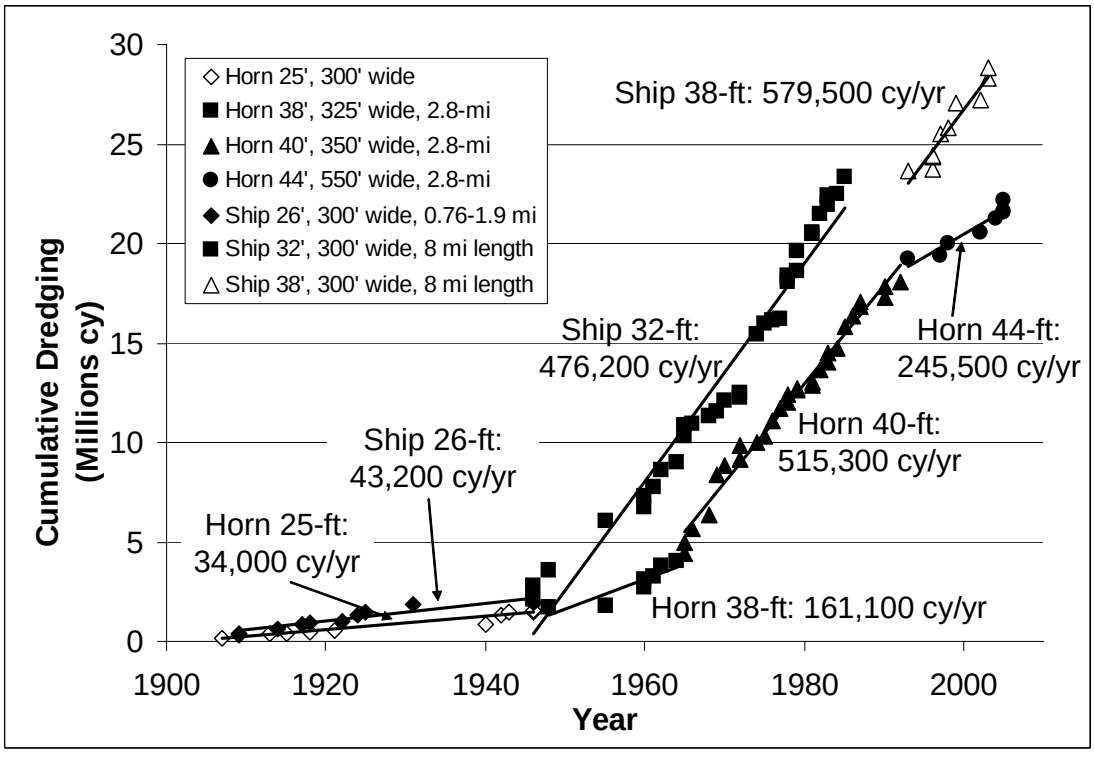


Figure 3.3-1. Cumulative maintenance dredging volumes and associated dredging rates for Horn Island Pass (Pascagoula Bar Channel) and Ship Island Pass (Gulfport Bar Channel)

These data indicate that deepening Ship Island Pass in 1948 by 23% (from 26 to 32 ft depth) and lengthening the channel (from 0.76 and 1.9 miles to 8 miles) increased the maintenance dredging rate by more than an order of magnitude (from 43,200 to 476,200 cy/yr). Dredging rates also increased more than an order of magnitude at Horn Island Pass through several depth increases from 25 to 40 ft, an increase in width from 325 to 350 ft, and length to 2.8 miles (dredging increased from 34,000 to 515,300 cy/yr). However, the dredging rate at Horn Island Pass decreased most recently when the channel was deepened to 44 ft and widened to 550 ft. This decrease in shoaling is opposite to what would be expected and possibly indicates a change in dredging or placement practices at Horn Island Pass. As these channels were deepened, they were also lengthened to provide safe navigation from a similar depth contour offshore. Thus, the deeper channels not only provided a better trap for sand moving alongshore but also resulted in longer channels which captured more of sand that is being transported in the offshore zone.

As mentioned previously, dredging for channels in the Sound do not modify the sediment budget for the barrier islands and mainland coast. The NDC's dredging database has been evaluated to provide a complete regional sediment budget as shown in Table 3.3-2.

Table 3.3-2.
Dredging Rates for Navigation Channels in Mississippi Sound (from SAM and NDC Database)

Location	Dates	Duration (years)	Shoaling Rate (cu yd/yr)	Notes
Gulfport Harbor Channel[1]	Jul 1991 – Sep 2004	8.3	1,151,000	Assume includes GIWW dredging
Biloxi Harbor Channel	Dec 1991 – Aug 2003	12.5	43,600	
Pascagoula Harbor Channel	Aug 1992 – Jan 2005	13.5	3,074,600	Assume includes GIWW dredging in vicinity of Pascagoula
Bayou Cassotte	Sep 1992 – Sep 2000	8	248,500	
Bayou La Batre	May 1996 – Sep 2004	8.3	732,400	Assume includes GIWW dredging

[1] Omitted Gulfport deepening in 1992.

3.4 Historical Data Analysis

A second phase of this study developed a historical sediment budget for the barrier islands and adjacent passes based on bathymetric change, shoreline position change, and dredging and placement data. The historical sediment budget is utilized to develop the present-day sediment budget. In this chapter, historical volumetric change, shoreline position change, and dredging data are reviewed. This portion of the study was conducted by Byrnes and Griffee (2007).

Shoreline and bathymetric data were compiled within a Geographic Information System (GIS) for the Mississippi Sound region. This database has associated metadata specifying the coordinate system, vertical datum, measurement units, and timing of data collection for each data set. Data are available for 1846/57, 1916/21, and 1960/71 periods, with coverage of the eastern portion of the study area available for 1984/89.

The primary goal of bathymetric change analysis is to identify regional sediment transport pathways and quantify net sediment volume changes associated with the historical evolution of nearshore morphology and adjacent beaches. Table 3.4-1 provides a summary of bathymetric data available for the Mississippi Sound area. Initial bathymetric surveys of the area were completed for the period 1847/56. All data have been compiled within a GIS framework, so metadata regarding coordinate

system, vertical datum, measurement units, and timing of data collection are provided in the attribute table for each data set. These data, in addition to recorded shoreline changes, have been used to quantify regional sediment dynamics throughout the study area and evaluate the historical sediment budget for the period 1917/21 to 1960/71. Limited coverage offshore of Horn, Petit Bois, and Dauphin Islands for the 1960/71 period limits volumetric change calculations and, ultimately, the historical sediment budget.

Table 3.4-1.
Bathymetry Source Data Characteristics (from Byrnes and Griffee 2007)

Date	Data Source	Comments and Map Numbers
1847/56	USC&GS Hydrographic Sheets 1:20,000	First regional bathymetric survey within the study area. 1847 - H-00191; 1847/48 – H-00192; 1848 – H-00193, H-00194; 1851 – H-00256, H-00261; 1852 – H-00329; 1853 – H-00328, H-00365; 1854 – H-00430; 1855 – H-00485, H-00488, H-00489; 1856 – H-00546.
1916/20	USC&GS Hydrographic Sheets 1:40,000 (all others) 1:80,000 (H-4171)	Second regional bathymetric survey in the study area. 1916/17 – H-03960; 1917 – H-04000; 1917/18 – H-04020, H-04021, H-04023; 1920 - H-04171.
1960/71	USC&GS Hydrographic Sheets 1:10,000 (H-08524, H-08525, H-08560, H-08561, H-08562, H-08642, H-08643, H-08644, H-08645, H-08646, H-08649 to 08652, H-08922, H-08923, H-08925, H-08970, H-09156, H-09177) 1:20,000 (all others)	Third regional bathymetric survey in the study area. 1960 – H-08524, H-08525, H-08562, H-08563); 1960/61 - H-08560, H-08561; 1961 – H-08642; 1961/62 - H-8643 to 08648; 1962 – H-08649 to 08652; 1966/68 – H-08922, H08923; 1967/68 – H-08924, H-08925; 1968 – 08970, H-08971; 1968/69 – H-09004; 1970 – 09103, H-09109; H-09028, H-09156, H-09177; 1971 – H-09200.
1984/89	USC&GS Hydrographic Sheets 1:20,000 (D-00079, F-00324, H-10179, H-10208, H-10226, H-10247, H-10261) 1:40,000 (D-00078, H-10206) 1:80,000 (D-00065)	Survey covering eastern portion of the study area; 1984/87 - D-00065, D-00078; 1985/87 - H-10179; 1985 - H-10206, H-10208; 1986/88 – H-10226; 1987 - H-10247, H-10261; 1988 - D-00079; 1989 - F-00324.

Several insights into forcing processes and engineering activities were observed from the bathymetric change data.

(1) Overall, the barrier islands have eroded on the eastern regions and accreted to the west, indicating the dominant direction of longshore sand transport from east-to-west. Similarly, the Passes between barrier islands have also migrated to the west, as noted by the ebb shoal that erodes to the east and reforms to the west. Thus, the migrating barrier islands naturally “push” the Passes to the west.

(2) Dredging of the ship channels in Mississippi Sound is readily observed in the bathymetric change maps that include the 1960/71 surface, with side-casting and placement of the dredged material shown on either side of the channels. This side-cast sediment does not appear to move within Mississippi Sound.

(3) As the barrier islands have eroded, portions of the barriers have rolled over towards the Sound. For example, East Ship Island and western Dauphin Island have eroded on the Gulf side and reformed in a more northerly location further into the Sound. The processes transporting sand into the Sound is a combination of overwash during storms and inlet formation and possible subsequent closure.

(4) Portions of the barrier islands are relatively stable and maintain position through time (this is observed in Byrnes and Griffee’s (2007) shoreline position data). Examples of these locations are

the widest portions of Horn, Petit Bois, and Dauphin Islands. These areas are likely more stable ancient Pleistocene formations along which the sand spits which comprise the rest of the barrier island morphology form.

(5) Cat Island is not part of the sand-sharing system that comprises Dauphin, Petit Bois, Horn, and Ship Islands and the Passes that separate these barrier islands. Cat Island is a separate entity and the bathymetric change maps do not indicate that sand from Ship Island naturally bypasses or transports to Cat Island. If there were connectivity between Ship and Cat Island, it would be evidenced by erosion or accretion of morphologic features between the islands.

(6) From the historical shoreline position data (Byrnes and Griffee 2007), it is evident that the barrier islands have experienced cycles of breaching and mending throughout history. For example, Dauphin Island breached in 1917 in response to the 1915 hurricane, and reformed by 1957 slightly further northward (into the Sound) at the location of the washover deposit. Dauphin Island again shows a breach in the 2006 shoreline position data. Similarly, Ship Island breached in response to the 1947 hurricane and the barrier had reformed by 1950. Ship Island has been divided into East and West Ship Islands since another breach formed in the 1960s. These cycles of breaching and reformation indicate that breaches will naturally mend through the dominant longshore sand transport direction to the west, if a sufficient source of sediment is available. The historical data analysis is further discussed in Byrnes and Griffee (2007) and Rosati et al. (2007).

3.4.1 Numerical Modeling

Two numerical models were applied to develop estimates of sediment transport magnitudes and pathways. First, GENESIS shoreline change modeling that was conducted as a part of a larger regional study was incorporated to provide potential longshore sand transport rates for the Gulfside of the barrier islands for representative yearly waves. This model used pre-Katrina shoreline positions. Next, regional wave transformation modeling was conducted with STWAVE to estimate breaking wave height and direction magnitudes for the Gulfside and mainland coast beaches. These wave parameters and the shoreline orientation for sections of the Gulf barrier beaches and mainland coast were used to calculate potential longshore sand transport rates. Potential longshore sand transport rates are those estimated to occur if a sufficient quantity of sand were available for transport. Thus, these calculations do not apply to muddy coastlines or wetland regions of the study area. Finally, STWAVE was also applied to estimate wind-induced wave parameters for the Sound side of the barrier islands and subsequent sand transport on the Sound barrier coast. The methodology and results for this numerical modeling are discussed in Rosati et al. (2007).

3.4.2 Sediment Budget

Using the calculated and historical sediment budgets, and dredging and placement practices from 1993-2005 as presented by Rosati et al. (2007), a present-day (post-Katrina shoreline position) sediment budget has been hypothesized. In formulating this budget, several assumptions were made as follows:

(1) The historical sediment budget (1917/20-1960/71) was weighted more heavily than the calculated sediment budget, because the historical budget is based on actual measured changes in the region. However, for portions of the barrier islands that have changed morphology since the 1917/20 to 1960/71 period, or would be modified by a change in dredging or placement practices, the calculated sediment budget was given preference. The calculated sediment budget was adopted for eastern Dauphin Island because volume change data have not yet been released, pending acceptance of the Dauphin Island mitigation study.

(2) In the absence of historical data, the calculated sediment budget and observed morphologic response were adopted for the mainland coast.

(3) Dredging and placement practices from 1993 to 2003/2005 were adopted for Ship Island Pass and Horn Island Pass, and the barrier island response to these activities was hypothesized. Dredging rates for Gulfport, Biloxi, and Pascagoula Harbor Channels, and Bayou Cassotte and Bayou La Batre were adopted as shown in Table 3.3-2. The source of sediment for these channels in Mississippi Sound was assumed to be fine-grained sediment that is mobilized during storms and wind events.

The hypothetical present-day sediment budget is shown in Figures 3.4-1 through 3.4-10, in which P=placement of dredged material, R=dredging or removal of sand, and sand fluxes are shown in thousands of cubic yards per year. It is emphasized that this sediment budget is only one of many possible solutions that could represent typical present-day conditions.

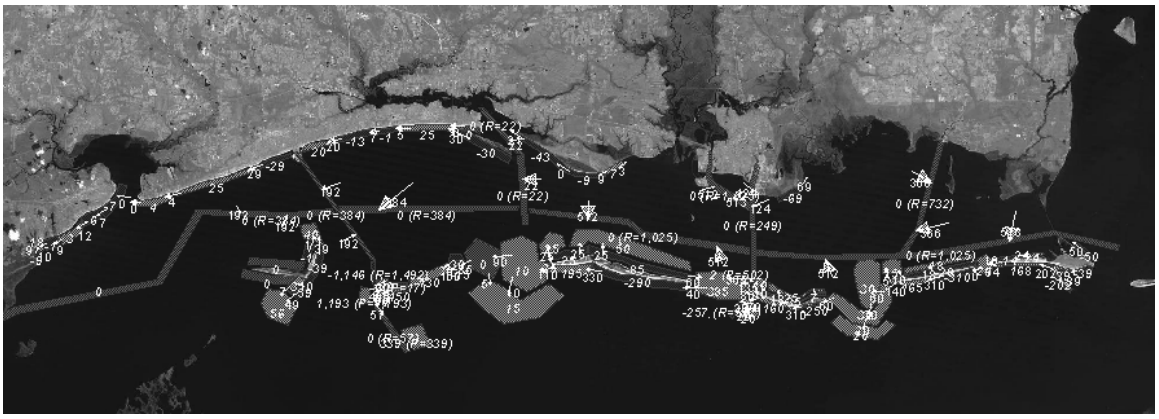


Figure 3.4-1. Overview of hypothetical present-day sediment budget (thousands of cy/yr)

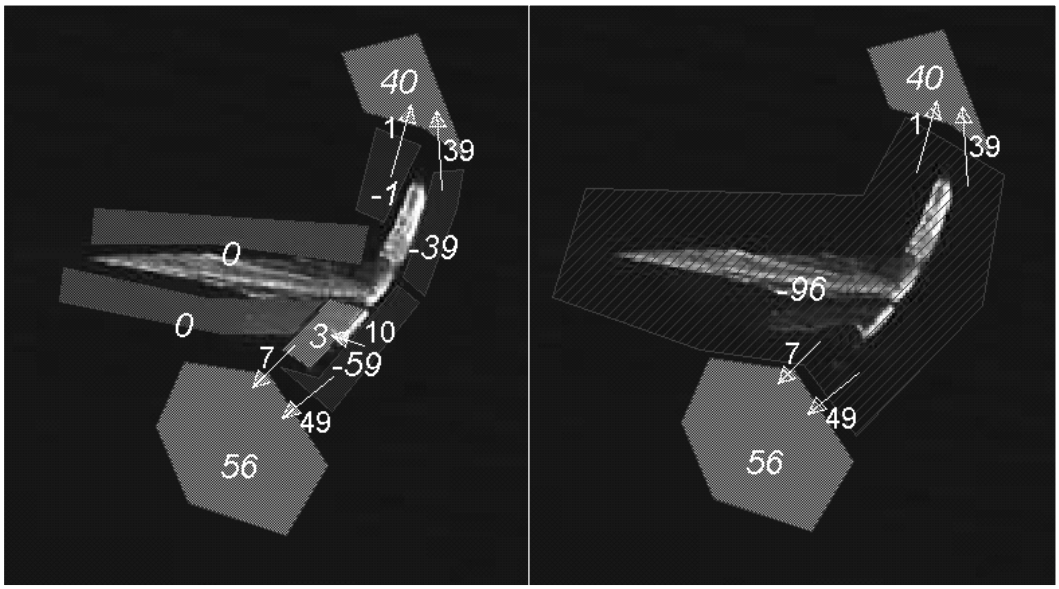


Figure 3.4-2. Hypothetical present-day sediment budget and macrobudget: Cat Island thousands of cy/yr).

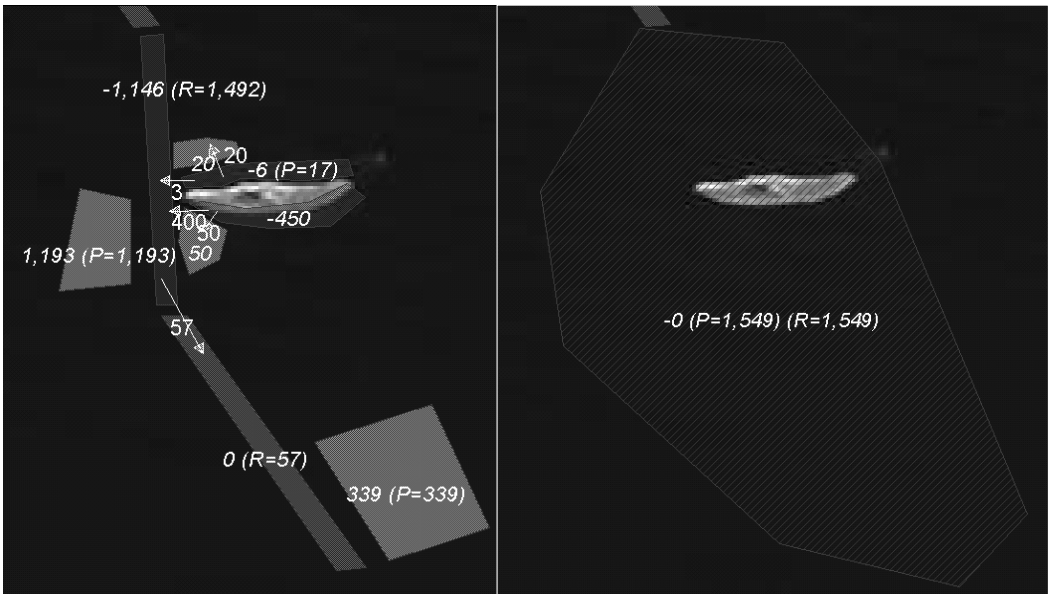


Figure 3.4-3. Hypothetical present-day sediment budget and macrobudget: West Ship Island and Ship Island Pass (thousands of cy/yr).

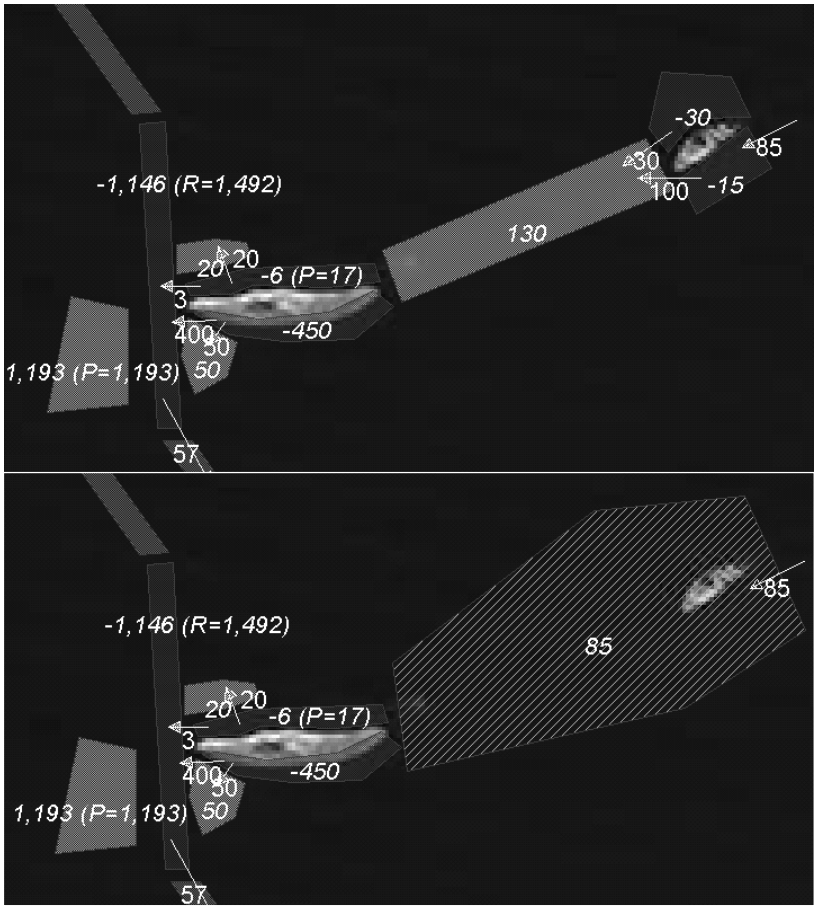


Figure 3.4-4. Hypothetical present-day sediment budget and macrobudget: East Ship Island and Camille Cut (thousands of cy/yr).

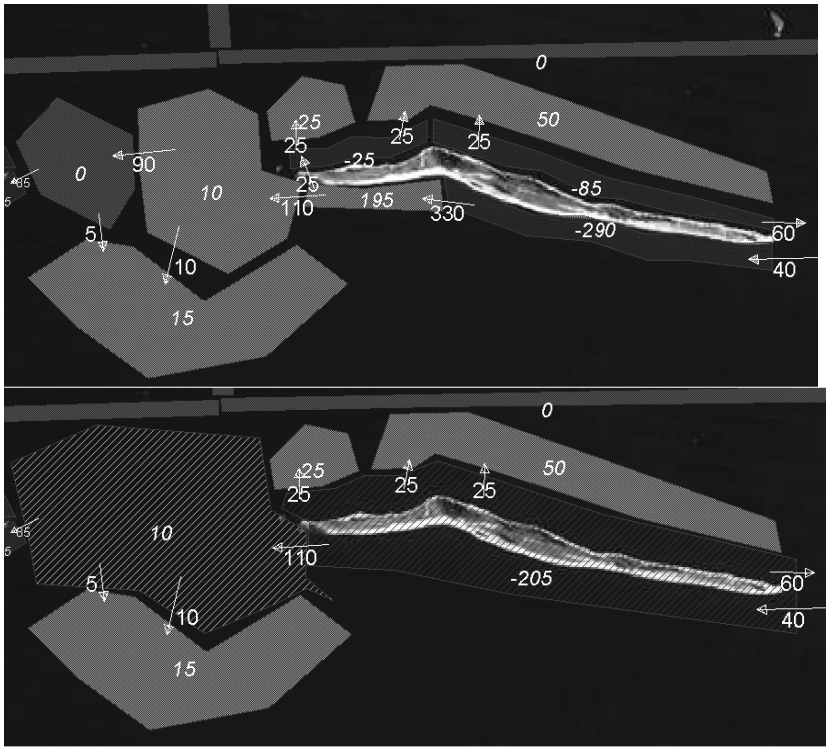


Figure 3.4-5. Hypothetical present-day sediment budget and macrobudget: Horn Island and Dog Keys Pass (thousands of cy/yr).

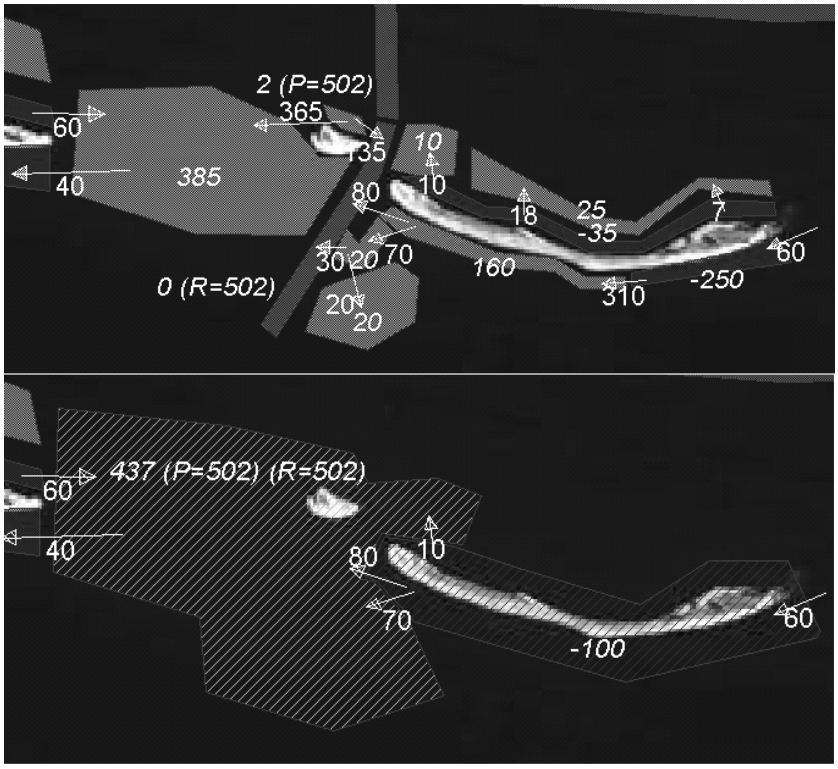


Figure 3.4-6. Hypothetical present-day sediment budget and acrobudget: Petit Bois Island and Horn Island Pass (thousands of cy/yr).

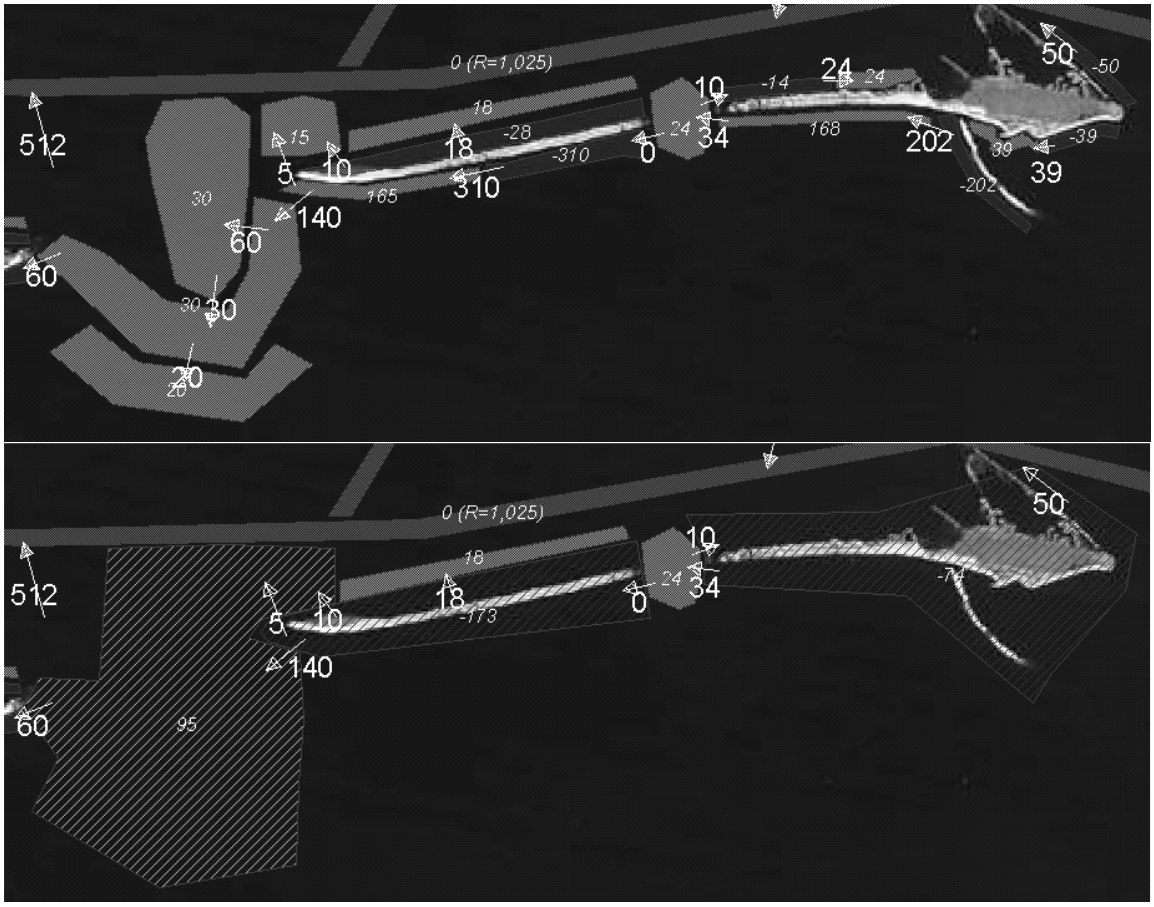


Figure 3.4-7. Hypothetical present-day sediment budget and macrobudget: Dauphin Island and Petit Bois Pass (thousands of cy/yr).

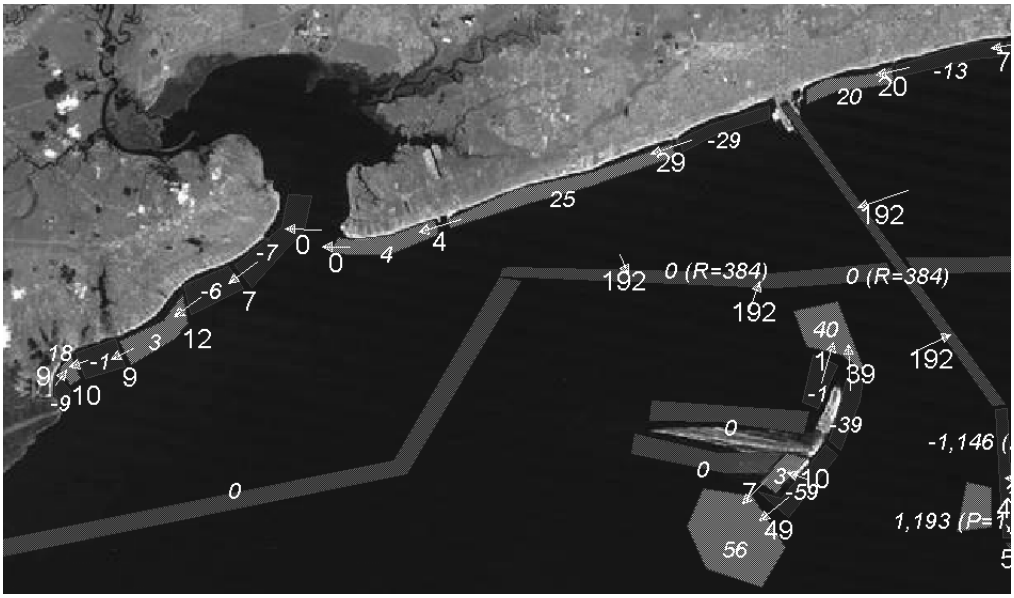


Figure 3.4-8. Hypothetical present-day sediment budget: Hancock County, Gulfport Harbor Channel, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

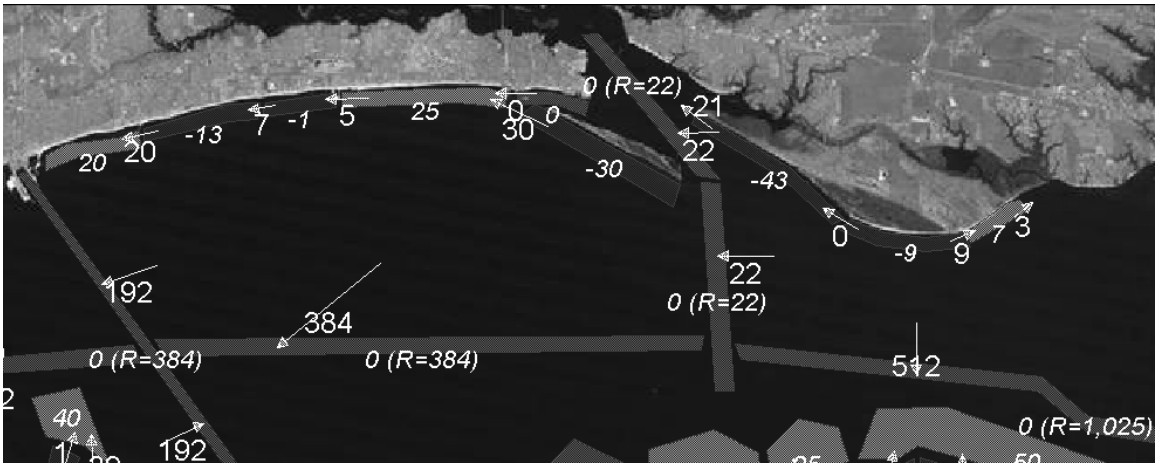


Figure 3.4-9. Hypothetical present-day sediment budget: Harrison County, Pascagoula Harbor Channel, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

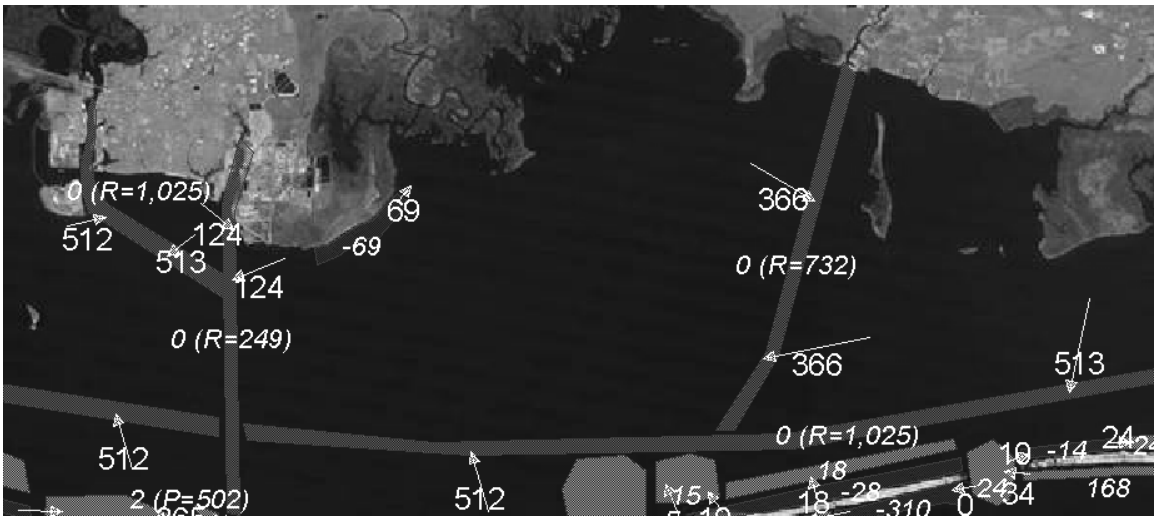


Figure 3.4-10. Hypothetical present-day sediment budget: Jackson County, Bayou La Batre, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

Knowledge gained through this study and recommendations that follow include the following:

(1) Cat Island is not a part of the barrier island littoral system represented by Dauphin, Petit Bois, Horn, and East and West Ship Islands. Cat Island is a separate morphologic feature that is naturally eroding due to waves, storm surge, and relative sea level rise in the region. Dredged sand that is placed in the littoral zone to the west of Ship Island Pass most likely will not be transported to Cat Island. Even in the absence of any engineering activities in Mississippi Sound, there is no evidence that sand from Ship Island would ever reach Cat Island.

(2) The net longshore sand transport rate for the barrier islands is from east-to-west. The barrier islands are migrating towards the west and, as they move west, also move the Passes between islands in a westerly direction. The source of sand for this region is the Mobile Pass ebb tidal shoal and the sandy shelf and shoreline to the east of Mobile Pass. Ship Island is the terminus of the longshore sand transport system in this region. Thus, the regional shortage of littoral sand will be most profoundly observed at Ship Island. Disintegration of this barrier island, especially since Hurricane Katrina in 2005 has been observed. It is also recommended that restoration of any barrier

islands in Mississippi Sound begin with Ship Island. Also recommended is back-passing sand dredged from Ship Island Pass, placing this sand either in Camille Cut, near East Ship Island, or in Dog Keys Pass. Sand can be placed in the surf zone (3 to 6-ft depths) and the natural longshore sand transport process will rebuild the island and begin to mend breaches.

(3) The historical sediment budget from 1917/20 to 1960/71 includes bathymetry change, shoreline position change, and dredging and placement practices representative of this period. However, data for the 1960/71 period are very sparse offshore of the barrier islands. This lends some uncertainty to the historical budget. In addition, Ship Island Pass and Horn Island Pass were deepened (and Horn Island was widened) in 1992/1993. Since that time, dredging rates have increased from those that occurred during the 1917/20 to 1960/71 period. Thus, the historical sediment budget is not representative of present-day dredging and placement activities, and has uncertainty with respect to bathymetric change offshore of the barrier islands. We recommend measurement of modern bathymetry (to 30 or 40-ft depths) and formulation of a sediment budget characterizing the period from 1917/20 (which has sufficient bathymetric coverage) to present-day.

(4) The historical analysis indicated that Horn Island has not experienced wash-over deposition across the entire island and has only been breached on a part of terminal spit during Hurricane Katrina (personal communication, Ms. Linda Lillycrop, May 2005). This cross-shore stability implies that the elevation and width of this barrier island might be a good template to evaluate for possible future restoration of the Mississippi Sound barrier islands.

(5) Wave modeling indicated that the mainland coast experiences a greatly reduced wave climate due to sheltering by the barrier islands fronting Mississippi Sound, as well as the Chandeleur Islands, and the Mississippi River's Bird's Foot delta. Restoration of the barrier islands could also consider lengthening the islands to recreate a previous historical footprint to provide additional wave protection for the mainland coast.

CHAPTER 4 INLAND RIVER SAND SOURCES FOR USE AT BARRIER ISLANDS

4.1 General Information

While off-shore sources of good quality sand exist, other inland sources of sand exist that could be used for barrier island restoration. After the construction of inland waterways in Alabama and Mississippi, maintenance dredging is required to maintain the channel depths and alignments. This material is typically moved to disposal areas along the banks of the river where it accumulates in diked areas. Dredging of some of the areas along the river produces large quantities of sand that have potential use for beach nourishment. An inventory of current disposal sites indicates that approximately 30,000,000 cubic yards of sand may be available. Only disposal sites that contain a minimum of 100,000 cubic yards of sand were included in the inventory. Of interest to this study are disposal sites that are located along the Black Warrior–Tombigbee River system and the Tennessee-Tombigbee Waterway. Figure 4-1 shows the relationship of these disposal areas to the project sites along the Mississippi coast. Material from these sites could easily be transported by barge down the river system for use along the beaches.

4.2 Prior "Beneficial Use of Sand" Studies

Because of the shortage of additional disposal areas, the Corps of Engineers' Operations Division has contracted for several studies on the beneficial use of the sand. Some of these studies have been targeted at using the sand for beach nourishment, (Thompson Engineering, 2001). Using sand samples from some of the inland disposal areas along the Black Warrior – Tombigbee River, a series of analyses were conducted on the samples. For comparison purposes, several samples of actual beach sand and from the littoral drift zone from coastal Alabama were taken and subjected to the same tests. These tests included grain size distribution (gradation), color and roundness. The results of the tests indicated that some of the samples may be suitable for beach nourishment. The sand samples from the river were typically a finer grain size that the beach sand with the predominant river size being a fine sand while the beach sand was mostly medium sand. It was also noted that the beach sand was slightly more rounded than the river sand.

The one factor that warranted further analysis was the color difference of the river sand as compared to the beach sand. All of the river sand had a brown tint described as "very pale brown" or "light yellow brown". This compared to the beach sand samples which were described as "pale olive, white or light grey". These colors were assigned along with evaluations for hue, value and chroma from a Munsell Soil Color chart which provides a standard method of assigning color to soils. These reports also indicated that the color may be due to staining on the sand grains and not included in the mineral structure of the sand itself. The report also noted that beach sand came from a higher energy environment where any staining due the depositional environment may have been removed by abrasion due to wave action. It also noted that the sand might undergo bleaching from the ultraviolet radiation from the sun if the color was caused by a mineral staining. To test these conditions that may change the color of the sand, a series of tests were conducted on samples from the same areas that were used during the initial analyses, (Thompson, 2002). The samples were subjected to two tests. The first involved actual bleaching of the samples using a chemical oxidizer, hydrogen peroxide, for different periods of time. These tests did indicate that the bleaching process was detectable after 72 hours. Other tests were conducted to simulate the process of wave action causing an agitation of the particles which may remove any mineral coating or staining along with

exposure to ultraviolet light. This process was conducted for 144 hours without a notable difference in color.

Other studies on the dredge disposal areas by the Bureau of Mines, U.S. Department of the Interior were conducted to characterize the sand for use as an aggregate in making concrete (Smith, 1995). While these tests were not directed at use of the sand for beach nourishment, they did supply information on chemical and physical characteristics of the materials from several locations. These tests provided data that shows the sand to be clean, mostly fine grained, quartz sand with little of no fines, to be non-toxic based on Toxic Characteristic Leachate Procedure (TCLP) and to contain very little heavy minerals. All of these tests would indicate the material would be safe to place on a beach.

Review of the documents referenced above indicated that the color issue was not resolved and this would be an important factor in the use of the sand on the barrier island beaches. The methods employed, bleaching and agitation with exposure to ultraviolet light, were not considered to be effective in removal of what is suspected to be the basis of the color on the sand grains, amorphous iron oxide more commonly referred to as rust. Hydrogen peroxide is a common household bleaching agent that is effective in oxidation of organic matter, but would no effect iron oxide through chemical removal. The same is true for the effects of ultraviolet light on iron oxide. The idea of using agitation would be the most effective of the methods attempted if the color was a coating on the mineral grains, but the test, as conducted, was not conclusive.

4.3 Additional Studies

With the renewed interest in the possibility of using the sand as a source of material for the littoral zone associated with the Mississippi barrier islands, the disposal areas warranted further study. Again the color of the sand is a concern that has been raised by the National Park Service who has control of the Mississippi Barrier Islands. This concern has both aesthetic and environmental aspects. Aesthetically, the beaches on the barrier islands are composed of relatively white sand. Numerous studies have indicated that the primary source of this sand is an Appalachian origin probably associated with river systems discharging onto the Continental Shelf of present-day Florida (Stone and Others, 2004). This sand is transported westward from the discharge of the river into the Gulf of Mexico. Transport of this sand along the prevailing littoral current has created the white beaches and barrier islands that extend from Florida westward across Alabama to Mississippi as shown in Figure 4-2.

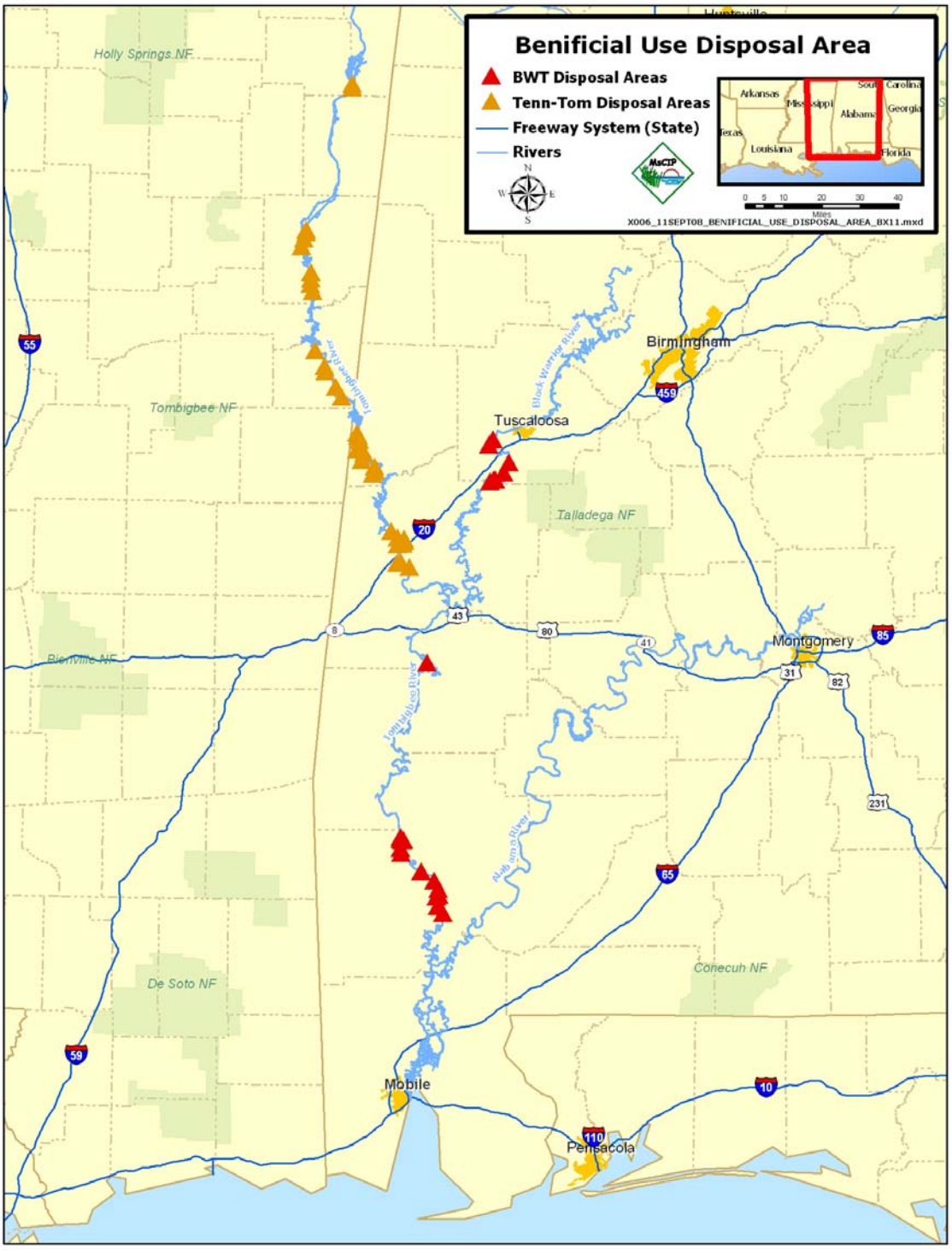


Figure 4-1. Location of Disposal Areas Along the Black Warrior–Tombigbee River System and the Tennessee-Tombigbee Waterway

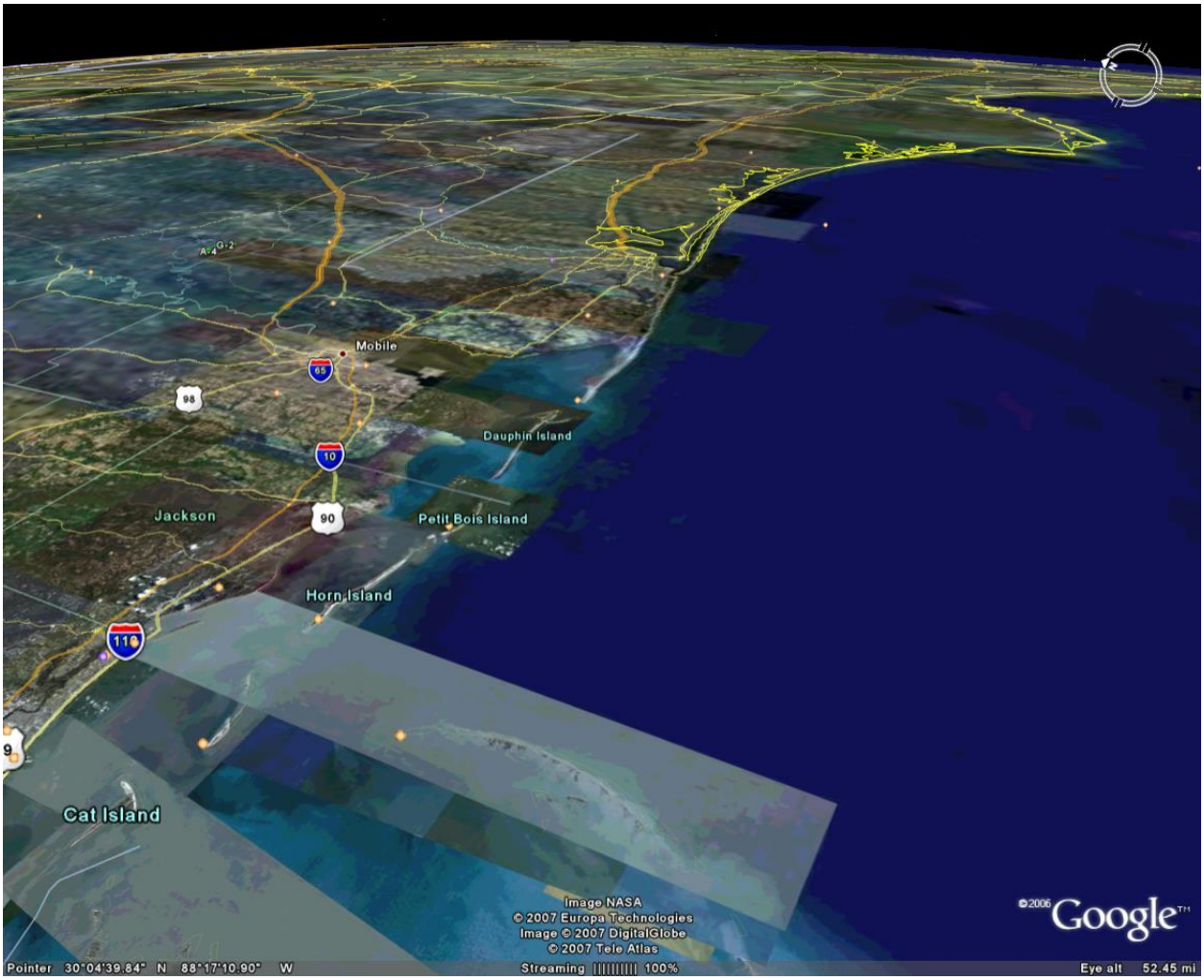


Figure 4-2. Littoral zone (white beaches and islands) along Central Gulf Coast extending from Bay County, Florida (top of picture) to Mississippi Barrier Islands (lower left), looking east.

Looking at the color differences of the sand along this system reveals a definite change as shown in Figure 4-3. The sample on the left was taken from sand dredged from the Chattahoochee River which is a major tributary of the Apalachicola River. This sampling location is approximately 150 river miles above the Gulf. The middle sample was taken from Disposal Area 39 on the Apalachicola River approximately 37 river miles above the Gulf. The sample on the right was taken from the south beach of Petit Bois Island in Mississippi. Note the progressive change in color from brown to tan to white.

Geochemical processes could account for the consistent staining of the sand grains while in the river system. As the sand entered the Gulf's littoral system, changes in the geochemical process would not allow additional staining of the sand and any removal of the coating would allow the underlying sand grain to display its true color. The mechanical process of abrasion would occur both in the river system and the littoral system, but if the iron oxide staining was continuously reoccurring in the river system, the resulting color would remain. As the sand grains entered a different geochemical environment where re-staining did not occur, it would account for the difference where the color was a coating. Review of selected sand samples taken from the Black Warrior– Tombigbee River system disposal areas the reveal the same general color that is characteristic of the Chattahoochee-Apalachicola River system. Figure 4-4 is a photograph of five samples that include the same

samples used in Figure 4-3 plus two additional samples, one from the Black Warrior River and another from the Tombigbee River. Note the similarities in color of the Apalachicola River (fourth from left), the Black Warrior (third from left and marked BWT North Star), and the Lower Princess (second from left, Lower Tombigbee River).



Figure 4-3. Samples of Sand taken from (left to right) Chattahoochee River Mile 150, Disposal Area #39 on the Apalachicola River, and Petit Bois Island



Figure 4-4. Samples of Sand taken from (left to right) Chattahoochee River Mile 150, Disposal Area #39 on the Apalachicola River, North Star Disposal Area on the Black Warrior River, Lower Princess Disposal Area on the Tombigbee River, and Petit Bois Island in Mississippi

Assuming that the previous testing was not effective at removing the iron oxide staining on the sand grains, a different bench-top test was performed. If iron oxide is only a coating on the sand grains and occurs as a stain, abrasion would be effective in the removal. The addition of a week acid would also aid in keeping the iron oxide from re-coating the sand grains as it is being removed. For the experiment, I used a small "rock tumbler" of the type used to polish small stones. Into the chamber of the rock tumbler was added a small quantity of sand obtained from the Lower Princess disposal area on the Tombigbee River, enough water to just cover the sand and a tablespoon of "Zud". Zud is a household cleaning product that is composed of oxalic acid and abrasives. Oxalic acid is a weak acid commonly used to remove rust stains. Zud contains about 10% oxalic acid and 90% fine abrasives. The tumbling chamber was closed and placed the tumbler. An electric motor spins the chamber which allows the contents to tumble. This process would mimic the process of sand grains being transported along the littoral zone with the sand grains being abraded as they strike each other. In the almost infinite volume of water in the Gulf, any iron stain that was removed would not re-coat the sand, but be diluted away. This process started on 4 October 2007 and concluded 10 October 2007. The tumbler did not run over the included long weekend, but did operate for about 4 days. At the completion of the tumbling process, rinse water was added and decanted several times until the turbidity levels dropped and the fines were removed. The remaining sand was air dried and placed in a clear plastic bag for comparison with sand from the same parent sample. As shown in Figure 4-5, the results of the experiment are quite dramatic. The tumbled sand lost most of the tan color and is approaching white. This supports the process that occurs with the tan sand from the Apalachicola River system becoming the white sand so familiar to beach-goers along the central Gulf Coast.



Figure 4-5. Samples of Sand taken from (left to right) North Star Disposal Area on the Black Warrior River, Lower Princess Disposal Area, and "Tumbled Lower Princess Disposal Area"

Adding the sand into the littoral system along the gulf coast could provide the proper geochemical and mechanical processes to remove the iron staining and provide the quality of sand that is desired as it is transported along the littoral drift zone which contain the Mississippi Barrier Islands. Littoral zone placement will also allow additional sorting by the currents and rounding of the sand grains through continued abrasion during transport. Additional research and testing will be performed to support this process prior to any use of any sand from disposal areas.

4.4 References

Smith, C. W., 1995, Characterization of Dredged River Sediments in 10 Upland Disposal Sites in Alabama, Report of Investigations 9549, U.S. Department of the Interior, Bureau of Mines.

Stone, Gregory W.; Liu, Baozhu; Pepper, David A.; Wang, Ping; 2004, The Importance of Extratropical and Tropical Cyclones on the Short-term Evolution of Barrier Islands along the Northern Gulf of Mexico, USA, Marine Geology 210, pages 63-78

Thompson Engineering, 2001, Dredged Material Suitability Analysis - BWT River Sediments, Project 01-2116-0102.

Thompson Engineering, 2002, Sediment Bleaching Analysis from Disposal Sites Along the Alabama, Black Warrior and Tombigbee River Systems in Alabama, Project 02-2116-0030.

CHAPTER 5 OVERVIEW OF ALL BARRIER ISLAND OPTIONS (LINE OF DEFENSE-1) FROM ENGINEERING APPENDIX

5.1 Line of Defense 1 – Offshore Barrier Islands

5.1.1 General

The coastline of mainland Mississippi is bordered on the south by the Mississippi Sound, a shallow body of water that separates the coast from four barrier islands that lie several miles to the south as shown in Figure 5.1.1-1. These barrier islands are located along a littoral drift zone that moves sand westward creating three elongated islands and then westward toward Cat Island, where littoral currents are not as well defined. The birds-foot delta system from the Mississippi River has extended through the historic littoral system, cutting off the sediment transport. Cat Island had the same origin than the other islands, but now being re-shaped by wave action and lack of new sediments moving into the system. Wave action has created a beach on the eastern side of the island forming a distinctive T-shape. From west to east, the islands are Cat, Ship (now actually two islands, West and East Ship Island), Horn and Petit Bois. As noted above, Ship Island has been breached by prior hurricanes and now is actually two small islands, West Ship Island and East Ship Island, with a shallow sand bar between the two. Since Hurricane Camille in 1969, this breach has existed with varying amounts of natural rebuilding between later storms and is now known as Camille Cut. The western ends of both Petit Bois and West Ship Islands have migrated westward and are now against maintained deep-water navigation channels and the continuing littoral drift of the sand into the channels is causing an artificial termination of the migration. A small, new island has emerged on the west side of the channel from Petit Bois Island, created from the dredged sand that is disposed of on the west side of the channel. This small island can be seen in Figure 5.1.1-1 as the small island just west of and across the channel from Petit Bois Island.

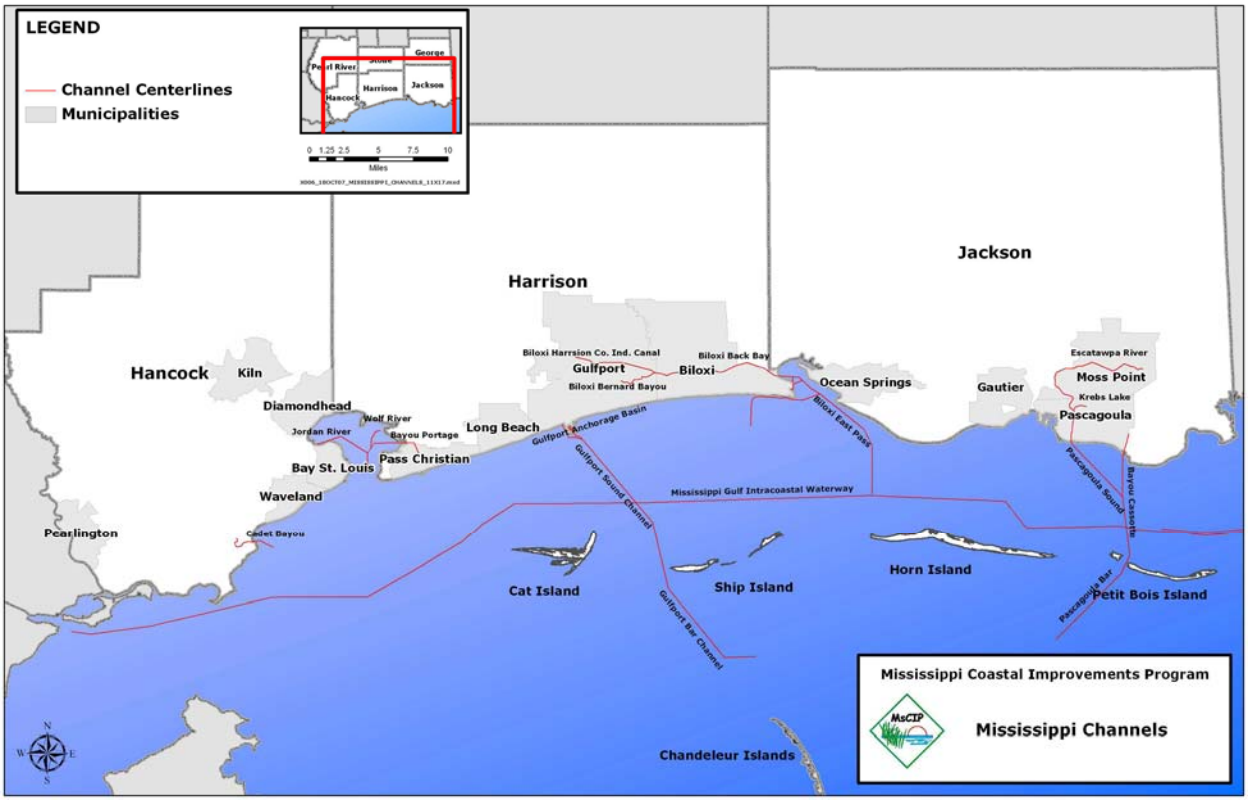


Figure 5.1.1-1. The Mississippi Barrier Islands shown in relationship to the numerous navigation channels near the islands

Immediately following Hurricane Katrina, most of the effort was spent protecting human life and securing structures throughout the impacted areas on the mainland; therefore, few assessments of the vegetation impacts exist, especially on the barrier islands. For the barrier island system, most all of the marsh vegetation recovered several months following Hurricane Katrina. The predominant vegetation that has long-term impacts consists of those pines found in the maritime forests. It is estimated that about 75% of these pine species were killed following the hurricane season of 2005, with most that attributable to Hurricane Katrina. Figure 5.1.1-2 is a photograph taken on Horn Island after Hurricane Katrina that shows the loss to the pine trees. The emergent marsh habitat is thriving so well it actually looks as though hurricanes never past through the barrier island system. The sea oats are still found in small patches due to the reduced dune system. Any option that includes the planting of marsh vegetation will have to consider the current population of nutria that inhabits the islands. These exotic animals from South America can destroy attempts to establish marsh planting and any program should include the control of these rodents.

In 1998, Hurricane George played a role in destroying many of the sand dunes on the islands. Although a relatively small storm, the constant pounding of the waves along the beaches eroded most of the dunes on the southern shores which were the higher elevations on the islands. Along with the destruction of the dunes was the loss of the associated vegetation and habitat. Figure 5.1.1-3 is a photo of the south beach of Horn Island where hurricanes have destroyed the dunes system.



Figure 5.1.1-2. Photo of interior of Horn Island. Note the mature pine trees that were killed from the effects of salt water that covered the island during Hurricane Katrina.



Figure 5.1.1-3. Photo of the south beach at Horn Island. Pre-existing dunes have been destroyed by numerous hurricanes over the last several years.

Prior to Hurricane Katrina, the State of Mississippi was working on a coastal storm protection plan that included restoring the barrier islands to the condition that existed prior to Hurricane Camille. The general assumption was that there would have been less damage along the coast from Hurricane Katrina if the islands had been in this improved condition. This was also included in the Mississippi Governor's Hurricane Katrina Recovery Plan which called for restoring the islands to a pre-Camille footprint. This concept was included in the hurricane protection study as LOD-1.

To determine the effects of the islands in reducing the surge damage to the mainland, a number of storms were selected to model against the chain of islands in a pre-Camille and a post-Katrina configuration. The post-Katrina condition can be considered a baseline condition for the modeling and the pre-Camille condition would be an improved condition. The pre-Camille footprint of the islands was obtained from historical records and an assumption was made as to a top of dune elevation and a typical island width. During the modeling process, the island sizes were held constant and not allowed to be destroyed. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. In general, the islands were modeled with a 2000-foot width and with an elevation 20.0 dunes, but may be in a slightly different position. Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. This area is the most protected from the restored islands and this protection may result in only up to a 10% reduction in storm surge. The effect of this protection diminishes rapidly to the west from Jackson County. An important aspect of the islands shown by the modeling is the reduction of the large sea waves as they advance towards the mainland. Reduction in wave height up to several feet is realized by the presence of the islands. Loss of Ship Island would leave a portion of the heavily developed Harrison County shoreline subject to these larger waves.

All of Petit Bois, Horn, and Ship Islands and part of Cat Island are within the boundaries of the Gulf Islands National Seashore under the jurisdiction of the National Park Service. The park boundaries are shown in Figure 5.1.1-4. In most cases, the boundary extends one mile from the shore of the island. Petit Bois and Horn Islands have also been designated as Wilderness Areas by the U.S. Department of the Interior and have a higher degree of protection than the other islands.

The formation of Camille Cut has created problems for the National Park Service due to the location of two historically important sites. Fort Massachusetts is located on the northern shore of West Ship and the French Warehouse is located on the northern shore of East Ship Island. Both of these sites are endangered by on-going erosion of the shoreline with Mississippi Sound. Another site known as the Quarantine Station as already been lost to erosion. These sites are shown in Figure 5.1.1-5. This photo was taken after Hurricane Katrina, but, would be similar to conditions after Hurricane Camille.



Figure 5.1.1-4. Boundaries of the Gulf Islands National Seashore

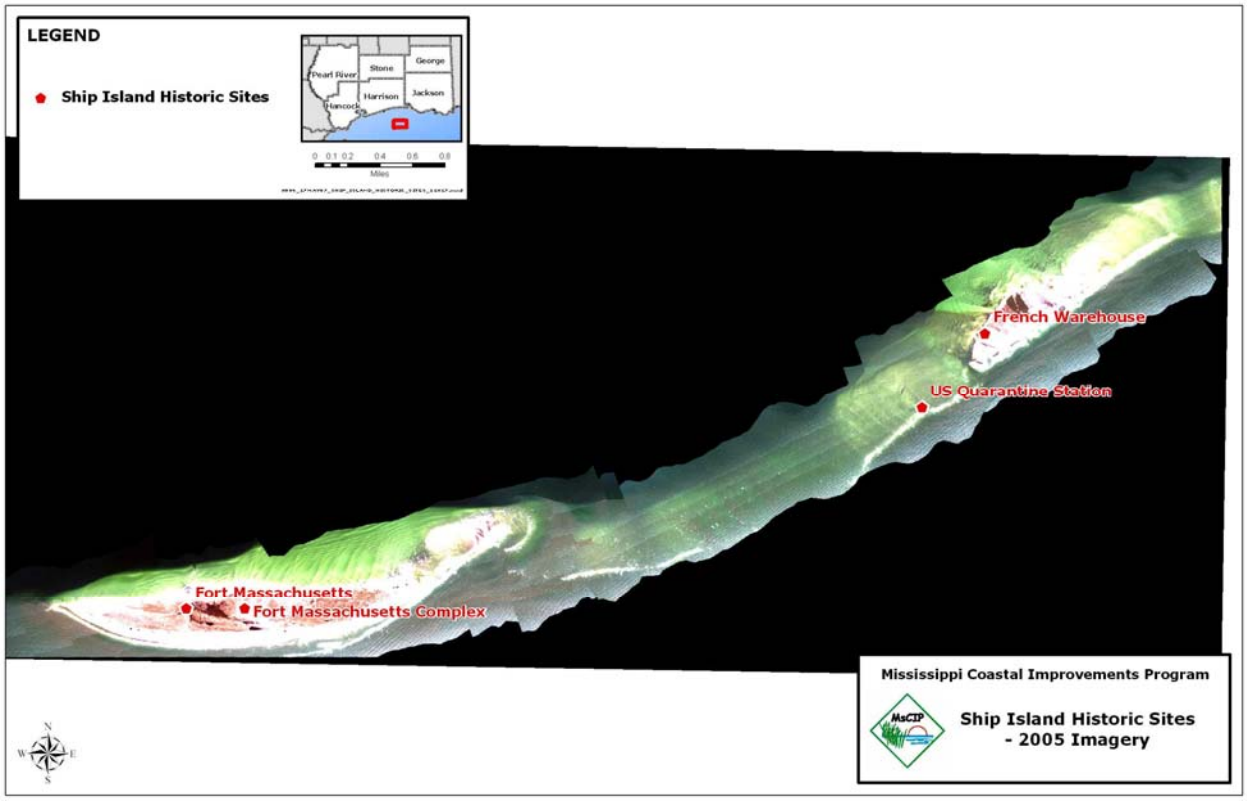


Figure 5.1.1-5. Aerial photo of West and East Ship Island taken in 2005 after Hurricane Katrina showing the locations of listed historical sites separated by Camille Cut

Fort Massachusetts was originally built on the western tip of Ship Island. The westward migration of sand along the southern shore and erosion of the northern shore now has put the fort almost a mile from the western tip of the island, but dangerously close to being in the Sound. Several emergency beach re-nourishments have taken place over the last 35 years to protect the fort from wave action during winter storms. At present, the NPS is again requesting that the Corps place sand along the shore near the fort in conjunction with dredging operations at the Gulfport navigation channel. This emergency placement of sand is being repeated about every five to six years.

The French Warehouse site has not had any sand placement on its shoreline in the past. The erosive process is slower at that location, but now there are concerns from the NPS about the integrity of the site. Unlike the location of the fort, the warehouse site is covered by maritime forest which may be added in slowing the erosion of the shore.

The Corps was asked to visit Fort Massachusetts with the NPS during July, 2007 to look at the present erosion problem and to discuss any possible long-term solutions to the loss of sand along the shoreline. The immediate erosion problem will require re-nourishment of the beach adjacent to the fort similar to the past protection projects. Any type of hardened structural feature as protection for the fort was not desired by the NPS nor was this recommended by the Corps. There was a breakwater placed north of the fort in the past (prior to the barrier islands becoming a National Seashore under the NPS) and seems to be compounding the erosion problems. The problem of a long-term fix may be tied to closing the three mile wide breach known as Camille Pass between West and East Ship Island. Review of historical footprints of the islands indicates that after the breach caused by Hurricane Camille, the westward migration of sand was continuing, but that the sand supply was being depleted before it reached West Ship Island. Aerial photos show the

formation of a sand spit that extends westward from East Ship Island. The volume of sand that is creating this spit is being depleted before it reaches West Ship Island. The photos also show that a deeper channel has formed a pass between the eastern end of West Ship Island and the western end of the spit. It appears that an ebb tidal delta at this pass moves the sand southward where it is removed from any migration along the northern shore of West Ship Island. The sand continues to supply the south beach and extends the western tip of the island in its migration. The loss of the sand from the littoral drift along the northern shore of West ship Island has resulted in erosion of that shoreline. Figure 5.1.1-6 shows an excellent aerial view of this process. Note the boat on the northern side of the pass.

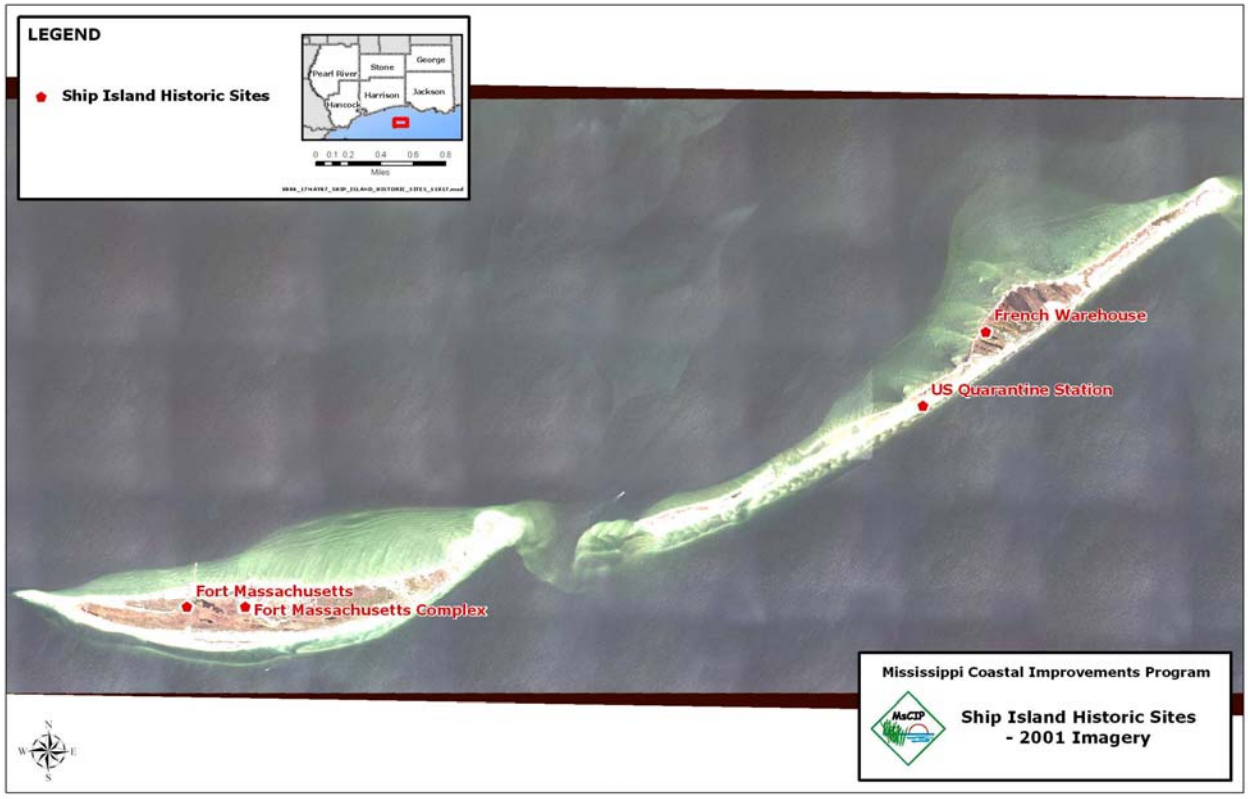


Figure 5.1.1-6. Aerial photo of West and East Ship Island taken in 2001. Note the sand spit extending westward from East Ship Island and the pass between the two islands.

A positive by-product of filling of the Camille Pass would be to provide a longer term solution to the erosion on the northern shores of West Ship Island. This will require modeling to better understand the benefits that are believed to be associated with this plan. The costs will be substantial due to the large quantities of sand high quality sand that will be required to fill the breach. Initial estimates for sand requirements are approximately 13 million cubic yards. The fill would be expected to prevent the continuing loss of sand to West Ship Island, but it is also understood that the islands are a dynamic system, ever changing to nature's forces. Different types of dune vegetation planting would also be included to restore habitat on the newly created land.

5.1.2 Restoration of the Offshore Barrier Islands

5.1.2.1 General

Soon after Hurricane Katrina, it was reported that many residents in Mississippi were of the opinion that if the islands had been in the condition that existed prior to Hurricane Camille, there would have been less damage along the coast from Hurricane Katrina. This initial concept was also included in the Mississippi Governor's Restoration Plan which called for restoring the islands to a pre-Camille footprint. Changes in the footprints are shown in Figures 5.1.2.1-1 through 5.1.2.1-4.

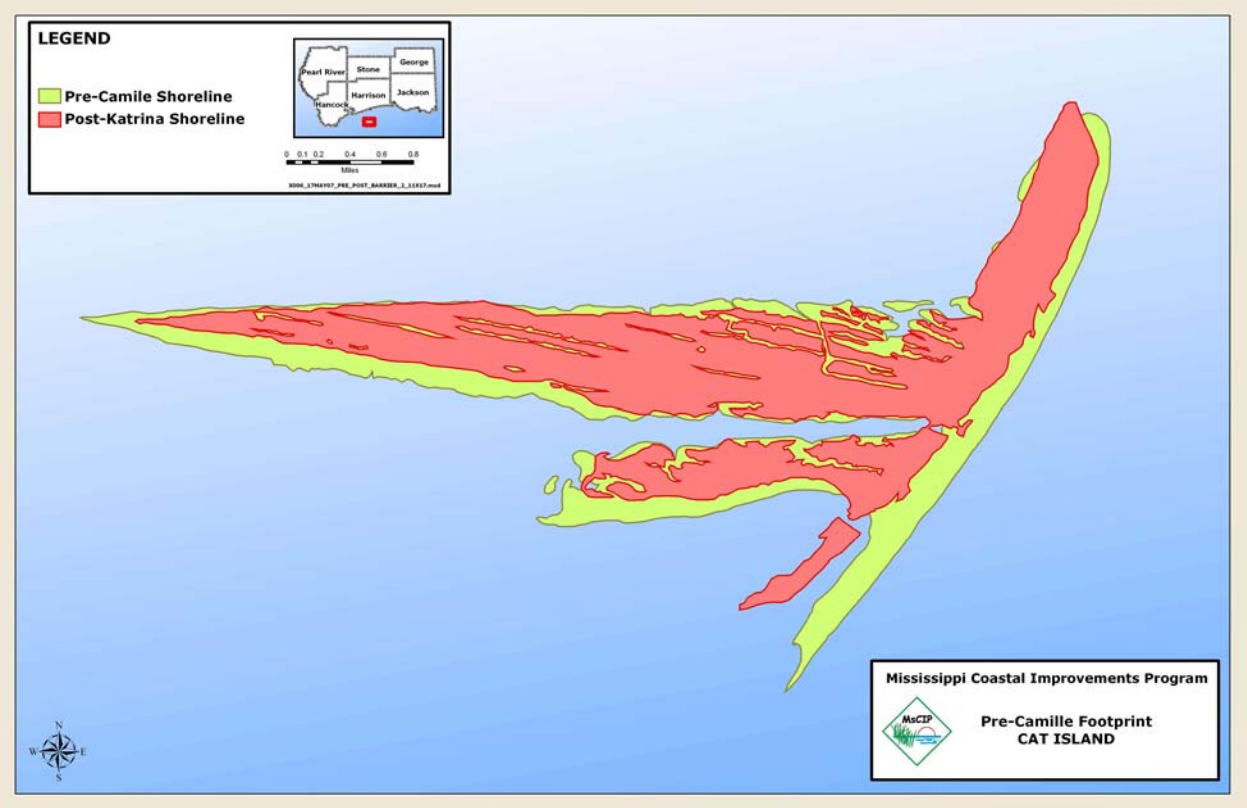


Figure 5.1.2.1-1. Changes in footprint of Cat Island from pre-Camille to post-Katrina



Figure 5.1.2.1-2. Changes in footprint of Ship Island from pre-Camille to post-Katrina

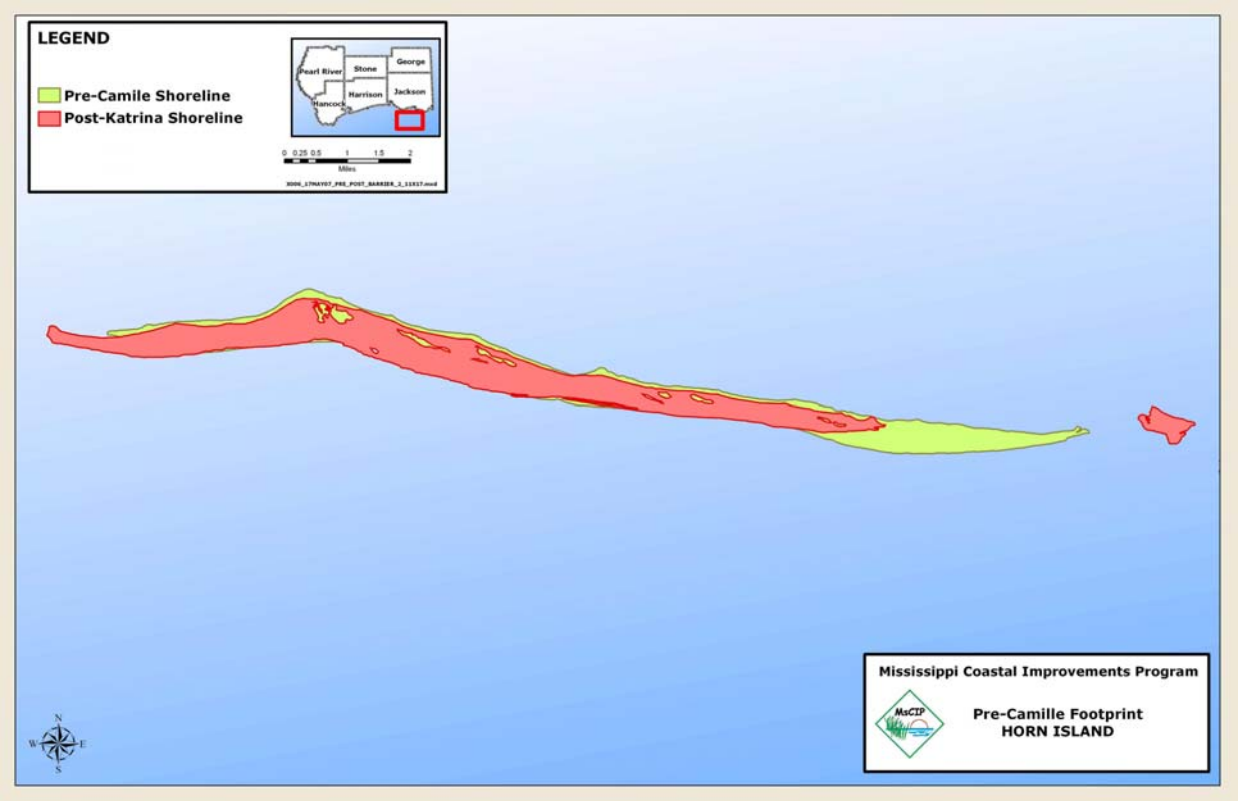


Figure 5.1.2.1-3. Changes in footprint of Horn Island from pre-Camille to post-Katrina

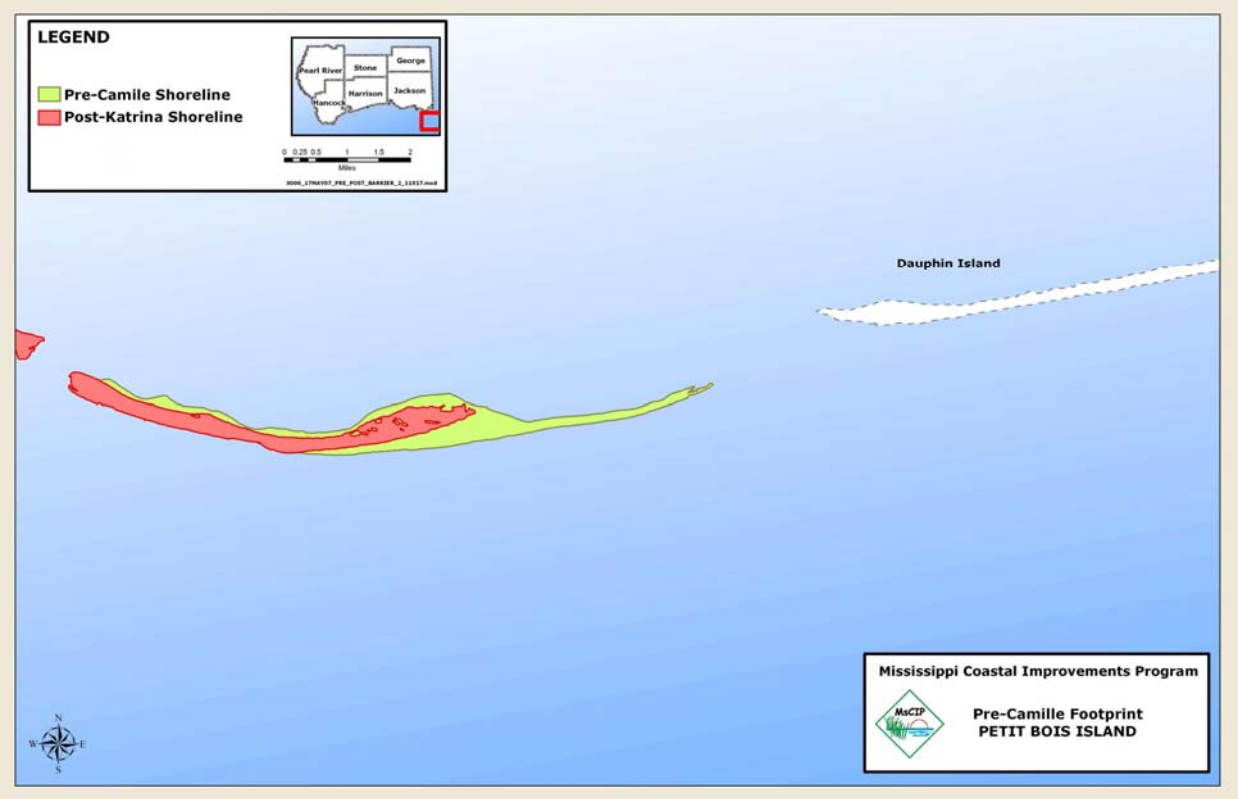


Figure 5.1.2.1-4. Changes in footprint of Petit Bois Island from pre-Camille to post-Katrina

As discussed in the Engineering Appendix, Part 2, a number of storms were selected to model against the chain of islands in a pre-Camille and a post-Katrina configuration. The post-Katrina condition can be considered a baseline condition for the modeling and the pre-Camille condition would be an improved condition. The pre-Camille footprint of the islands (USGS, 2007) was obtained from historical records and an assumption was made as to a top of dune elevation of 20 feet. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. This increase in size generally increased their length and maintained their typical width.

Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. This area is the most protected from the restored islands and this protection may result in only up to a 10% reduction in storm surge. As was shown in Figure 5.1.2.1-5, the effect of this protection diminishes rapidly to the west from Jackson County. With the consideration that these islands are within the National Park Service and that Petit Bois and Horn Islands are designated Wilderness Areas, any extensive restorations to these islands may not be feasible based on the limited reduction in storm surge.

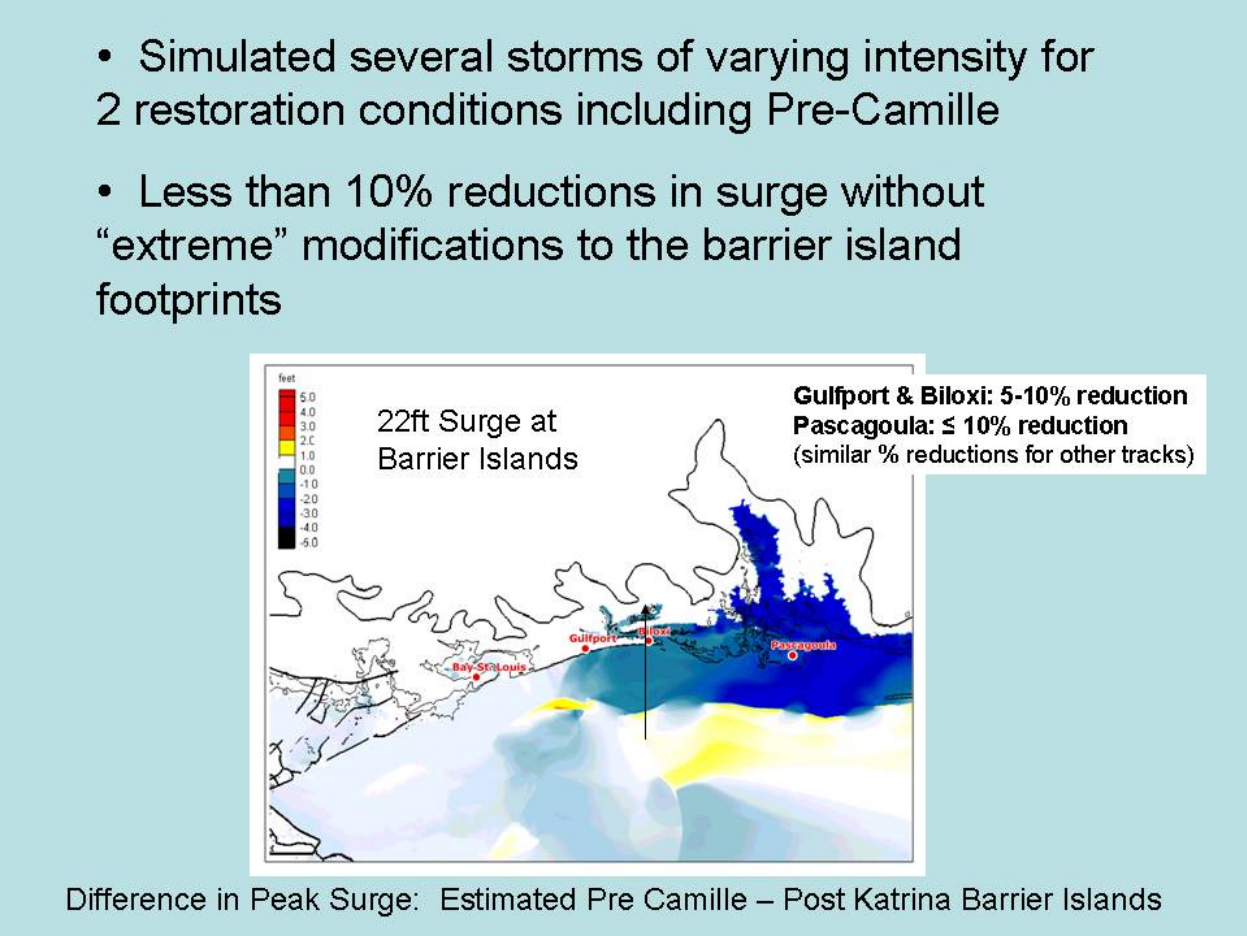


Figure 5.1.2.1-5 Difference in Peak Surge between pre-Camille and post-Katrina barrier islands

Another consideration to help restore the islands is to supplement the sand into the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This sand would not be put on the islands, but in areas between the islands where the currents that make up the littoral drift zone could transport the sand to the islands where the natural process of island building could take place. There, waves and wind could cause accretion on the islands. This may mitigate the loss of land mass at the islands that has been occurring since Hurricane Camille. The source of these sands may be from inland sources or from offshore borrow areas. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system.

A positive affect that the islands have is to provide a natural off-shore breakwater for the large sea waves that are generated from hurricanes. For this to occur, the islands only need to be a low stretch of sand or even a shallow sandbar. The presence of the islands and the relatively shallow water of the Mississippi Sound between the islands and the mainland prevent the sea waves from maintaining their considerable size as they move towards the mainland. Sea waves, often reported at heights of 40 feet and higher in large storms, would break as they approach the chain of islands. The open water between the islands and the mainland, generally ten miles or more, would have enough fetch for waves to regenerate, but at a much lower height do to the shallower water. The generally accepted relationship between water depth and wave height is that the wave can sustain itself at a height that is one half the depth of the water.

An environmental impact of the islands continuing to diminish in size is to allow salinity increases in the Mississippi Sound. Under current conditions, the islands provide a boundary condition between the sea water salinity of the open Gulf of Mexico and the brackish water found in the Sound. Loss of the islands would allow the salinity in the Sound to increase and result in a change of the ecological habitats that exist now. This would impact shellfish and other forms of marine life. This occurred at the Chandeleur Islands near the Mississippi barrier islands when almost the entire island structure was eroded away by Hurricane Katrina (see Figure 5.1.2.1-6). Mississippi Sound is classified as a 'bar-built' estuary as opposed to 'drowned river valley' (like Mobile Bay). The physics of bar-built estuaries is very different from others and you would expect to see broad zones of 'salinities' with the estuary which respond greatly to both river flow and wind conditions. Should the 'bars' go away then the estuary is totally lost because in general an estuary is considered part of the coast as opposed to forming the coast.

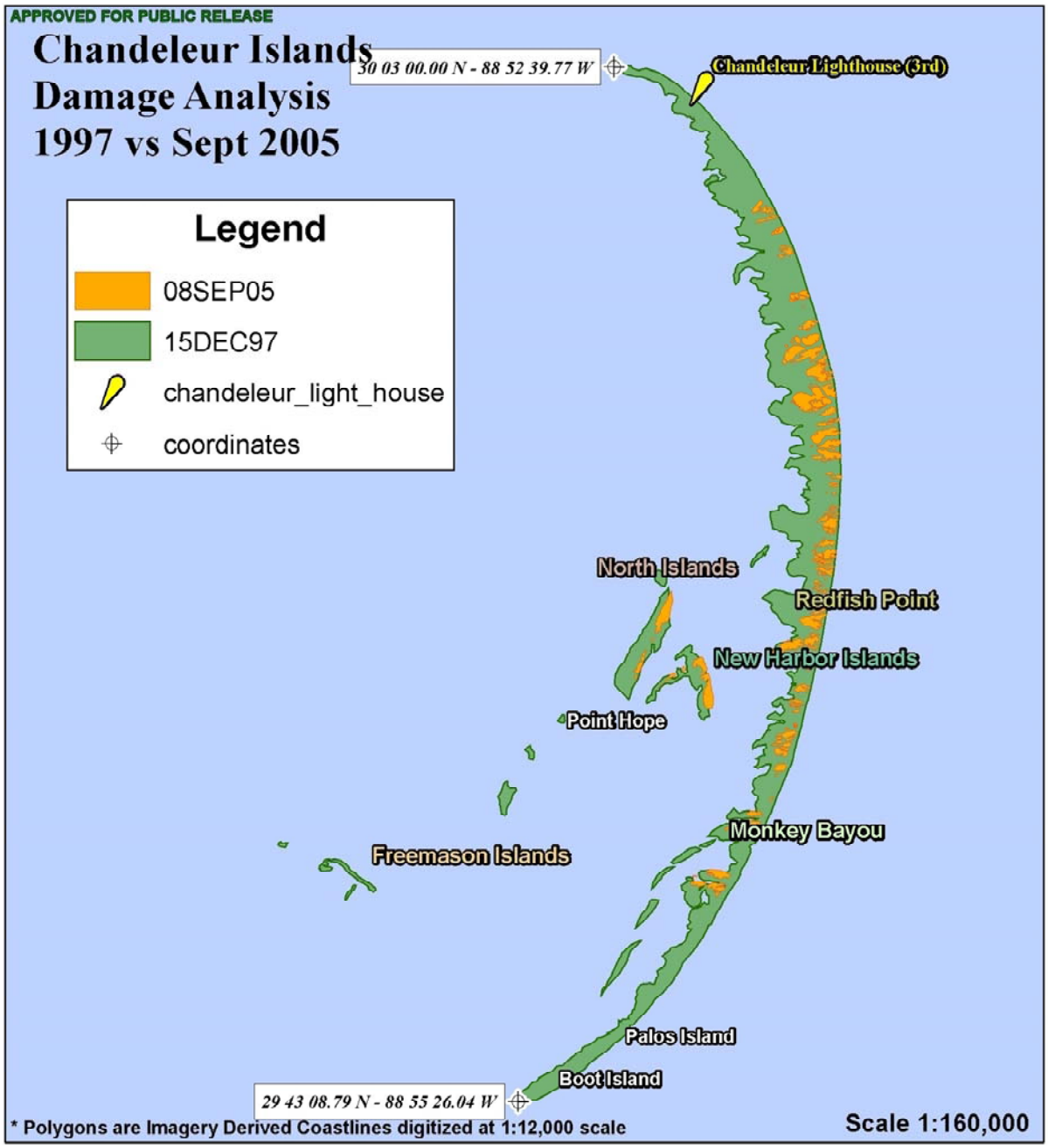


Figure 5.1.2.1-6. Loss of land mass from storm erosion at the Chandeleur Islands, 1997 to 2005. (US Navy)

One restoration option for the barrier islands would be to re-establish the vegetation that was destroyed by Hurricane Katrina. This option could involve environmental restoration of the existing islands through adding sand dunes on the beaches along with planted vegetation, planting of marshes and maritime forests, and planting sea grasses in the near-shore areas of the islands. This plan would not involve adding any land mass to the islands other than the possibility of adding to the dune system. The addition of vegetation from sea oats up to trees would aid in reducing erosion of the sand from wind thus helping in maintaining the stability of the islands. The vegetation would also aid in preventing erosion by water in the event that the islands gets overtopped by storm surge in a large hurricane. Sources of this sand could be from the beach area behind the dunes or from

sources off the island. Historically, large areas of sea grass existed north of the islands. Much of this sea grass is now gone and the loss of these areas have been mapped. Replanting the grasses and other vegetation will aid in establishing valuable habitat that was lost from the ecological system. Figure 5.1.2.1-7 shows the extent of vegetation on Horn Island prior to Hurricane Katrina.

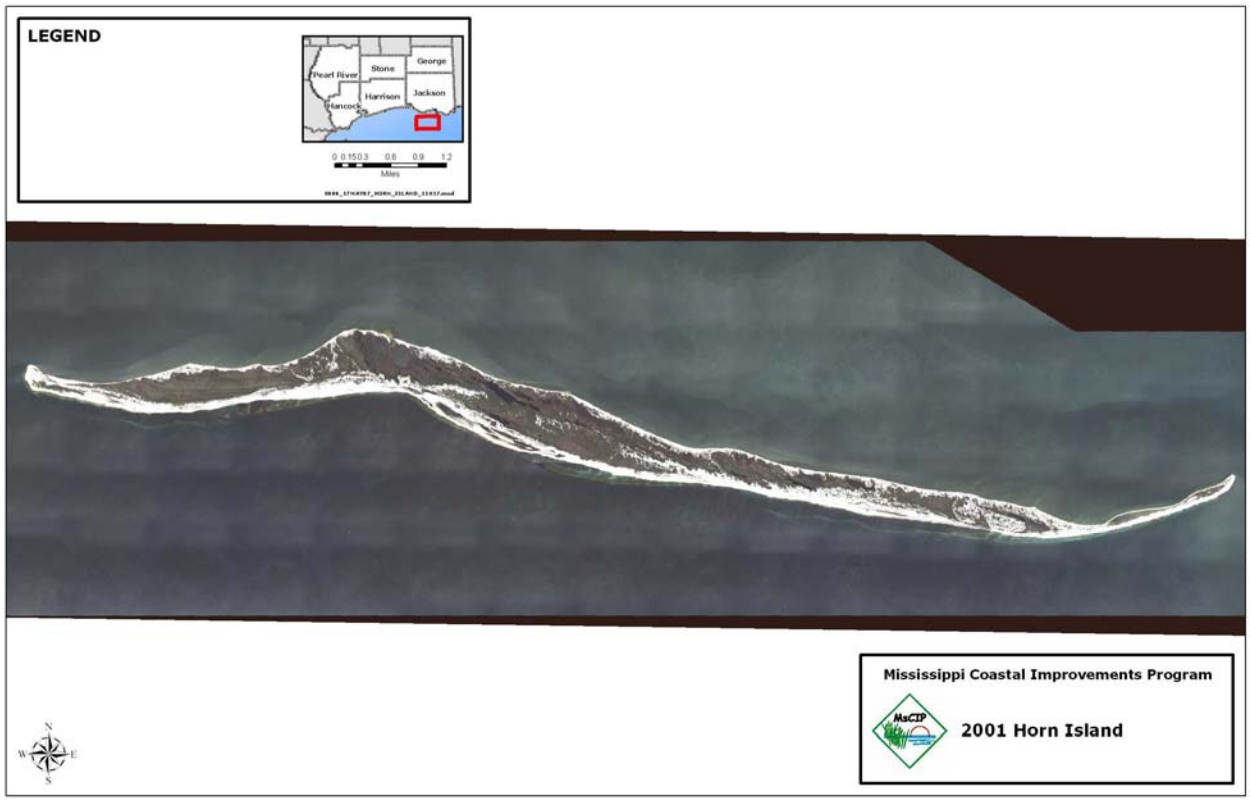


Figure 5.1.2.1-7. Aerial photo of Horn Island. The darker areas are vegetation consisting of maritime forest and marsh grasses.

As was mentioned at the end of Section 5.1.1 and will be discussed in more detail in Chapter 7 of this Appendix, an additional restoration option was added that will fill and close Camille Cut between West and East Ship Island. In addition to providing some storm damage reduction, this option will provide some protection to two historical sites on West and East Ship Island, respectively. This degree of protection is desired by the NPS and meets the goal of storm damage reduction and helping maintain the integrity of the Mississippi Sound estuary. This option will require additional study to model the desired results of slowing erosion near the two sites. These proposals have been incorporated into LOD-1 under Options C and G by adding sand into the littoral zone and closing the breach between West and East Ship island. A working paper that documents the NPS position on the barrier islands (NPS, Sept. 2007) along with other cooperating agencies is included in Chapter 6 of this Appendix. An important result of the NPS agreement was that any work that involved direct placement of sand into Camille Cut would be a one-time event without additional O&M sand placement. In accordance with 2006 NPS Management Policies (see Chapter 2, the NPS Vision Statement Section III), the NPS has concluded that this one-time placement of sand would mostly directly counteract the long-term reduction in sand supply which has resulted in Ship Island being diminished to the point where it may have lost the ability to restore and maintain itself as in the historical past. Natural re-building and maintenance of the barrier islands in the long-term would then be supported by the continuing placement of sand back into the littoral zone during future maintenance dredging of navigation channels under revised Regional Sediment Mamagement

Practices. Two important areas where this will be employed is the Pascagoula Navigation Channel and the Gulfport Navigation Channel.

5.1.3 Location

The barrier islands of Mississippi are located 10 to 15 miles south of the mainland as shown in Figure 5.1.1-1. Currently, there are five islands in the chain that extends for 45 miles west from a point south of the Alabama – Mississippi state line along the coast. Currently, Ship Island exists as two islands separated by Camille Cut. It was breached during Hurricane Camille in 1969 and remains today as West and East Ship Island. Two maintained navigation channels pass through the chain of islands. The Gulfport channel passes near the west end of West Ship Island and the Pascagoula channel passes near the end of Petit Bois Island. The present day location of the channels prevents any further westward migration of either island.

5.1.4 Existing Conditions

As is typical of most barrier island systems, the Mississippi islands are an ever-changing and dynamic landscape. Data shows that the islands have lost approximately 20 to 25 percent of their land mass since pre-Camille times. The islands have been heavily influenced by the various hurricanes including even the lower intensity ones. Hurricane George, in 1998, even though a small hurricane, proved to be devastating to the islands due heavy erosion from waves. Many of the higher dunes systems on the islands were destroyed and much of the elevation the islands once had is gone. Most of the islands are now very susceptible to over-wash during storms. Another result of being submerged during Hurricane Katrina was the loss of much of the maritime pine forest that existed on the islands. The trees, mostly now dead from the salt water submergence, played a major role in preventing erosion both from wind and any surges against the islands.

The westernmost island, Cat Island, has a similar origin from the other islands in the chain, but isolated from the littoral current by a historical birds-foot delta from the Mississippi River that cut off the path of the historical littoral zone. A change in wave climate has formed a T-shaped configuration. Sorting of the sediments has created a beach on the east facing portion of the island. Results of the sediment budget completed as part of this study indicates that little or no sand in being added to Cat Island from the littoral drift system that supplies sand to the other islands in the chain. The remainder of the islands have a westward drift that is more pronounced from the eastern-most Petit Bois Island and decreasing respectively to the west to West Ship Island.

5.1.5 Coastal and Hydraulic Data

The barrier islands protecting the Mississippi Sound experience a low energy wave climate, with average significant wave height at National Data Buoy Center (NDBC) Buoy 42007 (22 nautical miles south-southeast of Biloxi, in 45 ft depth) averaging 2.0 and 1.3 feet in the winter and summer months, with associated average peak wave periods of 4.0 to 3.5 s, respectively. Wave transformation modeling by Cipriani and Stone (2001) indicated that breaking wave heights on the barrier islands range from 1.0 to 2.0 feet. Waves in the Mississippi Sound are fetch and depth-limited. The Coastal Studies Institute's Wave-Current Surge Information System (WAVCIS) gage CSI-13 located at Ship Island Pass (23 foot depth) from June 1998 through July 2005 measured an average significant wave height of 0.3 feet and associated average wave period of 2.5 sec.

Tides in the Mississippi Sound are diurnal, with a tidal range of 1.5 and 2.8 feet for the mean and spring tides at Biloxi, Mississippi, respectively. However, the relatively shallow and large area of the Mississippi Sound create strong currents in the tidal passes between the barrier islands, ranging from 1.6 to 3.3 feet/sec and 6.0 to 11.5 feet/sec on flood and ebb tides, respectively (Foxworth et al. 1962). In the winter months, winds from the same direction and of a sufficient magnitude are capable

of lowering water surface elevations in the bays and nearshore from 3.6 to 2.0 feet (U.S. Army Corps of Engineers Mobile District 1984).

For the Gulf barrier island beaches, net longshore sediment transport is from east to west, although local reversals in the net transport occur adjacent to the tidal passes. The primary sources of sediment are longshore sediment transport from east to west, and, potentially, the offshore shelf (Otvos 1979, Cipriani and Stone 2001). Cipriani and Stone (2001) discussed that a well-defined cellular structure exists for each barrier island in which, over historic times, little sand transfer exists between islands. However, dredging records at Horn Island and Ship Island Passes (called Pascagoula Bar Channel and Gulfport Bar Channel, respectively) suggest that infilling of sand from adjacent barrier islands occurs, indicating the potential for transport of sand between islands. Eastern Dauphin Island, with a Pleistocene core, is more stable than the other barriers although eastern Dauphin Island has been eroding in response to the dominant westerly-directed transport. Based on grain size analysis, Cipriani and Stone (2001) inferred that offshore sources may provide some sediment to central Petit Bois Island. The Mississippi Sound barrier islands range from very well vegetated, with maritime forests on east Dauphin Island, to low elevation barriers that are overwashed and breached during hurricanes. Long-term relative sea level rise for Dauphin Island, Alabama from 1966 to 1997 was 0.12 inch/year +/- 0.02 inch/year.

5.1.6 Engineering Options

5.1.6.1 General

Seven separate options were included in the Engineering Appendix. All were based on some variation of direct sand placement and shaping, establishing vegetation and littoral zone sand additions. Each of the LOD-1 Options, A through G, have a brief description below. Full descriptions of each option can be found in the Engineering Appendix.

5.1.6.2 LOD-1, Option A

This option will only include new land mass that is being added to the islands by using sand dredged and transported from an off-shore location. The shaping of the sand into beaches, dunes and marsh areas will not affect the existing islands other than that narrow strip of land that will form the boundary between the existing island and the new land mass. This option can be used in combination with other options under this line of defense should it be desired to restore habitat on the existing islands.

5.1.6.3 LOD-1, Option B

Another consideration to help restore the islands is to supplement the sand in the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system. This option would obtain the sand from the beneficial use of dredged material from an inland river source.

5.1.6.4 LOD-1, Option C

Another consideration similar to Option B is to help restore the islands is to supplement the sand in the littoral system at Petit Bois and Ship Island. Sand will be obtained from offshore sources (same as Option A) for Ship Island and from inland river sources (same as Option B) for Petit Bois Island

based on sand quality and compatibility requirements. Like Option B, this could be accomplished by adding sand in specific locations based on sediment transport modeling.

5.1.6.5 LOD-1, Option D

This option would involve environmental restoration of the existing islands. This would consist of shaping existing beach sand into low, 2-foot high dunes on the beaches. This would be along with planted vegetation on the dunes and planting of maritime forests in the inland's interior where they were mostly destroyed by Hurricane Katrina.

5.1.6.6 LOD-1, Option E

This option would involve environmental restoration of the islands consisting of placing and shaping sand into 6-foot dunes on the beaches with planted vegetation and planting of maritime forests on the existing islands where they were mostly destroyed by Hurricane Katrina. The sand required to construct a dune of this size would be more than could be removed from the existing beach berm and would come from the same offshore borrow area as the sand used in Option A. Placement of the sand would require moving the sand from a hopper dredge to a staging area on the beach, then moving the sand to the area of placement along the beach.

5.1.6.7 LOD-1, Option F

This option would involve environmental restoration of the sea grass beds that have historically existed on the north side of the islands in the Mississippi Sound. Despite continual changes that occur, the barrier islands remain to buffer the mainland from storms and provide habitat for the rich, diverse wildlife residing within the area.

5.1.6.8 LOD-1, Option G

The pre-Camille footprint of Ship Island was obtained from historical records. This data showed the area that was breached during Hurricane Camille forming two separate islands. West and East Ship Island has two major historic sites that are in danger from the continuing erosion of the barrier islands. Current studies by the Corps indicate that restoring the two islands to a single island, pre-Camille condition may prevent the rapid erosion of the beaches that is now occurring. Estimates indicated that the restoration of Ship Island to a single land mass off the Mississippi coast will involve approximately 8 million cubic yards of sand. As happened during Hurricane Camille, the breach was opened during Hurricane Katrina leaving two islands with approximately three miles of open water between the remaining portions. To mitigate this problem, the breach could be filled as single operation up to an elevation that would help withstand over-wash until planted vegetation could be come established and promote stable dunes.

CHAPTER 6 MULTI-AGENCY MISSISSIPPI BARRIER ISLAND RESTORATION RECOMMENDATION

6.1 General

To complete its recommendation for the barrier islands the National Park Service met and coordinated with many different agencies including the Corps of Engineers, United States Geological Survey, National Marine Fisheries Service, Environmental Protection Agency, National Oceanic and Atmospheric Administration, US Fish and Wildlife Service, and Mississippi Department of Marine Resources.

6.2 Introduction

The Mississippi barrier islands consisting of Petit Bois, Horn, East and West Ship Islands, and portions of Cat Island are located within Gulf Islands National Seashore (Seashore), a park unit managed by the National Park Service (NPS). The NPS also administers the 401-acre Davis Bayou area on the mainland near Ocean Springs, Mississippi. The Seashore's purpose is to preserve, protect, and interpret its Gulf Coast barrier island and bayou ecosystem and its system of historic coastal defense fortifications, while providing for public use and enjoyment.

The Mississippi barrier islands are dynamic coastal landforms that act as the first line of defense between the ocean and mainland coast, and bear the full impact of atmospheric and oceanic energy (Figure 6.5-1). In addition, the barrier islands contribute to the maintenance of the highly productive Mississippi Sound ecosystem. Hurricanes, variations in sediment supply, and relative sea level rise drive changes in island location and morphology, and effective barrier island management requires adaptation to their dynamics.

The Mississippi barrier islands have experienced substantial changes in shoreline position and island landmass since the mid-1800s. Lateral island migration (erosion along the eastern end of the islands and sand deposition to the west) has occurred, driven by dominant east-to-west longshore sand transport. The long-term and accelerating erosion and land loss experienced by the barrier islands is of major concern to the NPS.

Factors contributing to erosion of the barrier islands include storms, relative sea level rise, and anthropogenic activities, including dredging of sand from the Horn Island Pass Outer Bar Channel (Figure 6.5-1). Such activities have likely resulted in a progressive reduction in sand supply downdrift to Horn Island and Ship Island (now East and West Ship Island). Significant storm events and a reduction in sand supply has contributed to substantial upland land area losses between 1847 and 2005 ranging from 24% at Horn Island to 64% at the Ship Islands. In addition, Petit Bois Island, which is located east (updrift) of Horn Island Pass, has experienced a 56% reduction in upland land area between 1847 and 2005 (Morton, 2007).

The regional shortage of littoral sand for barrier island maintenance is most profound at the Ship Islands, located at the terminus of the sediment transport system along the Mississippi barrier islands. Cat Island, located west of the Ship Islands, is not part of the sand-sharing system that comprises the other barrier islands, and is considered to be a separate entity (Rosati et al., 2007). Consequently, the Ship Islands' vulnerability to breaching has progressively increased with time.

Because of the island's diminished state, it may now have lost the ability to restore and maintain itself as in the historical past (Morton, 2007), placing the island's cultural resources, historic Fort Massachusetts and the French Warehouse archeological site, at great risk (Figure 6.5-2).

Given the altered state of natural resource processes due in part to human-caused intervention, as well as the resulting threats to cultural resources, the NPS in collaboration with other agencies (USACE, USGS, NMFS, EPA, NOAA, USFWS, and MDMR) has concluded that specific emergency actions and long-term restoration of the sediment transport system and budget are crucial and necessary for preserving and protecting the Mississippi barrier islands' natural and cultural resources. This Mississippi barrier island restoration recommendation represents the results of extensive interagency consultation and collaboration.

6.3 Background

6.3.1 NPS Management of Mississippi Barrier Islands

Gulf Islands National Seashore includes outstanding natural, cultural, and recreational resources along the northern Gulf of Mexico coasts of Florida and Mississippi. These resources include several coastal defense forts spanning more than two centuries of military activity, archeological values, pristine examples of intact coastal barrier islands, salt marshes, bayous and submerged seagrass beds, complex terrestrial communities, emerald green water, and white sand beaches. The barrier islands within the Seashore are nationally significant for several reasons. Specifically, these islands:

- contain one of the most complete collections of publicly accessible seacoast defense structures in the United States, representing a continuum of development from early French and Spanish exploration and colonization through World War II;
- provide the public with recreational opportunities on natural and scenic island, beach, dune and water areas which possess the rare combination of remaining undeveloped and in a wilderness state, yet are located in close proximity to major population centers;
- provide habitat for several endangered species in diverse ecosystems, stop-over habitat for migratory birds, and critical nursery habitat for marine flora and fauna, and serve as an enclave for complex terrestrial and aquatic plant and animal communities that characterize the northern Gulf Coast, and fully illustrate the natural processes which shape these unique areas;
- contain land and marine archeological resources which represent a continuum of human occupation in a coastal environment and are important in enhancing the knowledge of the past including interactions between the earliest settlers and original inhabitants of this area of the Gulf Coast; and
- provide a benchmark to compare conditions in developed areas of the Gulf Coast to natural areas within the park.

The NPS's vision for management of the Mississippi barrier islands (Chapter 2) includes the preservation of natural biological and geological marine and terrestrial conditions and processes, and the preservation of cultural resources, consistent with peer-reviewed and documented scientific study. Horn and Petit Bois Islands, which are designated wilderness areas, receive an even higher level of protection. In these areas, the NPS vision and management focuses on providing park visitors with an undisturbed environment, a pristine and unencumbered viewshed, an atmosphere of solitude, an opportunity for primitive, unconfined recreation, and negligible evidence of resource impairment. The NPS implements this vision by controlling nonconforming uses, preventing

unnecessary or undue reduction of wilderness values, and applying the “minimum requirement” concept of the 1964 Wilderness Act to all proposed projects involving these islands.

Based on federal statutes such as the National Park Service Organic Act and the Seashore’s enabling legislation, NPS Management Policies, and management plans, the NPS is mandated to preserve and protect the natural conditions and processes affecting the barrier islands, and to preserve the significant cultural resources existing on the islands. In addition, the Seashore’s enabling statute directs that beach erosion control measures and spoil deposition activities in the park undertaken by the U.S. Army Corps of Engineers must be carried out in a manner that is acceptable to the NPS and consistent with the park’s purposes (16 U.S.C. § 459h-5). NPS decision-making must also integrate the results of scientific study (16 U.S.C. § 5936).

6.3.2 Impacts to Mississippi Barrier Islands and Processes

Net longshore sand transport is from east to west along the Mississippi barrier islands, although local reversals in the net transport occur adjacent to the tidal passes. Based on analysis of historical shoreline and bathymetry data, Ship Island is the terminus to the longshore sand transport system in this region. Modern Cat Island beaches, located west of Ship Island, appear to be affected by littoral processes not directly related to those of the islands to the east. Thus, the regional shortage of littoral sand for barrier island maintenance is best observed at Ship Island (Rosati et al., 2007).

Between the late 1840s and 2005, all of the Mississippi barrier islands managed by the NPS have eroded and migrated appreciably. Petit Bois Island lost about 56% of its surface area, Horn Island lost approximately 24%, East and West Ship Islands have cumulatively lost about 64%, and Cat Island lost approximately 26% (Morton, 2007). Furthermore, island erosion rates have increased more than three fold between 1847 and 2000/2002. For example, Ship Island lost about 0.9 hectares/year between 1848 and 1917, increasing to approximately 2.5 hectares/year between 1917 and 2000 (Rosati, et al., 2007). Additionally, between 2000 and 2005, a period of significant storm events, the Ship Islands lost about 22 hectares/year (Morton, 2007). In 1847, Ship Island had a surface area of approximately 603 hectares (Rosati, et al., 2007), but by 2005 the total surface area for East and West Ship Islands had decreased to about 216 hectares (Morton, 2007).

The principle causes of Mississippi barrier island erosion and land loss are frequent intense storms, a relative rise in sea level, and a deficit in the sediment budget. Of these causes, the one that experienced the greatest change over the last 100+ years is the reduction in sand supply related to dredging of navigation channels through the outer bars of the tidal inlets near the islands (Morton 2007). According to Rosati et al. (2007), maintenance dredging operations conducted between 1897 and 1948 in the Horn Island Pass Outer Bar Channel removed sediment at a rate of approximately 34000 cubic yards per year (cy/yr). After the channel was modified to 38-feet deep by local interests in 1949 at their expense, maintenance dredging quantities continued to increase as authorized channel depths increased. Maintenance dredging rates increased to161,104 cy/yr in 1949-1965, increased again to 515,320 cy/yr in 1965-1993, and decreased to a rate of 245,483 cy/yr in 1993-2005.

Therefore, between 1909 and 2005, a total of approximately 22 million cubic yards of sand were removed from the Horn Island Pass Outer Bar Channel by maintenance dredging (Rosati et al., 2007). Much of the sand dredged from the outer bar channel during maintenance dredging operations likely originated from littoral zone transport east of the channel. Offshore disposal of sand dredged during channel maintenance operations conducted in the past may have removed such sand from the barrier island sediment budget downdrift of the channel. However, a detailed analysis of the dredging/placement records and the resulting impact on the barrier island sediment budget has yet to be determined. Additional investigations into past dredged material placement quantities and locations relative to the regional barrier island sediment budget need to be conducted.

Ship Island experienced breaching by hurricanes in 1852, 1916, 1947, and 1969 (Hurricane Camille). However, pre-Camille breaches eventually shoaled and the narrow, low-profile barrier beach reformed through natural processes. Since 1969, Ship Island has been separated into two islands (East and West Ship) by "Camille Cut." Between 1969 and 2002, the average width of Camille Cut between the Ship Islands was approximately one mile. However, the breach widened to about three miles following the passage of Hurricane Georges in 1998, creating a shallow subaqueous shoal across the eastern one-mile of the breach area. Although precise depth measurements are not yet available, water depth across most of the breach area is estimated at 1 to 5 feet, and the channel that has formed adjacent to the east end of West Ship Island is about nine-feet deep (Figure 6.5-2).

Recent scientific reports present concerns regarding the existing condition of the Ship Islands and their ability to restore themselves to a single island once again based on current trends (i.e., accrete enough sand to shoal, closing the Camille Cut breach and channel, and redeveloping the narrow, low-profile barrier beach). Morton (2007) states "the historical record for Ship Island indicates that its vulnerability to breaching progressively increased with time and that because of its diminished state, the Camille Cut inlet will not shoal and East and West segments will not become reattached as in the past." Rosati et al. (2007) also notes "disintegration of this barrier island (Ship Island), especially since Hurricane Katrina in 2005."

Beach erosion along the Mississippi Sound (Sound) shoreline of East and West Ship Islands currently threatens the French Warehouse archeological site and historic Fort Massachusetts (constructed between 1859 and 1866), respectively. Relatively small-scale beach renourishment projects with sand volumes ranging from 44,346 to 160,566 cubic meters were authorized in 1974, 1980, 1984, 1991 and 2002 to advance the north shoreline on West Ship Island to protect Fort Massachusetts. Observations indicate that Camille Cut may be exacerbating erosion along the northeast shoreline of West Ship Island, and it may be interrupting sediment transport downdrift toward Fort Massachusetts.

The consequences of continued erosion of the Mississippi barrier islands affect not just the islands themselves, but the physical, chemical and biological integrity of the Sound and the Mississippi mainland coast. In the broader regional sense, the physical integrity of these barrier islands may provide the Sound and coastal counties some degree of protection from the energy generated by tropical storms and hurricanes. Ocean surge generated by hurricanes has been modeled with and without these islands for a variety of storm tracts, intensities and forward speed. As modeled, ocean surge protection provided by these islands is estimated between two (2) and four (4) feet, with a general tendency of greater protection toward the eastern area of the Mississippi mainland coast (Ty Wamsley, personal communication, Sept. 18, 2007).

Wave height modeling for a variety of storm tracts, intensities and forward speed also shows that the physical presence of the barrier islands may reduce expected wave height at the Mississippi mainland shoreline by four (4) to six (6) feet. Again, the barrier islands afford a greater degree of protection relative to wave height reduction toward the eastern area of the Mississippi mainland coast (Ty Wamsley, personal communication, Sept. 18, 2007). Furthermore, combining predicted surge and wave height modeling results shows that total loss of the Mississippi barrier islands may increase the elevation of adverse impacts on mainland coastal areas on the order of an additional six (6) to ten (10) feet.

The loss of any one barrier island would result in a more localized coastal impact. Localized increases in surge, wave height and current speeds would likely occur due north and west of a barrier island lost from the system. Additional modeling is necessary to determine the potential impacts to the mainland coastal area if the Ship Islands continued to erode to a shallow sand shoal.

Water chemistry within the Sound would be expected to change as well with the physical loss of any one or more of the barrier islands. Specifically, salinity gradients may increase in the Sound north of any area of greater exposure to Gulf of Mexico waters resulting from continued erosion and loss of the barrier islands, or the creation of additional water exchange pathways (passes, cuts, etc.). Baseline salinity modeling completed by USACE Engineer Research and Development Center demonstrates this potential gradient increase. Salinity gradient increases resulting from new or expanded passes or cuts would result in greater penetration of oyster drills into the Sound. The expansion of salinity gradients and related penetration of oyster drills increases potential adverse affects on Sound oyster beds.

Other biological communities, such as submergent and emergent grass beds, marshes, scrub/shrub and forest vegetation communities could be adversely affected by the continued erosion and land loss of the barrier islands. Predicted higher storm surge, waves and energy would likely shift these vegetation communities landward over time. Disruptions of these existing vegetation communities exposes highly erodeable soils, and when subjected to high energy, may increase water turbidity and decrease light penetration, reducing submergent vegetation and depositing sediment on existing oyster beds. Emergent vegetation in the Sound and along the coastline provides protection from storm surge and wave action. These components also provide significant benefits for aquatic and aquatic-dependent faunal species of this area. Food, cover, spawning and nursery sites for estuarine and marine organisms require some or all of these submergent and emergent vegetative communities during their life cycles. Coastal areas that have significant emergent marshes, scrub/shrub and forested vegetative communities in the tidal zone have significantly less wind and storm surge damage than coastal areas adjacent to open water.

Continued erosion and loss of the Mississippi barrier islands within Gulf Islands National Seashore could result in significant adverse consequences not only to the natural and cultural resources managed by the NPS, but also to the overall health of the Mississippi Sound ecosystem and mainland coastal communities. Under a no action scenario, barrier island land loss will continue to increase. At the current rate of erosion and land loss on East and West Ship Islands, these islands may be eliminated within a decade. If so, significant natural and cultural resources managed by the NPS, including Fort Massachusetts, will be in peril.

6.4 Barrier Island Restoration Strategy

Given the value of these barrier islands as natural habitat, recreation sites, and possible protection for the mainland to some degree, the following recommendations are designed to address chronic losses in surface area along the islands to restore the natural transport system and island habitat that existed historically. Priority is assigned to East and West Ship Island because these islands have recorded the greatest losses throughout the system and significant cultural resources on both islands are at risk.

6.4.1 Restoration Goals

The overarching goal is to restore the crucial sediment transport system and budget, including littoral zone geologic processes around the Mississippi barrier islands, to a natural state as much as possible given the realities of navigation channel dredging, climate change (sea level rise, increased frequency of storms, etc.) and other anthropogenic activities. Restoring the sediment transport processes of the Mississippi barrier islands to a condition similar to the natural system that functioned before human intervention offers the best opportunity to ensure the long-term viability of these islands.

The preferred restoration approach includes (1) littoral zone deposition of compatible sand, consistent with the quality, especially color, grain size, absence of contaminants, and angularity of sand that would be present in the barrier island system under natural conditions, in appropriate volumes and locations near Petit Bois, Horn and East Ship Islands; (2) up to two small-scale beach nourishment projects on the Mississippi Sound shoreline of West and East Ship Islands to protect historic Fort Massachusetts and the French Warehouse archeological site; and (3) the direct deposition of acceptable beach-quality sand in the area of chronic breaching and inlet formation at Camille Cut to reconstruct the narrow, low sand spit that historically connected East and West Ship Island. The primary objectives of this alternative are to restore the Mississippi barrier island sediment transport system and budget disrupted by anthropogenic activities conducted near these islands, facilitate the restoration of Ship Island to a natural condition, and reduce erosion threats to significant cultural resources.

This preferred restoration strategy would also provide for (1) additional scientific investigations and modeling on which project planning, restoration benchmarks, goals, monitoring protocols and adaptive management prescriptions will be based; and (2) restoration of the regional sediment transport processes, including at a minimum the bypassing of all beach-quality sediment dredged from the navigation channels near the Mississippi barrier islands, and the proper placement of such sediment in the littoral system to replicate natural coastal geologic processes and provide for the protection and preservation of these nationally significant islands.

The sand placement strategy considered for restoration of Ship Island is based on the general geomorphic characteristics of the circa 1916-1917 shoreline and island land mass. The 1916-1917 baseline condition represents the most recent shoreline data available which documents a continuous Ship Island (Rosati et al., 2007; Morton, 2007). Applying data presented in Rosati et al. (2007), this baseline condition also represents a time frame prior to significant increases in maintenance dredging rates and thus volumes of sand removed in the Horn Island Pass Outer Bar Channel which began to occur in 1949. The land mass that connected East and West Ship Islands in 1916-1917 was a narrow, low sand spit measuring approximately 1000-feet wide (north-south width) with a likely elevation of approximately five (5) feet.

The volume of sand necessary to achieve the prescribed “emergency actions” and “advanced engineering and design actions” described below is based on the premise that the 22 million cubic yards of sand removed from the Horn Island Pass Outer Bar Channel during the period of 1909-2005 should be properly placed back into the sediment transport system to restore the barrier islands. In addition, sand removed from the Horn Island Pass Outer Bar Channel during future maintenance dredging operations should be properly placed west of the channel to mimic the natural sediment transport system.

6.4.2 Emergency Actions

Emergency actions would include direct placement of compatible sand on the Sound shoreline of West Ship and East Ship Islands to protect the integrity of historic Fort Massachusetts and the French Warehouse archeological site, direct placement of compatible sand in Camille Cut to suture (fill-in) the existing gap between East and West Ship Islands to a circa 1916-1917 geomorphic condition, and concurrently placing compatible sand in the littoral zone near East Ship Island.

Beach renourishment to protect the integrity of Fort Massachusetts and the French Warehouse archeological sites would include the direct placement of approximately 100,000 cubic yards of beach-quality sand along the Sound shoreline of West Ship Island to protect Fort Massachusetts, and direct placement of about 100,000 cubic yards of beach-quality sand on the Sound shoreline of East Ship Island to protect the French Warehouse archeological site. Sand source locations, compatibility requirements, precise depositional locations, depths of sand deposition, etc., would be

determined by the NPS and USACE. A second round of direct sand placement at the same volumes and locations is contemplated within five years following initial emergency beach renourishment to protect these significant cultural resources until such time as restoration of the barrier island sediment transport system and budget is achieved through additional planned actions described below.

In order to restore the 1916-1917 geomorphic condition of Ship Island, approximately 7 million cubic yards of compatible sand would be directly placed in the Camille Cut breach and inlet area to reconnect East and West Ship Islands (Figure 3). The proposed dimensions of the Ship Island breach restoration project are three (3) miles in length, 1000 feet wide (north-south width), with a proposed sand thickness of approximately six (6) to 14 feet to achieve the desired five (5) feet subaerial elevation across the restored spit reconnecting East and West Ship Islands. However, the anticipated volume of sand required to achieve these restoration dimensions could be slightly modified based upon the results of a planned bathymetric survey of the breach area by the USGS. The sand placement approach would be adaptively managed based on monitoring of project performance measures. The restored sand spit would be planted with native vegetation species (e.g., seaoats, bitter panicum, etc.) to hold the sand in place and to foster future entrapment of wind-blown sand and long-term island stabilization. Native vegetation species would be planted in 60 feet swaths and no closer than approximately 100 feet from both the Gulf and Sound shorelines.

Sand placement in the littoral zone near East Ship Island is essential for continued nourishment to the restored spit at the Camille Cut breach and inlet. Approximately 10 million cubic yards of beach-quality sand would be placed within water depths affected by normal to moderate wave action and no deeper than 15 feet, the USACE definition of maximum littoral zone depth for this area (Hallermeier, 1981 (USACE Coastal Engineering Tech. Aid No. 81-2)) over a large area on the south-southeast side of East Ship Island. This phase of restoration is essential for supplying sand to the beaches west along Ship Island, including those occupying the reconstructed connecting spit. Westward sand transport from the reconstructed spit will also nourish the shoreline near Fort Massachusetts through natural alongshore currents in the Sound. Detailed planning for such deposition in the littoral zone near East Ship Island would be subject to the results of additional research and modeling efforts, including near-shore bathymetry and numerical modeling of waves, currents, and sediment transport.

During and following the placement of sand in all the aforementioned restoration locations, the effectiveness of such placement should be evaluated for success as part of an adaptive management strategy. If metrics indicate successful performance for island restoration and littoral zone placement, projects will continue as planned. Otherwise, at the end of year one, a reassessment and potential change in location for littoral zone placement may be implemented. Successful performance should be based on several factors, including, but not limited to, proper sand placement to nourish the islands and to protect Fort Massachusetts and the French Warehouse archeological site for the next 20 years without a need for annual or repetitive maintenance. Additional sand placement and native vegetation replanting may be required, depending upon success rate, to achieve the desired percent cover.

6.4.3 Advanced Engineering and Design Actions

This restoration strategy will also include the proper placement of approximately 5 million cubic yards of beach-quality sand in the littoral zone updrift of Petit Bois Island in water depths affected by normal to moderate wave action and no deeper than 15 feet. In addition, this strategy proposes to place all sand removed during maintenance dredging operations from the Horn Island Pass Outer Bar Channel to the west of the channel and east of Horn Island so that the dredged sand remains within the littoral zone. The bypassed sand will also be placed in water no deeper than 15 feet. Such

bypassing of sand transported to Horn Island is essential to the long-term health and maintenance of downdrift islands (Horn, East and West Ship Islands). It is estimated that approximately 1 million cubic yards of sand will be bypassed every 2.5 years.

Detailed planning for such deposition in the littoral zone near Petit Bois and Horn Islands would be subject to the results of additional research and modeling efforts, including near-shore bathymetry and numerical modeling of waves, currents, and sediment transport. During and following the placement of sand in the littoral zone near Petit Bois and Horn Islands, the effectiveness of such placement should be evaluated for success as part of an adaptive management strategy. If metrics indicate successful performance for littoral zone placement, projects will continue as planned. Otherwise, at the end of year one, a reassessment and potential change in location for littoral zone placement may be implemented.

6.4.4 Long-term Restoration Actions

Restoring and replicating the sediment transport processes and budget of the Mississippi barrier islands to a condition similar to the natural system that functioned before human intervention offers the best opportunity to ensure the long-term viability of these islands. Therefore, the best long-term restoration solution is to plan for the bypassing of compatible sand routinely dredged from navigation channels in the area that are located east of Petit Bois and Horn Islands. Appropriate volumes of sediment would then be available in the littoral zone transport system to replenish sand lost from all of the Mississippi barrier islands due to natural geologic processes. Any long-term planning to achieve this objective must be based on sound scientific information and understanding of the barrier island sediment budget and transport system, and must be consistent with NPS mandates.

6.4.5 Data Collection, Analysis and Modeling

Prior to implementing the recommended barrier island restoration actions presented above, additional data collection, analysis and numerical modeling must be completed to ensure that project design is based upon the most current scientific information and understanding of the sediment transport system and budget. Recommended data collection and analysis needs include:

- conduct bathymetric survey throughout the island chain and inlets to document water depth in Camille Cut between East and West Ship Islands, identify sand resource targets, and update the existing sediment budget related to island restoration (Figure 6.5-4);
- analyze U.S. Coast Survey topographic maps of Ship Island prepared in 1848, 1853, and 1917 to confirm the subaerial elevation of the narrow sand spit in the central part of the island during that period;
- obtain current orthophotography to document island geomorphology and vegetation characteristics as part of CHARTS data acquisition, and to derive high-water shoreline position for each barrier island;
- acquire seismic and vibracore data at dredged material disposal site locations identified by comparing the modern bathymetric survey to the 1917/18 survey;
- determine sedimentologic characteristics of existing dredged material disposal sites to verify the quantity of sand available for barrier island restoration;
- review past dredged material placement quantities and locations relative to the regional sediment budget; and

- review historical breaching and breach closure data for all islands, and assess available geologic and morphologic data for Ship Island relative to the other barrier islands, to determine why Ship Island has breached several times, whereas Horn Island and Petit Bois Island have not.

To adequately design sand placement throughout the system and to evaluate potential impacts of the no action and preferred alternative scenarios, numerical modeling of waves, currents, and sediment transport should be conducted. Modeling analysis will validate the regional beach response to evaluate dredging and placement alternatives, and restoration of East and West Ship Islands. All historical data since the mid-1800s will be utilized in developing and calibrating the model so that future evolution (decades to a century) can be estimated with and without anthropogenic activities. Recommended modeling tasks include:

- develop input data for the Cascade Model, including shoreline position, topographic cross sections, sediment sources and sinks, vegetation composition and density through time, aerial photographs, storm and typical wave, wind, and water level data, and incorporate spatial data into the existing MsCIP sediment budget GIS;
- calibrate and validate Cascade (including sub-modules: breaching, wind-blown sand and dune building);
- demonstrate application of Cascade for proper dredged material placement, interim beach fills, and large-scale renourishment;
- evaluate placement locations for dredged material disposal at Horn Island Pass and Ship Island Pass for effective bypassing of littoral sand to mimic the barrier island natural sediment transport processes;
- conduct wave climate and surge modeling with and without the Ship Islands to assess potential impact on the mainland; and
- conduct salinity modeling to predict change in the salinity regime under present conditions, without the islands, and with a restored Ship Island (continuous island across the present location of Camille Cut).

6.5 Adaptive Management Strategies for Mississippi Barrier Island Restoration

Adaptive management strategies employed during the restoration project will provide the means to monitor the progress of the project, to assess whether immediate or short-term impacts are those intended or unintended, and a means to halt or modify project activities, or to mitigate the effects of activities, should negative or adverse impacts to natural or cultural resources be noted during monitoring. Monitoring activities should be continued for a specified time period after project activities are completed to measure long-term or cumulative impacts, and whether the goals of the project have been met.

6.5.1 Monitoring Protocols

Monitoring during and following the implementation of the barrier island restoration actions described above is needed to assess the progress of the restoration and short- and long-term impacts to the barrier island system and cultural resources. Monitoring recommendations include:

- obtain orthophotography of each barrier island on an annual basis to determine shoreline position change;

- map bathymetry in the barrier islands area pre- and post-project, 1 year after project completion, 5 yrs after project completion, and immediately following passage of a tropical storm or hurricane to document movement of sand placed in Camille Cut and in the littoral system;
- use topographic, bathymetric and hyperspectral sensors on the Compact Hydrographic Airborne Rapid Total Survey (CHARTS) system to document land elevation and vegetation density change annually, and process and analyze acquired data in an efficient and timely manner to make adjustments in sand placement strategies if desired results are not being achieved; and
- obtain daily real-time water quality data adjacent to all beach renourishment, direct placement and littoral zone placement areas in coordination with EPA Gulf of Mexico, MS Department of Marine Resources and MS Department of Environmental Quality.

During the barrier island restoration process, information obtained through the adaptive management monitoring protocols outlined above will be reviewed by a committee consisting of representatives from NPS, USGS, USACE, NOAA and the State of Mississippi. This committee would determine whether the restoration objectives were being met, and if not, whether sediment placement strategies should be modified or terminated.

6.5.2 Barrier Island Restoration Success Benchmarks

Suggested benchmarks to use to measure the degree of success of the restoration project include:

- 80% vegetation survival in the Camille Cut fill area two (2) years following completion of replanting efforts;
- absent a storm of record, Ship Island should remain continuous for 20 years, and expected minor breaches that occur should heal within 10 years;
- rate of accretion along the western edge of Ship Island should respond as it did in the historical record based upon the best available scientific information; and
- sand placed in the littoral system east of Horn and Petit Bois Islands should result in restoration of the east ends of these islands as measured by an increase in the surface area or a significant decrease in the rate of surface area loss documented during the past two decades.

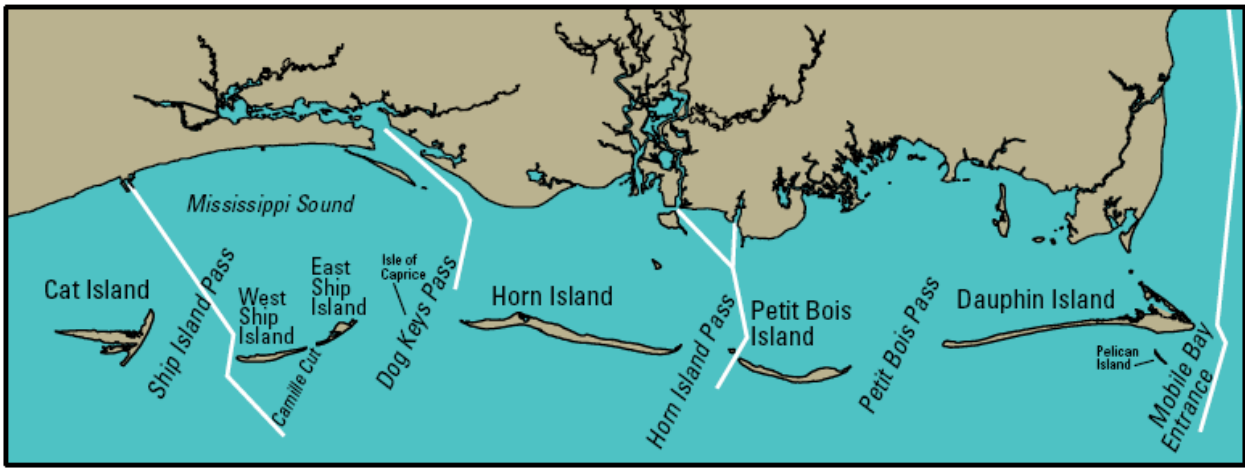


Figure 6.5-1. Locations of the Mississippi-Alabama barrier islands and associated tidal inlets. Deep draft shipping channels maintained by periodic dredging are show as white lines. (from Morton, 2007)

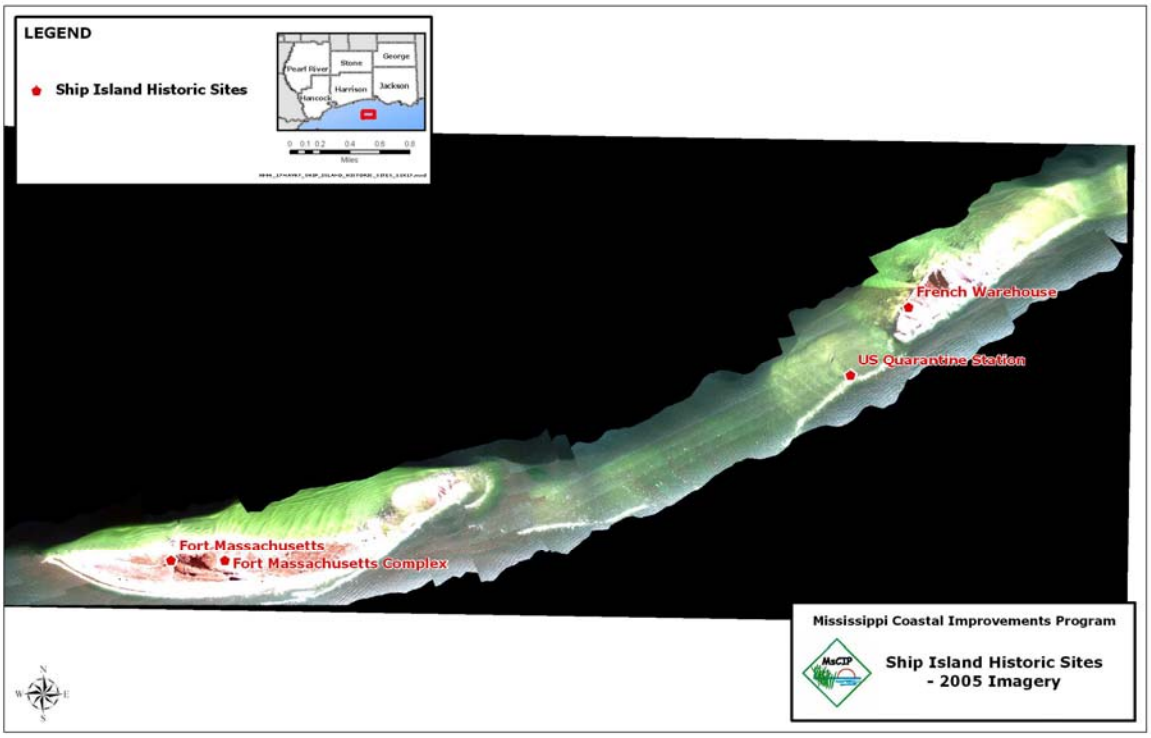


Figure 6.5-2. Aerial photo of West and East Ship Island taken in 2005 after Hurricane Katrina showing the locations of listed cultural resource sites. Note the presence of Camille Cut tidal inlet adjacent to the east end of West Ship Island.



Figure 6.5-3. Approximate conceptual dimensions of the proposed island restoration project connecting East and West Ship Island and filling Camille Cut.

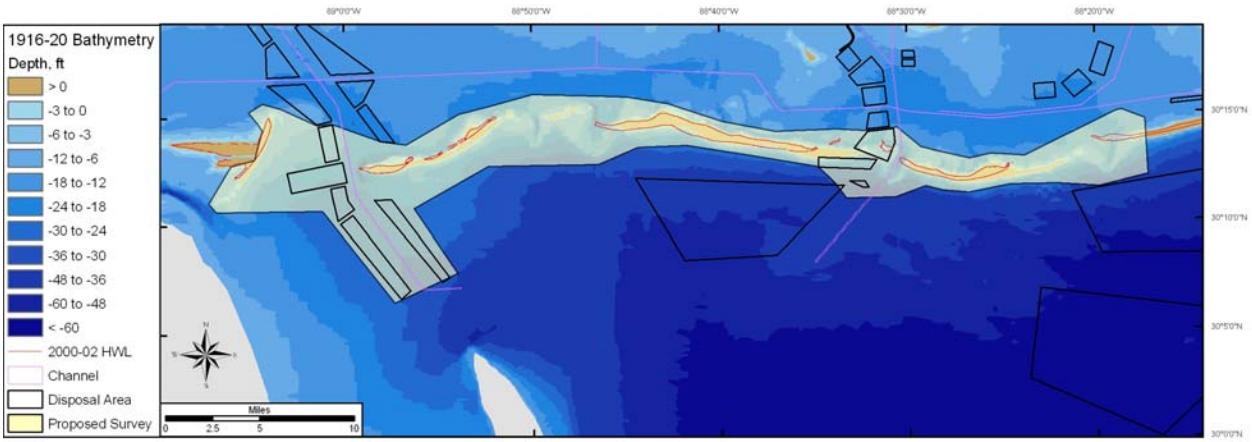


Figure 6.5-4. Proposed location (outlined in the light blue area surrounding the barrier islands) for modern bathymetry survey for identifying potential sand resource targets and updating the existing sediment budget related to island restoration.

CHAPTER 7 THE COMPREHENSIVE BARRIER ISLAND PLAN

7.1 General

The Comprehensive Barrier Island Plan is recommended for construction and will consist of the combination of two engineering options for the barrier islands combined with recommended changes in the local Regional Sediment Management practices. This alternative is recommended to help prevent the accelerated erosion of the barrier islands, especially what is now West and East Ship Island (a single island prior to Hurricane Camille) as well as Petit Bois Island to the east. The National Park Service has endorsed a restoration of islands as described below based on the anthropogenic activities that have compartmentalized the Gulf Islands National Seashore based on national interests including shipping, cultural resources, federally listed species and Essential Fish Habitat components. Stabilizing the outermost barrier islands appears to be the best way to ensure the Mississippi Sound and coastal shoreline ecosystems remain intact. These islands also are the first natural features that protect the coastal counties of the State Mississippi.

To provide needed data on some aspects of completing this plan, additional studies will be conducted during the Engineering and Design (E&D) phase of this project. It is generally understood that the loss of these islands will change the entire ecosystem of the Mississippi Sound as well as having affects on the amount of storm damage incurred along the mainland coast. Since the islands form the Mississippi Sound estuary, continued loss of the islands will allow a different salinity interface as fresh water from the mainland river systems and the salt water from the Gulf of Mexico adjust to new tidal and littoral currents. Under E&D, additional storm surge, wave, water quality,and sediment transport modeling will be conducted to predict the affects of not having West and East Ship Island in place during future hurricanes. Initial modeling indicate that taking Ship Island(s) out of the system will not have a great effect on surge, but will have a major impact on waves that affect the mainland. The additional sediment transport modeling will also be used to optimize the placement of sand in the littoral zone under this plan. Water quality models will also be conducted to predict the changes to salinity levels in the Sound without Ship Island.

Immediately following Hurricane Katrina, the State of Mississippi proposed restoring the barrier islands back to a pre-Hurricane Camille condition with the concept that this would reduce storm surge on the mainland. Analysis of the land loss among the four islands indicated that from 1917 to 2006 (post-Katrina) over 1600 acres of the islands had been lost. To return the islands back to a 1917 footprint (when there was good data available), a supply of beach quality sand would be required that was estimated at 66,000,000 cubic yards. The quality of the sand source would need to be similar in color, grain size, and roundness to the sand that currently comprises the barrier islands. The NPS had concerns over the State's proposal in that it directly contradicted their policy of letting nature take its course unless it was to restore the activities of man or to protect historical sites within Park boundaries. As modeling efforts to evaluate storm surge were being conducted, a sensitivity analysis was performed on different restoration changes to the barrier islands. These results indicated that reductions in surge would not be large, but that the increase in wave heights would be significant if the barrier islands eroded away. Other studies by the USGS and ERDC showed a continuing trend in erosional loss of the islands and that West and East Ship Island would probably be totally lost in the future. Loss of the islands would also be expected to drastically change the ecology of the estuary formed between the islands and the mainland. With all these considerations, the NPS and the Corps formulated a plan (referred to as the NPS Plan) for the barrier islands that would help mitigate some of the loss at the islands and prolong the existence of the islands. This plan includes direct placement of sand to fill a breach in Ship Island, commonly called Camille Cut,

that has existed since Hurricane Camille, add sand to the littoral zone in two areas, and to propose changes in the disposal practices of littoral zone sediment removed from local navigation channels.

7.2 Additional Studies - Littoral Zone Placement and Cat Island Coastal and Ecological Processes and Confirmation of Borrow Areas

Prior to any placement of sand, additional modeling is required to confirm the quantity and quality of sand in borrow areas, better define the optimal locations for the littoral zone placement and obtain additional data needed to understand the ecology and geomorphic fate of Cat Island.

7.2.1 Confirmation of Offshore Sand Borrow Areas

After funding is obtained, an acoustic survey will be conducted in some areas near the barrier islands to identify areas that may contain sufficient sand to use in both direct island and littoral zone placement at Ship Island. These areas will be both disposal areas where disposal from maintenance dredging may have concentrated usable material and sediments that have been pushed out and deposited with the ebb tide currents at the pass west of Ship Island. Any deposits that have useful quantities will be sampled to test for quality requirements. If these surveys fail to located suitable material, the program will then concentrate on the submerged islands that make up St. Bernard Shoals that lie south on the barrier islands. To verify the quantity of sand available for borrow at St. Bernard Shoals and to obtain physical samples for quality characteristics, a geophysical survey and sampling program will be conducted.

7.2.2 Optimal Littoral Zone Placement

The model that was completed and described in Section 3.0 will be used as a basis to further study the optimal locations to place both littoral zone additions of sand and the locations for disposal of material from future maintenance dredging.

7.2.3 Cat Island Coastal and Ecological Processes

Cat Island has a different coastal process that has been identified, but not thoroughly investigated. The littoral zone currents that help replenish the other Mississippi barrier islands does not cross the pass between West Ship Island and Cat Island to the west. The formation of the Mississippi River delta cut off the path of the historic littoral current and had left Cat Island without the natural nourishment of sand. Little information is available on Cat Island, but the additional study will include not only coastal processes, but also ecological processes that will provide valuable information on the little known habitat on Cat Island.

7.3 Camille Cut and Barrier Island Restoration

West Ship has migrated westward along the littoral drift zone with the western end of the island now terminating against the deep-water, Gulfport navigation channel that prevents further drift. Studies (Rosati, 2007) have confirmed that West Ship Island is the last active island system in the littoral zone that originates in northwest Florida. The same type of land loss exists for Petit Bois Island where the east end is migrating westward and the western end is now terminated against the Pascagoula navigation channel. Records indicate that over 22 million cubic yards of sediment have been removed for maintenance from the Pascagoula Channel since it was created. This quantity of sand was used as the basis of adding sand back into the littoral system since, theoretically, this sand

would have continued its transport along the littoral system. Three measures were adopted to return this sand into the system. The first would be to fill the three mile breach in Ship Island, Camille Cut, to a 1000-foot width and a height that would require approximately 13-million cubic yards of sand including loss during placement and the re-nourishment of some erosion along the northern shore. The other two measures would be to add sand into the littoral system with about 5-million cubic yards going into the area east of East Ship Island and the rest (4-million cubic yards) going to the area east of Petit Bois Island. Placing more sand at Ship Island is assumed because of the accelerated erosion that has taken place there. The quantities of material assumed for the littoral placements would be subject to change after additional sediment transport modeling if this modeling indicates this adjustment.

Loss of these islands from the barrier islands chain will have severe impacts to both cultural and ecological resources in Mississippi. The islands play a major role in maintaining the ecosystem of the Mississippi Sound. The various types of vegetation found on the islands provide habitat to many species including endangered birds such as Least Tern and Piping Plovers. Oysters, shrimp and many species of fish depend on the role the islands play in maintaining lower salinity levels found within the Sound and the presence of these species are tremendously important to the local economy and provide a way of life for the thousands of local residents employed by the seafood industry. The many miles of beaches associated with the islands also provide recreation for tens of thousands of visitors annually.

The pre-Camille footprint of Ship Island was obtained from historical records and this data showed that the island was breached during Hurricane Camille in 1969 forming two separate islands as mentioned above. This breach had been partially filled with a sand spit extending westward from East Ship Island when Hurricane Katrina again opened the breach in 2005. As happened during Hurricane Camille, the new breach was formed leaving two islands with approximately three miles of open water between the remaining portions. West Ship Island has been experiencing severe erosion in some areas because of the loss of sand in the system from the ebb tidal flows through the breach. East Ship Island is also losing land mass as the sand in its system migrates into the breach area. Currents studies (USGS, 2007 and Rosati, 2007) indicate that West and East Ship will probably not recover from their current severely eroded state.

West and East Ship Island also have two major historic sites that are in danger from the continuing erosion of the barrier islands. The presence of these historic sites led to the inclusion of the barrier islands off the coast of Mississippi as a National Seashore. Current studies by the Corps indicate that restoring the two islands to a single island, pre-Camille condition may prevent the rapid erosion of the beaches that is now occurring at these sites and aid in the reduction of erosion that is endangering Historic Fort Massachusetts on West Ship Island.

The addition of sand into the littoral system on the eastern ends of East Ship and Petit Bois Islands will provide a sediment source for the islands and help mitigate any affects from the maintenance of the navigation channels. The additional sediment transport modeling will include modeling to predict the optimal location for the placement of sand into the littoral zone near the islands to provide a source of sand for the natural healing on the breach.

The quantity of sand required for these options are considerably less than the total restoration of the islands, but still substantial. To fill the breach, the sand would have strict requirements on color, grain size, and roundness. In discussions with the USGS, a potential source of sand was identified at St. Bernard Shoals which is a submerged chain of barrier islands approximately 45 miles south of the Mississippi barrier islands. Both quality and quantity are assumed to be available, but further investigations are required to verify the source. Activity from oil and gas production in the local area must also be considered. As described above approximately 13,000,000 cubic yards of the high quality sand are needed to fill the breach. An additional 5,000,000 cubic yards of sand is being

proposed for placement into the littoral zone east of East Ship Island. This sand would still have physical compatibility characteristics to the sand in the littoral system that must be considered. The last measure of the plan would be to add approximately 4,000,000 cubic yards of compatible sand into the littoral zone east of Petit Bois Island. The source of this sand is proposed to be from the inland river system that flows into Mobile Bay if additional quality testing demonstrates it's compatibility with sand within the littoral system. While maintaining channel depths, sand is dredged from these rivers and placed in numerous upland disposal areas along the river. The lower Tombigbee River has several million cubic yards of sand stored along its banks that may be useful for the littoral zone placement. Due to the location of the disposal areas, this sand is being considered for use for the Petit Bois Island littoral zone placement. This source will provide the beneficial use of sand and at the same time provide additional dredged material storage capacity along the river system. The sand in the disposal areas has a tan color as opposed to the whiter sand on the barrier islands, but this is believed to be a iron staining that will obtain a good color match after placement in the littoral zone and being transported (and abraded) by the transport process. The quantity of sand required for littoral zone east of Petit Bois is available along the lower Tombigbee River and can easily be transported down the river and over to the island. It was assumed that 20% of this sand would be lost in handing. If this sand source proved not to be compatable, the sand would be obtained from sources used for Ship Island.

Also during the E&D phase, another potential source of sand would be investigated that would be much closer to the project site and would also allow the beneficial reuse of dredged material. This further study would look at historical disposal areas for the Gulfport navigation channel that crosses through the littoral zone. The sediments that are removed from the channel during routine maintenance dredging have been placed in approved disposal areas that have been used for an extended period of time. While the material placed in these areas was not segregated by grain size, there may be substantial quantities of beach quality material that has potential use at Ship Island, either for filling Camille Cut, adding to the littoral zone, or both. Reuse of the sediments from the disposal areas would follow Regional Sediment Management practices that promote keeping sediments in the littoral system and/or beneficial use of material that is removed during both new and maintenance dredging.

In this same local area, recent sediment transport studies have shown that westward sediment migration has been affected by the southward extension of the Mississippi River delta. This extension has cut off the littoral current and terminated the westward migration of sediments in the pass in the vicinity between Cat and West Ship Island. The fate of these sediments has not been determined, but there may be a large deposit of sand that could be used at Camille Cut or replaced in the littoral system.

The placement of sand to fill Camille Cut and the two large littoral zone placements are planned as one-time events to restore some of the islands land surface that may have been lost to erosion from mans past activities or from mass erosion during storm events. This decision was based on an agreement with the NPS that allows them to mitigate ay damage from mans activities or to perform necessary means to preserve historic sites. This agreement has a positive aspect to MsCIP with the replacement of sand that has been lost from the littoral system. This sand addition will extend the life of the islands and the closure of Camille Cut will help maintain the boundaries of the estuary. It is understandably difficult to quantify either of these sand loss causes because the barrier islands themselves are dynamic systems that are undergoing constant change

7.4 Regional Sediment Management Issues

The presence of two deepwater navigation channels that pass through the littoral zone have created artificial boundaries to the westward migration of the islands. The continued maintenance of these

channels will require that sand and other sediments be removed, but under the guidelines of the Regional Sediment Management Practices, the sand removed from the channels will be returned to the littoral system. The placement of this sand in the future will be supported and guided by the results of additional focused sediment transport modeling that will be conducted prior to any placement.

This continuing study would evaluate future placement of maintenance material dredged from the Pascagoula Harbor Navigation Channel. It has been recommended that sand from the channel be placed down-drift in a newly designated disposal area located in the littoral zone near Sand Island. Much of the sand dredged in the past was placed down-drift, but was formed into a small island commonly called Sand Island. Sand Island has become a prime environmental resource vegetated with dune grasses that provide habitat to many types of shore birds. With no further sand additions, the sand within this islands will probably return to the littoral system as wind and currents erode the land mass.

Material removed from the Gulfport Channel has historically been placed in disposal areas south of the littoral zone. In keeping with the guidelines of the Regional Sediment Management Practices, revised recommendations will be made to more properly dispose of the material removed from the littoral zone segment of the channel so it will have improved beneficial use. The existing channel alignment is at the western tip of West Ship Island and is a trap for the migrating sand. It has been recommended to study and model placement zones that will maximize the benefits of deposing of this sand. This practice will allow the sand to continue to nourish the barrier islands and slow the erosional processes of the land masses. How to best achieve this will be considered in the continuing study of the islands. Initial ideas include immediate reuse by littoral zone placement or stockpiling high quality sand in selected disposal areas so the material would be readily available in the future for relocating the sand into the littoral zone as needed. The disposal areas that are currently designated may be used or additional areas could be defined.

7.5 Long Term Monitoring Program

Monitoring during and following the implementation of the barrier island restoration actions described in this plan is needed to assess the progress of the restoration and short- and long-term impacts to the barrier island system and cultural resources. Monitoring recommendations include:

- Task 1 - Obtain orthophotography of each barrier island on an annual basis to determine shoreline position change annually for five (5) years and for an additional three (3) events every two (2) years;
- Task 2 - Map bathymetry in the barrier islands area pre- and post-project, 1 year after project completion, 5 yrs after project completion, and immediately following passage of a tropical storm or hurricane to document movement of sand placed in Camille Cut and in the littoral system;
- Task 3 - Use topographic, bathymetric and hyperspectral sensors on the Compact Hydrographic Airborne Rapid Total Survey (CHARTS) system to document land elevation and vegetation density change annually, and process and analyze acquired data in an efficient and timely manner to make adjustments in sand placement strategies if desired results are not being achieved; and
- Task 4 - Obtain daily real-time water quality data adjacent to all beach renourishment, direct placement and littoral zone placement areas in coordination with EPA Gulf of Mexico, MS Department of Marine Resources and MS Department of Environmental Quality.

7.6 Emergency Sand Placement for Fort Massachusetts and French Warehouse

An emergency project to place sand in two areas is being included in the Comprehensive Barrier Island Restoration Plan. This sand placements is to protect Fort Massachusetts on West Ship Island and the French Warehouse site on East Ship Island from damage or destruction from erosion of the northern beaches at their respective locations. This project has been requested by the National Park Service to mitigate the recent storm damage to these two historic sites. This project was included in the Main Report Section 5.3.14 - Public Input and Review of Planning Options, Round One, but was not selected in the initial group of Interim Projects because of extensive coordination that was required by multiple agencies. This effort made it impossible to meet the short time frames required for the Interim Projects.

CHAPTER 8 COST ESTIMATES

8.1 General

The Comprehensive Barrier Island Restoration Plan has many study components will be included within the "Engineering and Design" cost based on the estimated contract cost. These studies were requested as part of the overall plan, but will be covered under the required studies for design. They include the Optimal Littoral Zone Placement and Cat Island Coastal and Ecological Processes. Studies that will have an additional cost are associated with a recommended monitoring plan to document from the pre-construction conditions at the barrier islands, then for about ten years post-construction. The summary costs for the Comprehensive Barrier Island Restoration Plan is shown in Table 8-1. The local Regional Sediment Management Practice team has been heavily involved in the Mississippi barrier island study and will make revisions to their operating practices at the Mississippi Barrier Islands. These changes will not have a direct cost to the Comprehensive Barrier Island Restoration Plan.

Table 8-1.
Summary of Costs for the Comprehensive Barrier Island Restoration Plan

Project Sub-item	Costs
Sand Placement, Ship Island Breach and Littoral Zones	$516,000,000
Long Term Monitoring	$4,950,000
Cat Island Cat Coastal and Ecological Processes and Optimal Littoral Zone Placement	$0 (see note)
Regional Sediment Management Practice Revision	$0 (see note)
Emergency Sand Placement, Fort Mass and French Warehouse	$3,000,000

Note: As described in Section 8.1, these cost are incorporated into the Engineering and Design costs for the "Sand Placement, Ship Island Breach and Littoral Zones"

8.2 Construction (Sand Placement) Costs

The Total Project Costs for the construction associated with the barrier island restoration will include all costs that were described in Options C1, C2 and G under the LOD-1 estimates in the Cost Appendix. These detailed costs were combined into a single estimate and is included in Table 8-2.

8.3 Monitoring Program

The total costs for the long term monitoring program (over a period of 11 years) as described in Section 7.5 are included in Table 8-3. The tasks are fully described in Section 7.5.

8.4 Emergency Sand Placement, Fort Massachusetts and French Warehouse

An emergency project to protect Fort Massachusetts on West Ship Island and the French Warehouse on East Ship Island has been requested by the National Park Service to mitigate storm damage to these two historic sites. This project was included in the Main Report Section 5.3.14 - Public Input and Review of Planning Options, Round One, but was not selected in the initial group of Interim Projects because of extensive coordination that was required by multiple agencies. This effort made it impossible to meet the short time frames required for the Interim Projects. The cost for this project is included in Table 8-4.

Table 8-2.
Sand Placement, Ship Island Breach and Littoral Zones

TOTAL PROJECT — **** TOTAL PROJECT COST SUMMARY **** — PAGE 1 OF 2

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Barier Islands
LOCATION: Mississippi Coastal Barrier Islands
DISTRICT: MOBILE
P.O.C.: Joseph H. Ellsworth

ACCOUNT NUM	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ/BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... COST ($K)	CNTG ($K)	FULL ($K)
17---	BEACH REPLENISHMENT (Barrier Islands) *(Barrier Islands)*	326,279,000	107,543,280	33%	433,822,280	326,279,000	107,543,280	433,822,280	353,465,241	116,490,463	469,955,704
30---	PLANNING, ENGINEERING & DESIGN	13,051,160	4,301,731	33%	17,352,891	13,051,160	4,301,731	17,352,891	13,490,461	4,448,199	17,938,660
31---	CONSTRUCTION MANAGEMENT	19,576,740	6,452,597	33%	26,029,337	19,576,740	6,452,597	26,029,337	21,207,914	6,989,428	28,197,342
	TOTAL PROJECT COST ========>	**358,906,900**	**118,297,608**		**477,204,508**	**358,906,900**	**118,297,608**	**477,204,508**	**388,163,616**	**127,928,090**	**516,091,706**

rounded

100% **TOTAL FEDERAL COSTS ==========>** **$516,000,000**

0% **TOTAL NON - FEDERAL COSTS ======>**

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING

_____ CHIEF, REAL ESTATE

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, PROGRAMS MANAGEMENT

_____ PROJECT MANAGER

_____ DDE (PM)

Table 8-2.
Sand Placement, Ship Island Breach and Littoral Zones (continued)

FEDERAL COSTS — **** TOTAL CONTRACT COST SUMMARY **** — PAGE 2 OF 2

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE Feasibility, DATED: Aug 08

PROJECT: Mississippi Coastal Improvemnets Program, Barier Islands — DISTRICT: MOBILE

LOCATION: Mississippi Coastal Barrier Islands — P.O.C.: Joseph H. Ellsworth

ACCOUNT No.	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: Aug 08 EFFECTIVE PRICING LEVEL: Aug 08 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: FY-09 EFFECTIVE PRICING LEVEL: Aug 08 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
	Contract 1													
17---	DREDGING (Hopper)	183,829,000	58,825,280	32%	242,654,280	0.0%	183,829,000	58,825,280	242,654,280	Apr 12	7.9%	198,351,491	63,472,477	261,823,968
30---	PLANNING, ENGINEERING & DESIGN, 4%	7,353,160	2,353,011	32%	9,706,171	0.0%	7,353,160	2,353,011	9,706,171	Apr 09	1.6%	7,470,811	2,390,659	9,861,470
31---	CONSTRUCTION MANAGEMENT, 6% +-	11,029,740	3,529,517	32%	14,559,257	0.0%	11,029,740	3,529,517	14,559,257	Apr 12	7.9%	11,901,089	3,808,349	15,709,438
	Contract # 1 Subtotal	202,211,900	64,707,808		266,919,708		202,211,900	64,707,808	266,919,708			217,723,391	69,671,485	287,394,876
	Contract 2													
17---	DREDGING (Hopper)	78,350,000	28,206,000	36%	106,556,000	0.0%	78,350,000	28,206,000	106,556,000	Apr 12	7.9%	84,539,650	30,434,274	114,973,924
30---	PLANNING, ENGINEERING & DESIGN, 4%	3,134,000	1,128,240	36%	4,262,240	0.0%	3,134,000	1,128,240	4,262,240	Oct 10	4.7%	3,281,298	1,181,267	4,462,565
31---	CONSTRUCTION MANAGEMENT, 6% +-	4,701,000	1,692,360	36%	6,393,360	0.0%	4,701,000	1,692,360	6,393,360	Apr 12	7.9%	5,072,379	1,826,056	6,898,435
	Contract # 2 Subtotal	86,185,000	31,026,600		117,211,600		86,185,000	31,026,600	117,211,600			92,893,327	33,441,597	126,334,924
	Contract 3													
17---	DREDGING (Hopper)	64,100,000	20,512,000	32%	84,612,000	0.0%	64,100,000	20,512,000	84,612,000	Apr13	10.1%	70,574,100	22,583,712	93,157,812
30---	PLANNING, ENGINEERING & DESIGN, 4%	2,564,000	820,480	32%	3,384,480	0.0%	2,564,000	820,480	3,384,480	Apr 11	6.8%	2,738,352	876,273	3,614,625
31---	CONSTRUCTION MANAGEMENT, 6% +-	3,846,000	1,230,720	32%	5,076,720	0.0%	3,846,000	1,230,720	5,076,720	Apr 13	10.1%	4,234,446	1,355,023	5,589,469
	Contract # 3 Subtotal	70,510,000	22,563,200		93,073,200		70,510,000	22,563,200	93,073,200			77,546,898	24,815,008	102,361,906

Table 8-3.
Long Term Monitoring Program

Task	Program Costs
1 - Orthophotography	Included in Task 3
2 - Bathymetry	$1,400,000
3 - CHARTS	$3,300,000
4 – Water Quality	$250,000

Table 8-4.
Emergency Sand Placement, Fort Massachusetts and French Warehouse

COMPREHENSIVE PLAN "STRUCTURAL" COST ESTIMATE						
PROJECT:	Mississippi Coastal Improvements Program "MsCIP"		ITEM NO.		DATE	7-Jan-09
LOCATION:	Mississippi		SHEET NO.	1	OF	1
			PREPARED:	Joseph H. Ellsworth	CHECKED:	Gary A. Payton
WORK ITEM:	*Line of Defense 1*		BASIS of ESTIMATE:	info furnished per Project Delivery Team		
	Beach / Dune Construction		FILE NAME:			
	DESCRIPTION		Quantity	Unit	Unit Price	ESTIMATED AMOUNT
	Ship Island	***Fort Mass & French Warehouse***	***Emergency Beach Nourishment***			
Mobilization, Preparatory Work, Demobilization (Dredge Plant)			1	job	allow	$900,000
Mobilization, Preparatory Work, Demobilization (Land Base Equipment			1	job	allow	45,000
Construct Sand (dune), Dredged from near Shore Borrow Site			125,000	cy	9.00	1,125,000
Misc Site Items			1	ls	allow	2,800
			Current Contract Cost, Jan 09			$2,072,800
		CONTINGENCY		@	**25.0%**	518,200
						$2,591,000
		01 Account, Lands & Damage		PCA	**LS**	25,000
						$2,616,000
		30 Account, Plan, Engr.& Design		@	**8.0%**	209,280
						$2,825,280
		31 Account, Constr. Management		@	**6.0%**	169,517
						$2,994,797
		ESCALATION		@	**1.0%**	29,948
						$3,024,745
						rounded
			TOTAL PROJECT COST, Oct 09			$3,000,000

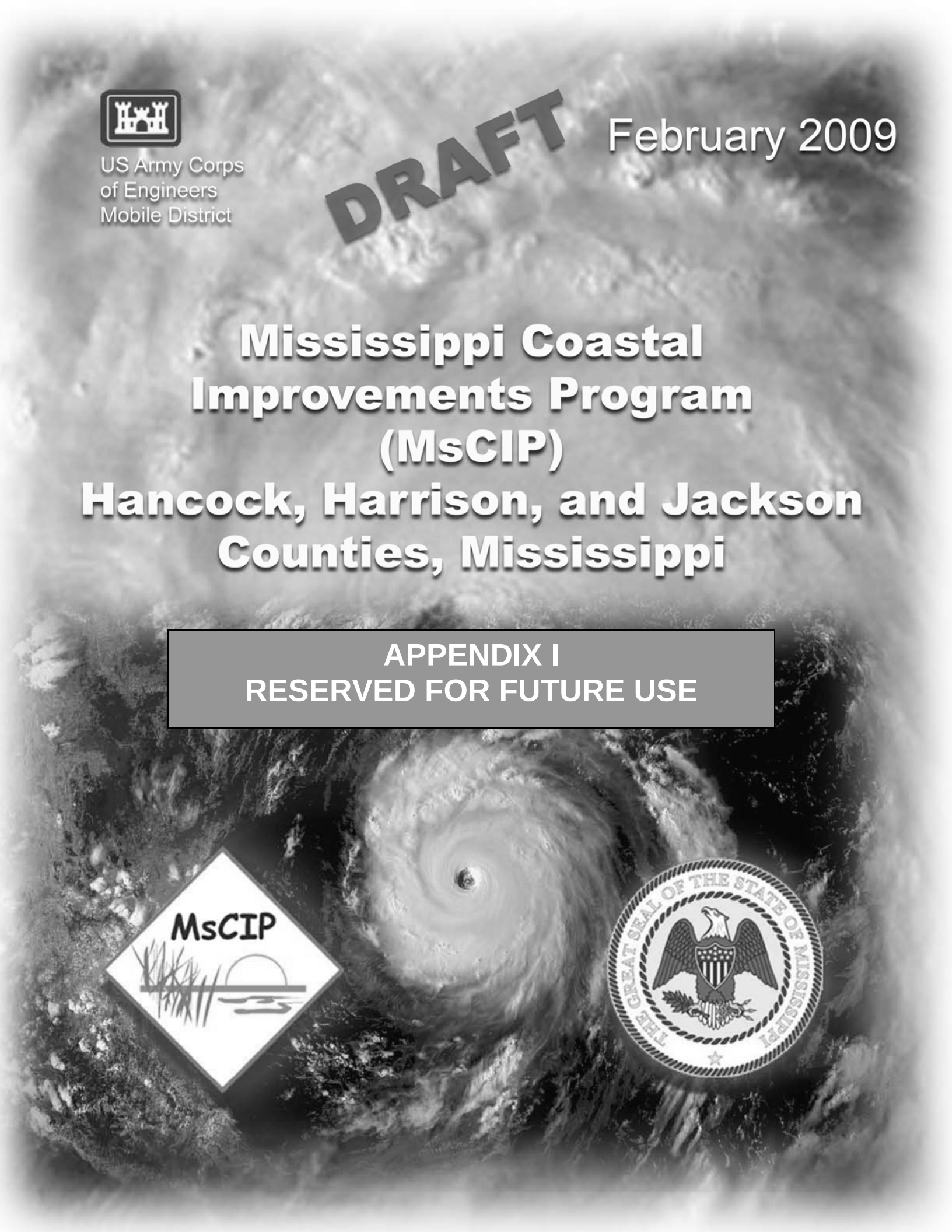
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Mobile District

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February 2009

Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

APPENDIX I
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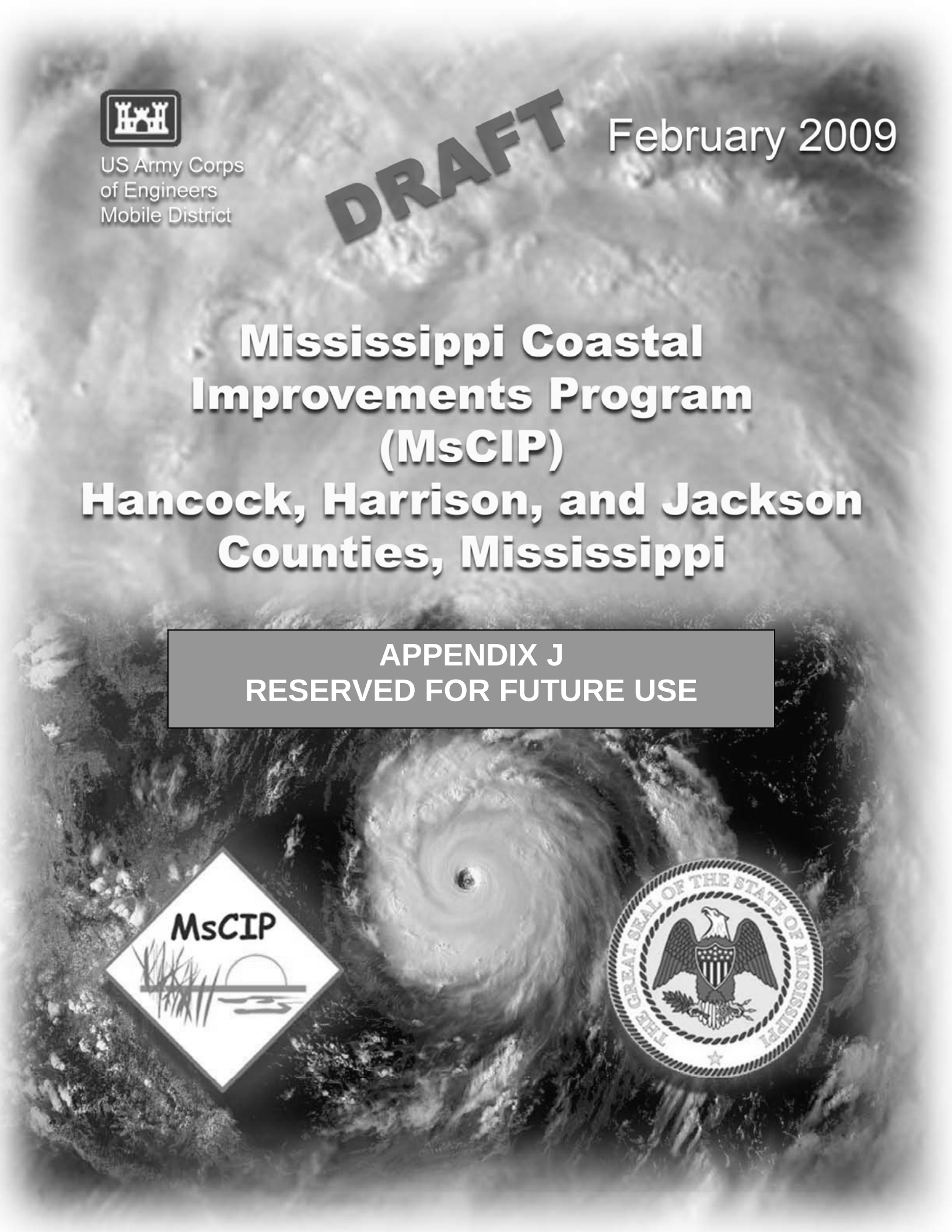
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Mobile District

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February 2009

Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

APPENDIX J
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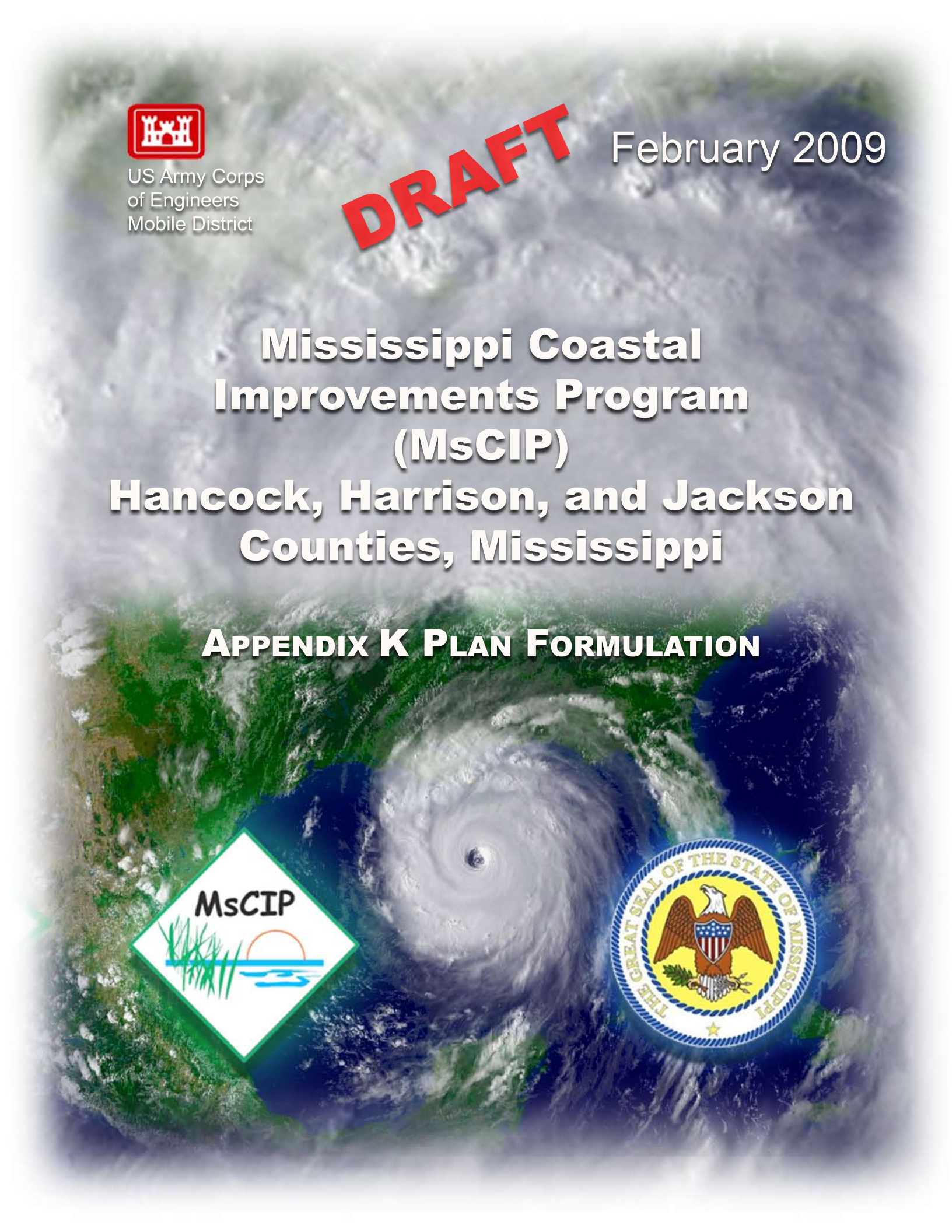
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Mobile District

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February 2009

Mississippi Coastal Improvements Program (MsCIP) Hancock, Harrison, and Jackson Counties, Mississippi

Appendix K Plan Formulation



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Plan Formulation Appendix

FOREWARD

This document is one of a number of technical appendices to the *Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Feasibility Report and Environmental Impact Statement*.

The *Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Integrated Feasibility Report and Environmental Impact Statement* provides systems-based solutions and recommendations that address: hurricane and storm damage reduction, ecosystem restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion. The recommendations contained in the Main Report/EIS also provide measures that aid in: greater coastal environmental and societal resiliency, regional economic re-development, and measures to reduce long-term risk to the public and property, as a consequence of hurricanes and coastal storms. The recommendations cover a comprehensive package of projects and activities, that treat the environment, wildlife, and people, as an integrated system that requires a multi-tiered and phased approach to recovery and risk reduction, irrespective of implementation authority or agency.



The MsCIP Study Area

The purpose of the Comprehensive Plan Report is to present, to the Congress of the United States, the second of two packages of recommendations (i.e., the first being the "interim" recommendations funded in May 2007, and this "final" response, as directed by the Congress), directed at recovery of vital water and related land resources damaged by the hurricanes of 2005, and development of recommendations for long-term risk reduction and community and environmental resiliency, within

the three-county, approximately 70 mile-long coastal zone, including Mississippi Sound and its barrier islands, of the State of Mississippi.

The USACE has taken a system wide approach in formulating the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan to ensure that both the MsCIP and the Louisiana Coastal Protection and Restoration (LaCPR) efforts are fully coordinated and develop complementary plans for the restoration of the U.S. Gulf coastal region as an integrated system.

In addition, the planning effort has taken a "top down" comprehensive planning approach, beginning with development of a Comprehensive Plan to address the overall water resources problems and opportunities of the region. Building off of the comprehensive identification of problems and opportunities, the planning effort then proceeded to develop site specific problems, opportunities and solutions that contribute to accomplishing the Comprehensive Vision for the restoration and protection of the Mississippi Gulf Coast. The results of this effort are a comprehensive regional plan that addresses hurricane and storm damage reduction and environmental restoration needs, as well as recommending a variety of site specific projects for either immediate implementation or for further investigation and subsequent implementation.

The analyses presented in this Plan Formulation Appendix support recommendations for approval of the Comprehensive Plan and for immediate implementation for a variety of water resource development projects that were developed through the comprehensive planning process. The Plan Formulation Appendix also supports recommendations for additional study for those components of the Comprehensive Plan which require additional investigations prior to identifying a specific recommendation for construction.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and will be presented for an External Peer Review (EPR). Both review processes will have been conducted in accordance with the Corps "Peer Review of Decision Documents" process, has been reviewed by Corps staff outside the originating office, conducted by a Regional and national team of experts in the field, and coordinated by the National Center of Expertise in Hurricane and Storm Damage Protection, North Atlantic Division, U.S. Army Corps of Engineers.

This Plan Formulation Appendix presents problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing recommendations directed at assisting the people of the State of Mississippi in recovery, recommended actions and projects that would assist in the recovery of the physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

The MsCIP also developed and employed risk-based concepts which engaged stakeholders and allowed for informed decision making. The MsCIP planning process made extensive use of public and agency involvement, which introduced ideas, provided feedback, and gave first-hand accounts of the damages suffered as a result of the disaster. In an effort to demonstrate reliable public service professionalism, the public, state and local government input received at public workshops was also used to identify the degree of importance placed on environmental issues and to give indication of the likely Locally-Preferred Plans, should those be pursued as options to more cost-effective recommendations, consistent with Federal guidelines.

The results of the planning process (as expressed in the Systems of Accounts tables):

- identify cost-effective solutions,

- provide the best choices based on an extensive set of criteria, and
- identify the trade-offs made during the evaluation of alternatives.

The System of Accounts tables present the culmination of technical analyses, public input, and systematic evaluation. The selected alternatives stand out in their ability to fulfill the Congressional authorization and the needs of the nation.

This appendix contains detailed technical information used in the analysis of existing and future without-project conditions, in the development of problem-solving measures, and in the analysis, evaluation, comparison, screening, and selection of alternative plans. Each appendix functions as a complete technical document, but is meant to support one particular aspect of the feasibility study process. However, because of the complexity of the plan formulation process used in this planning study, the information contained herein should not be used without parallel consideration and integration of all other appendices, and the Main Report/EIS that summarizes all findings and recommendations.

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1 THE MSCIP PLANNING PROCESS – REACHING BEYOND THE TRADITIONAL PROCESS

The process of developing technically sound, environmentally sensible, cost-effective, publicly acceptable, and comprehensive solutions to the problems caused by the hurricanes of 2005, and with the potential to be caused by future events, required a thorough, and highly iterative process. This process had to incorporate both traditional planning requirements (which have served the nation well), as well as a more direct process of identifying and fully discussing potential risks and consequences of any given action, in a way that all might participate in, and understand the full meaning of.

This Appendix follows the plan formulation process in its applied sequence, and each step of this process must be fully laid out, to understand how the study team formulated plans, screened measures and alternatives, and arrived at a cost-effective, environmentally beneficial, and technically sound package of recommendations.

Plan formulation for the Comprehensive Plan utilized the highly-successful process discussed in Corps of Engineers' Engineering Regulation 1105-2-100 (also known as the "Planning Guidance Notebook"), with the addition of a number of new tools required in this specific study effort, including an extensive set of tools and evaluative and screening processes involving the potential risks and consequences of any action.

The directive language for the Mississippi Coastal Improvements Program included the requirement to address not only hurricane and flood (storm) damage, but also coastal erosion, fish and wildlife preservation and recovery, and salt water intrusion. Additionally, the study language also specified a different approach toward identification of a plan, in that it specifically directed that the report "shall recommend a cost-effective project", and furthermore, that the report "shall not perform an incremental benefit-cost analysis...and shall not make project recommendations based on maximizing net national economic development [NED] benefits..". This guidance demanded that the study team both develop an approach that met those mandates, while not deviating significantly from the traditional Federal planning process.

The MsCIP planning process uses the familiar Corps and NEPA study processes, which compare and contrast measures and alternatives for a full range of anticipated impacts and effects, with the former also requiring a "System of Accounts" analysis. Because the study area is so large and diverse, however, the mandates so broad, and the consequences of exceedance or failure so potentially catastrophic, the study effort also required that the Plan Formulation process be more iterative and risk-aware than is usually the case. The process had to be capable of re-visiting each and every assumption and piece of data, and modifying the measures developed as solutions, so as to create the most cost-effective package of potential options for review by decision-makers. This is also reflected in the study recommendations. Cost-effectiveness was determined by comparison of implementation costs to that of the damage reduction benefits each measure would provide.

The MsCIP study utilized an additional evaluative tool to address risks and consequences of potential alternatives, by use of a Risk-Informed Decision Framework (RIDF), to allow comparison of highly disparate factors affected by plan implementation, particularly those factors that were not dealt with well under the traditional Corps planning process. A key component of this process was the "weighing-in" of the public and other decision-makers, which reflect the factors most important to them, in deciding what might be done to address identified problems. Most notable among these factors were the potential risks (including residual risks), to population, environmental recovery and preservation, cultural, aesthetic and historic resources, and other factors that remain very difficult to

compare and contrast. The Risk-Informed Decision Framework process is discussed in great detail in the RIDF Appendix.

The MsCIP process integrated a highly inclusive public and agency involvement process. This process was critical in the conduct of plan formulation activities, in that it introduced ideas, provided feedback, and gave first-hand accounts of the damages suffered as a result of the disaster. Public input (which included local and State governmental input) received at these public workshops was also used to define the "weight" of factors discussed above (such as the degree of importance they placed on environmental issues) examined in the Risk and Consequences analysis of potential plans, and to give indication of the likely direction of Locally-Preferred Plans, should those be pursued as options to more cost-effective recommendations.

Finally, the tentative recommendations derived by this process and presented in the Comprehensive Plan may be used as guidelines concerning the most cost-effective solutions, the best choices for a given set of criteria, and the trade-offs required. These are the tools required by local government and residents in the selection of plans that best meet their needs, and the needs of the nation.

1.1 The Traditional Federal Planning Process

The traditional Federal planning process has served this nation well. It has allowed the development of thousands of water resource projects that have prevented billions of dollars in damages, and saved countless lives. Unfortunately, it has also not always addressed the difficult-to-evaluate elements of risk and consequences, both of failure, and also of residual risk not addressed by projects, in situations both where the design event is exceeded, and also where different choices are made that may affect future conditions. It has also not necessarily accommodated the values of residents and decision makers in the analysis and selection process, in particular in weighting factors, which are of particular importance to concerned interests other than economic factors.

Recent guidance has reinforced the need to utilize methods capable of evaluating factors that resist quantification by traditional means, as part of the plan formulation and selection process. This includes means by which a study team might evaluate the trade-offs inherent in any design, those of residual risks inherent in each design, and also those of factors that are difficult to evaluate and prioritize under the traditional process.

The six traditional Planning Steps include:

1) Identifying Problems and Opportunities
2) Inventorying and Forecasting Resources
3) Formulating Alternative Plans
4) Evaluating Effects of Plans
5) Comparing Alternatives
6) Selecting the Recommended Plan

1.1.1 The MsCIP Comprehensive Plan – The Planning Process

The planning process utilized in the MsCIP study was a highly iterative process, which actually went beyond that done in the traditional six-step Corps feasibility study planning process. This was required, due to the fact that new problems or data were constantly being identified, but also because analysis of comprehensive plans, such as a "Lines of Defense" (LOD), constantly brought new problems and opportunities to light, requiring modification of, or development of, new measures; and the analysis, evaluation, and comparison that this requires.

A key element of the modified planning process utilized for the MsCIP study also included an additional sub-step of forecasting and analyzing not only one future "without-project" scenario, but a

series of potential future scenarios, including highly speculative future re-development, and relative sea level rise scenarios.

In addition, and as discussed above, the addition of a RIDF, which evaluates the risks and consequences of a certain action, required additional sub-steps to be inserted in this process.

The sequence of steps developed for the MsCIP effort (*with additional sub-steps or iterative steps italicized*) can be shown in figure 1 and included:

1) Identifying Problems and Opportunities (*or Further Refined)*
1a) Constraints Identified (*or Further Refined)*
2) Inventory and Forecast Resources *(and Define Multiple Future Without-Project Scenarios)*
3) Preliminary Measures Developed for Each Problem Area (*followed in later iterations by formulation of true alternative plans*)
4) Evaluation of Effects of Measures (*followed later by Alternative Plans*)
5) Comparing Measures (*followed in later iterations by comparison of Alternatives*)
5a) Measure Screening by Traditional Initial Screening Criteria - Technical, Environmental and Economic Feasibility (*followed in successive iterations by screening by progressively more rigorous criteria)*
5b) Refinement of Measures - Development of Data at Higher Level of Detail, on Remaining Plans, in concert with development of data on other impact areas such as cultural, environmental, etc. effects.
5c) Development of metrics, units of measure, etc., for Risk Evaluation
5d) "Weighting" of Risk metrics by residents of coastal Mississippi
5e) Risk-Informed Decision-Making with Refined Data.
5f) Final presentation of measure and/or alternative outcomes , including benefits, costs, risks, and consequences, to decision-making population
6) Selection and Presentation of Recommendations.

It must be pointed out that addition of these sub-steps, additional iterations, and inclusion of risk-based analysis is not an exclusive process, but a complementary process, that ensures a more rigorous identification of risks and consequences, and also greater inclusion of the public in a decision-making process.

The plan formulation process actually began during the Interim Phase of study, with development of a comprehensive list of problem areas, consisting of single or multiple problems associated with a given site or resource, and identified as having been caused or exacerbated by the hurricane events of 2005. Each of the problems identified were related to one of the four key areas of: a) hurricane storm damage, b) coastal zone erosion, c) damage to fish and wildlife resources, and d) saltwater intrusion.

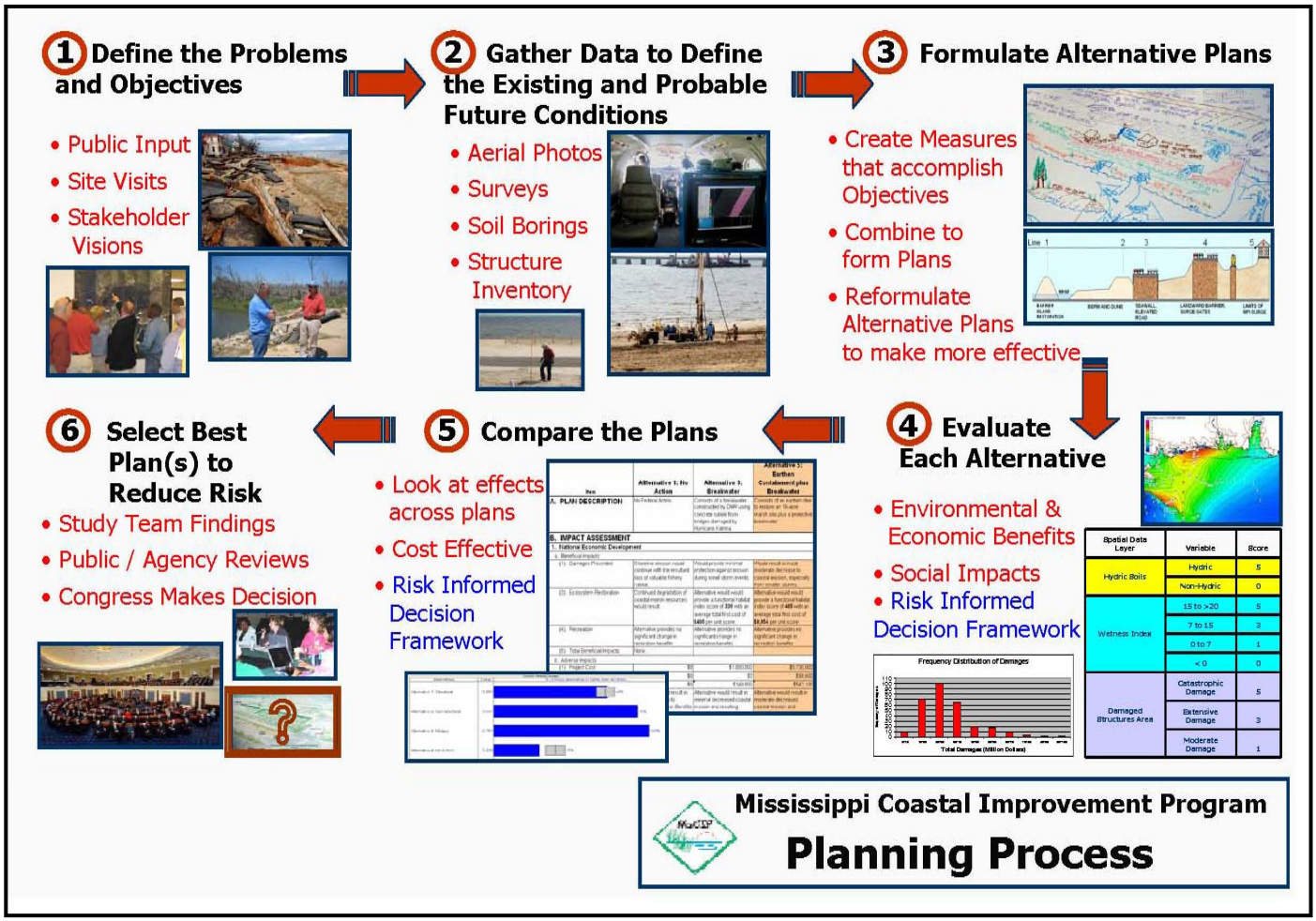


Figure 1 The MsCIP Planning Process

1.1.2 Internal Technical Review and External Peer Review

Internal Technical Review (ITR) was lead and coordinated by the Corps' National Center of Coastal Storm Damage Reduction Expertise, at the North Atlantic Division. ITR involved the use of experts in many fields, from multiple disciplines, and located in numerous parts of the country. ITR was conducted as a completely separate enterprise from internal technical review quality control, and quality assurance. No member of the ITR team was involved in any aspect of the study effort but that of independent technical review of products.

ITR consisted of multiple levels of review, at several points in the process. Details on the timing, sequencing, and disciplines engaged, are contained in the ITR / External Peer Review (EPR) Appendix.

The EPR was coordinated by the Corps' Baltimore District. No member of the District was involved in this wholly-external review process. The EPR process was lead by the Batelle Corporation, a private company with expertise in this particular requirement. Batelle staff chose the members of the EPR team from the ranks of academia, private concerns, and other sources of particular expertise. At no time were the names of credentials of any member of the EPR team shared with any member of the study team, but all EPR team members represent highly qualified individuals in those specific

fields of endeavor. EPR was also conducted as a completely separate enterprise from internal technical review quality control, quality assurance, or independent technical review. No member of the EPR team was involved in any aspect of the study effort but that of external peer review of products.

EPR consisted of a single level of review. Details on the timing, sequencing, and disciplines engaged, can be found in ITR / EPR Appendix.

1.1.3 Introduction to Addressing Risks and Consequences

The approach chosen by the study team on the MsCIP Comprehensive Plan effort was a multi-layered assessment, evaluation, and presentation of risk, uncertainties, and consequences.

Risks and uncertainties were evaluated and incorporated into numerous technical analyses, such as the degree of uncertainty the coastal engineer felt about wave heights, surge heights, or storm behavior. Risks and uncertainties were also accounted for in the technical analysis of ecosystem functions values, and long-term project performance. Risks and uncertainties were also evaluated for a variety of economic indicators, and for multiple future without-project scenarios, including those of relative sea level rise, and of multiple future re-development scenarios.

The MsCIP Comprehensive Plan phase of study utilized an additional evaluative tool to address risks and consequences of potential alternatives, by use of a “RIDF”, which allowed comparison of highly disparate factors affected by plan implementation, particularly those factors that were not dealt with well under the traditional Corps planning process. A key component of the RIDF process was the “weighing-in” of the public and other decision-makers, which reflected the factors most important to them, in deciding what might be done to address identified problems. Most notable among these factors were the potential risks (including residual risks), to population, environmental recovery and preservation, cultural, aesthetic and historic resources, and other factors that remain very difficult to compare and contrast. The Risk-Informed Decision Framework process is discussed in great detail in the RIDF Appendix.

In addition, the team also spent a great deal of effort evaluating the risks, uncertainties, and consequences of any given action, outside that framework, so that complete and unbiased information on those factors could be presented and evaluated, by the broadest possible group. Information on risks, uncertainties, and consequences (including that of residual risk), is presented in both the table of factors used in the RIDF process, but also as a separate System of Accounts category, for full disclosure in that process, also. Key in this recognition of risks, uncertainties, and consequences, was also the recognition of multiple future without-project scenarios, most importantly those addressing uncertainties in the behavior of human beings and political realities within the study area, and those of uncertainties regarding sea level changes and subsidence.

1.1.3.1 Accommodating Uncertainty in Future Re-Development Through Scenario Testing

Field surveys were conducted to observe structure and content characteristics, where damages occurred, and the magnitude of damages incurred by Hurricane Katrina. The magnitude of structures that sustained significant damage, 50% or more structural damage and would have to completely rebuilt, was significant. It was estimated from the field surveying of structures that 32,446 structures within the study area sustained this level of damage; 9,555 in Hancock County, 16,528 in Harrison County, and 6,363 in Jackson County.

Given the magnitude of the long-term rebuilding effort, two re-development scenarios were identified. The first scenario is the full redevelopment of structures as existed pre-Hurricane Katrina

to exactly what they were before the storm (i.e. if a structure was a residence before it will rebuild as a residence, a condominium will rebuild as a condominium, etc.). The second scenario includes the full re-development of the study area to its pre-Katrina levels but differs slightly from the first re-development scenario with respect to the coast line, which would see commercial re-develop. This scenario is based on observations of re-building efforts in other counties and states along the Gulf Coast and Florida Panhandle following Hurricane Ivan in 2004. Those re-development efforts suggest that a large portion of the beach front and back bay areas may re-develop to condominium structures. In addition to condominiums, current Mississippi law allows casinos to be built in these counties on land within 100-feet of the Mississippi Sound.

These re-development scenarios are intended to determine the level of risk of future surge events depending on the types of development that might be seen in the future. They were coupled with various levels of relative sea level rise and evaluated to determine the extent of plan performance, expected annual damages, and residual damages of flood damage reduction measures using the Hydrologic Engineering Center - Flood Damage Analysis (HEC-FDA) Monte Carlo Simulation program. More detail on these scenarios can be found in the Economic Appendix to this report.

1.1.3.2 Accommodating Uncertainty in Future Sea Level Rise Through Scenario Testing

Systematic long-term tide elevation observations suggest that the elevation of oceanic water bodies is gradually rising and this phenomenon is termed 'sea level rise.' The rate of rise is neither constant with time nor uniform over the globe. Present estimates of recent (over about the last 100 years) global average, or eustatic, sea level rise are varied but the average value is about 2 millimeters per year. Sea level is rising due to global warming, and there is uncertainty as to the future rate of sea level rise, how much sea level will rise at any particular location, what the primary drivers of global warming really are, and whether the rate of rise will be relatively constant or accelerate. Regardless of these uncertainties, more than half of the world's population lives near the sea, and sea level rise is a phenomenon which requires society's sustained attention and requires planning with consideration to the needs and protection of future generations.

Preliminary analysis of available data suggests a 20th century relative sea level rise of nine inches along the Mississippi coast. Relative sea level rise is what an observer standing on the shoreline over a long period would observe and includes the combined effects of land subsidence (or uplift) and the rise of sea level in and of itself. For the last twenty five years, the climate change community has also been arguing that sea level rise will accelerate in the 21st century, though to date, there is no clear confirmation that an acceleration is actually taking place, and the rates at which sea level rise is predicted to accelerate have been somewhat inconsistent. There is therefore some uncertainty as to the future prevailing natural environment which a proposed project must function within. Society relies on project performance. Therefore, it is important to recognize that sea level has been rising, and it's prudent (and required by USACE regulations) to recognize inherent uncertainties by exploring the ramifications of varying levels of possible relative sea level rise scenarios on project performance. This present study employs sensitivity analysis to do so. Sensitivity analysis is nothing more than an exercise where one changes an assumption and examines how outputs change accordingly. There are two primary assumptions that are modified in this program. The first is the magnitude of the relative sea level rise over the evaluation period. This program examines the implications to project performance for existing sea level; expected (i.e. moderate, or 'central value') relative sea level rise of about 2 feet; and high relative sea level rise of about 3.4 feet. Changes to these inputs provide a sense of project robustness (i.e. how well does the project perform over a range of uncertain futures?) and vulnerability (i.e. if a future materializes whereby the project would fail, how bad would the failure be?). Additionally, project performance is evaluated at a lifetime of 50 years; changes to the project lifetime provides insight as to the value over time of the initial investment, and whether an investment might be better delayed into the future,

or whether more significant investments might be required in the future than might be expected, amongst other considerations. Numerous outputs are examined according to these alternative scenarios, including expected annual damages, damages reduced, and the annual probability of a surge level being exceeded.

2 IDENTIFYING PROBLEMS AND OPPORTUNITIES

Problem areas and sites, and opportunities associated with those sites, were solicited from, and then discussed, with members of the public, state, local, and other Federal agencies, representatives of industry and commerce, and resource agencies concerned with study area resources, at the series of open meetings, at individual meetings, and through other open forums. The meetings also included web-casts intended on reaching those that could not physically attend one of the in-field meetings.

2.1 Problems

Hurricane-caused problems were also investigated in a series of on-going site investigations conducted in partnership with local representatives, to ensure a complete grasp on the nature of all identified problems, and to ensure development of a full range of suitable measures and plans to deal with the identified problems. The general nature of ***problems*** identified by the study team, State, County, and City officials, residents, and agency staff, included:

- Hurricane-induced storm surge and wave damage to structures and infrastructure within a specific site/problem area;
- Hurricane-induced storm surge and wave damage to structures and infrastructure within the entire three-county study area (analyzed as both specific areas, depending on the siting of the measure, but also as an entirety as a specific problem area);
- Hurricane-induced storm surge and wave damage to specific ecosystems/sites/problem areas within the identified three-county area;
- Hurricane-induced storm surge and wave damage to the entirety of all ecosystems within the entire three-county study area (analyzed as both specific areas, depending on the siting of the measure, but also as an entirety as a specific problem area);
- Hurricane-induced saltwater intrusion within the Mississippi Sound ecosystem and associated coastal environments;
- Hurricane-induced erosion of specific coastal wetlands and coastal infrastructure.

To facilitate the gathering of information, several workshops and public meetings were held in each county. Lists of the identified problems from each meeting are provided in Tables 1 through 15.

Table 1.

Coastal-wide Stakeholder Input: Coordination with Local Communities

Item#	Name
1	Coastal Mississippi Hurricane Evacuation Plan
2	Coastal Mississippi Artificial Reef Project for Remediation of 2005 Hurricane Damage

Table 2.

Coastal-wide Stakeholder Input: Regional Coordination Workshops

Item#	Name
3	Wetland area buy-outs
4	Barrier Islands - Restoration
5	USE selected levels of rip-rap instead of bulkheads for erosion control
6	Replace structures with marshes.
7	Provide 100 acres of oyster reef restoration
8	Work with State to authorize transfer of development rights in state statute
9	Include repair standards in building codes
10	Dredge access channels to existing public marine industry and recreation
11	Review main drainage systems to determine where improvements are most necessary and will decrease future erosion and/or failure issues
12	Improve comprehensive retention/detention systems in each entity to reduce rainfall-related flooding.
13	Form a monitroing network network that will survive and function throughout a major storm to provide data that is critical to emergency managers
14	Provide an incentive for replacing failing septic systems in rural areas to improve water quality along bayous and bays.
15	Implement a barrier or check valve system to isolate freshwater detention from saltwater inundation during surge events.
16	Add wetlands along main drainage systems in each location to increase capacity of the systems during rainfall and surge flooding events.
17	Complete snagging/clearing, etc. to restore the capacity of existing drainage.
18	Repair existing bulkheads or other structural drainage components that were damaged during the storm to reduce future failures during similar events.
19	Maximize Beneficial Use of Dredge Materials
20	Consider brown water system to minimize demand on ground and surface waters and limit saltwater intrusion.
21	Re-establish Benchmark Information Coastal-wide
22	Relocate wastewater treatment facilities out of the surge-prone areas
23	Inspect and Rehabilitate Wastewater and Piping Systems
24	Develop additional Offshore Breakwaters or Sand Dunes where determined most Beneficial through Modeling
25	Barrier Islands - Combat invasive species
26	Consider all archaeological sites in planning process Many significant coastal sites are eroding and need to be preserved.
27	Barrier Islands - Sensitivity towards barrier islands
28	Barrier Isalands - Remove hazardous materials
29	Barrier Islands - Develop Baseline Flora-Fauna Studies
30	Barrier Islands - Protect From Spills
31	Barrier Islands - Evaluate Sediment Transport - Ensure sand minimg does not Impact Islands
32	Barrier Island - Indicate NPS boundaries on project maps
33	Marsh Restoration where Feasible This can be done in conjunction with private and government dredging projects
34	Partnership Efforts with Louisiana to Marsh Island Areas

Table 3.

Coastal-wide Stakeholder Input: Public Workshops

Item#	Name
35	Barrier Islands - Restoration (to a natural setting)
36	Allow nature to dictate wetlands vs. beach to a greater degree.
37	Provide protection for public facility (i.e., WW treatment plants).

Table 4.

Hancock County Stakeholder Input: Study Team Coordination

38	Bay St. Louis Downtown HSDR
39	Cowand Point Seawall Erosion Control
40	Hancock County Beach Ecosystem Restoration and HSDR
41	Clermont Harbor Seawall HSDR and Erosion Control
42	Hancock County Comprehensive HSD - Ecosystem Restoration
43	Jackson Wetland Restoration
44	Bayou Caddy Shore Protection and Ecosystem Restoration
45	St. Louis Bay Comprehensive Ecosystem Restoration
46	Lakeshore Beach Ecosystem Restoration
47	Clermont Lake Ecosystem Restoration
48	Hancock County Communities Flood Damage Reduction
49	WhiteÆs Road Evacuation Route Protection

Table 5.

Hancock County Stakeholder Input: Regional Coordination Workshops

50	Biloxi Marshes Comprehensive Ecosystem Restoration
51	Magnolia Branch Ecosystem Restoration
52	Jordan River Shores Ecosystem Restoration. . Buy out landowners, return hydrology, begin mitigation, prohibit new/more development
53	Pearlington Ecoystem Restoration - Buy-out homeowners and return hydrology
54	Shoreline Park buyout

Table 6.

Hancock County Stakeholder Input: Public Workshops

55	Restore more natural freshwater flows by closing the MRGO
56	Remove storm debris (i.e., demolition debris carried in by surge retreat) from aquatic environments. Restore traditional shrimping and fishing areas rendered un-trawlable by storm debris.
57	Ferries to Temporarily Replace Bridges.
58	Restore all Hancock (all cosatal MS) marshes damaged by storm
59	Restore Hancock County Beaches to Pre-Katrina conditions
60	Widen Hancock County Beaches, jump-start dunes
61	Preserve Bayou Caddy Area
62	Protect Hancock County wetlands from filling for development
63	Construct a N/S rail link connecting Port Beinville Industrial Park to the Norfolk and Southern Railroad through Stennis Buffer. Hurricanes cause CSXT rail outages which cost > $20,000/day

Table 7.

Hancock County Stakeholder Input – Additional Input from Regional Coordination Workshops

Item#	**Name**
64	Open the east Pearl River channel so it can be used by commercial marine traffic from Port Bienville
65	Pursue the development of additional breakwater structures in low-use areas.

Table 8.

Harrison County Stakeholder Input: Study Team Coordination

66	Mississippi Coastal Pump Station Inundation Protection
67	Mississippi Coastal Urban Communities HSDR
68	Mississippi Coastal Barrier Island Restoration
69	Mississippi Coastal Improvement and Hurricane Storm Damage Reduction Program
70	WhiteÆs Road Evacuation Route Protection
71	WhiteÆs Road Evacuation Route Protection
72	Harrison County Beach Ecosystem Restoration and Erosion Control
73	Long Beach Harbor HSDR
74	Highway 90 û Rodeburg to St. Charles St. HSDR and Flood Control
75	Pass Christian Harbor HSDR
76	Biloxi Point Flood Damage Reduction
77	Cedar Lake Road Flood Damage Reduction
78	Gulfport Commercial Harbor
79	Turkey Creek Watershed Improvements
80	Turkey Creek Flood Damage Reduction
81	North Gulfport Interior Drainage
82	Long Beach Interior Drainage HSDR (includes Canals 2 - 3)
83	Harrison County Industrial Seaway Harbor of Refuge
84	Tchoutacabuffa River Flood Damage and Watershed Improvement
85	Courthouse Road Wetlands Ecosystem Restoration and Preservation
86	Deer Island Ecosystem Restoration
87	DÆIberville Wetlands Ecosystem Restoration
88	Biloxi Back Bay Watershed Management and Ecosystem Restoration

Table 9.

Harrison County Stakeholder Input: Regional Coordination Workshops

Item#	**Name**
89	West Ship Island. Continue to re-nourish the north shore of the island east and in front of Fort Massachusetts, a national historic site.
90	Evaluate Dredging and Channelization when preparing flood controls from rain events to consider impact for storm surge in costal zone.
91	Extend South Side of Deer Island. Extend 200 yards to repair breach in island and restore original footprint of island.
92	Deer Island enhancements. Cap shell middens on western side of the island and restore top soil in maritime live oak forest
93	New Sewage Treatment Plant in Woolmarket Lagoon Area - Move the Woolmarket Lagoon to north of I10 north of the area. would protect the citizens by moving the sewage from the flood prone areas:
94	Flood-Proof Existing Infrastructure
95	Enhance Lee and Bayview Docks for commercial shrimpers.
96	Enhance Maine Street Docks for commercial shrimpers.
97	Acquire wildlife corridors in lands that repeatedly flood
98	Develop Concrete Staging Center in Industrial Canal. Develop Harrison county industrial canal artificial reef staging area to stockpile concrete debris for oyster reef and other useful projects.
99	Restore or enhance Mississippi oyster reefs.
100	Open hw 90 Bridges quickly
101	Utilize HW 90 bridge as artificial reef material
102	Provide Compensation for Persons in Flood-prone Areas to Relocate. Areas prone to flooding, such as Eagle Point, should be offered buy-outs.
103	Economic Development of Downtowns. Orderly expansion of municipal harbors along with revitalization of downtowns would provide green space; non-water dependent retail, and a manageable beach blvd. (NOT HW 90).
104	Turkey Creek: Mt. Pleasant UME Audubon site 41, Tidal Creek restoration of flood plain.
105	Complete the purchase of “optional” Cat Island for inclusion into Gulf Islands Nationals Seashore
106	Rebuild the Harrison County boardwalk with concrete to accommodate pedestrians, BICYCLES, and possibly street vendors.
107	Provide inland marine vessel storm shelter location with adequate moorings.

Table 10.

Harrison County Stakeholder Input: Public Workshops

108	Restore grassbeds in MS Sound
109	Retention/Detention basin to hold runoff while waiting for surge to go down from Brickyard Bayou.
110	Surge gates along Biloxi Bay to help ease drainage areas during storm events
111	Wiers (low level dams) within estuaries to control water flow
112	Purchase riparian buffers, wetland areas.
113	Reconsider dioxin cleanup on navy base post Katrina.
114	Long Beach Interior Drainage HSDR (includes ôCanals 2 - 3)
115	Reduce toxic exposure which exacerbates storm damage – Dioxin, Creosote, Titanium Dioxide, Gypsum.
116	Turkey Creek watershed Greenway
117	Forrest Height Levee :- Restore; Vegetate with native species; Footbridges; Nature trail atop
118	Dredge shoaled channels hinfering storm evacuation
119	Dredge shoaled marinas

Table 11.

Harrison County Stakeholder Input: Additional Input from Regional Workshops

Item#	**Name**
120	Deer Island re-nourishment of south side.
121	Provide protection of public infrastructure from flooding, surges and sedimentation.
122	Possibly add height to the existing beach elevation and redevelop lost dune vegetation.
123	Flood-proof low-lying sewer treatment plants. Lift stations and wells and their electrical and electronic controls.
124	Construct reservoir or detention system to provide storage for rain events to reduce or prevent flooding along coastal rivers.

Table 12.

Jackson County Stakeholder Input: Study Team Coordination

125	West End Landing Coastal Erosion
126	Front Beach Blvd. Ecosystem Restoration and Erosion Control
127	Front Beach Road Wetlands
128	Shearwater Bridge Erosion Control
129	East Beach Road Ecosystem Restoration
130	Belle Fontaine Marsh
131	Pascagoula Beach Blvd. Restoration
132	Beach Park Storm Damage Reduction
133	Beach Boulevard Erosion Control
134	Pascagoula Breakwater HSDR
135	Chicot Road Flood Damage Reduction
136	Monster Ditch/Ocean Springs Flood Damage Reduction
137	West Bayou/Rhodes Bayou Flood Damage Reduction
138	Upper Bayou Cassotte Flood Damage Reduction
139	Biloxi Back Bay
140	Davis Bayou Ecosystem Restoration
141	Grand Batture Island Ecosystem Restoration
142	Greenwood Island Ecosystem Restoration
143	West Pascagoula Delta Flood Damage Reduction and Ecosystem Restoration/Study
144	Jackson County Marsh Outlet Ecosystem Restoration
145	Upper Old Fort Bayou Comprehensive Flood Damage Reduction
146	Old Spanish Trail Comprehensive Flood Damage Reduction/Drainage
147	Old Spanish Trail Comprehensive Flood Damage Reduction
148	Old Spanish Trail Comprehensive Flood Damage Reduction
149	Gautier Hurricane Storm Damage Reduction and Ecosystem Restoration
150	Franklin Creek Floodplain Restoration/Franklin Creek and Pecan Hydrology Project
151	Gautier Hurricane Storm Damage Reduction and Ecosystem Restoration
152	Gautier Hurricane Storm Damage Reduction and Ecosystem Restoration/Ladnir Rd

Table 13.

Jackson County Stakeholder Input: Regional Coordination Workshops

Item#	Name
153	Bayou Chico Beach HSDR/Bayou Chico Bulkhead Rehabilitation
154	Round Island Ecosystem Restoration/Round Island Lighthouse Relocation
155	Upper Old Fort Bayou Comprehensive Flood Damage Reduction/C. Byrd Road Drainage
156	Upper Old Fort Bayou Comprehensive Flood Damage Reduction/C. Byrd Road Drainage
157	Pascagoula beaches, offshore breakwater/dunes/reefs/marshes to dissipate wave energy
158	Restore natural drainage ways upper Bayou Castelle (vic Fishhawk Rd, Meadow Dale Dr., Longwod Dr, and Bayou Castelle Dr)
159	Restore natural drainage ways upper Sioux Bayou (vic Laville Subdivision and Westgate Subdivision)
160	Restore natural drainage ways upper Mary Walker Bayou (vic Northwood Hills, Rolling Meadows, and Bayou Oaks subdivisions)
161	Robert Hiram Bridge (Gautier) Hurricane evacuation route. Wetlands restoration, drainage
162	Graveline Rd Bridge at Shepard St Park (County)
163	W River Delta restoration. Bulkhead western channel. Beneficial use. Wave protection for subdivisions.
164	Bennett Bayou tidal marsh restoration
165	Pascagoula Beach Restoration. Dunes, grasses, trees, with intermittent pockets of sand beach
166	W Land Lake Pascagoula. Dredge to recover retention qualities and install new drainage pipes to north.
167	New Drainage Channel West Side of Martin Rd Bridge
168	Study same as 58
169	11th St Bridge and Drainage Canal. Bridge is failing and canal walls are caving in.
170	Drainage improvements - same as 166
171	Old Mobile Hwy Bridge Failing
172	Bridge at Old Mobile Highway and Hospital Road is damaged
173	Restore Bates St Drainage to Open Water
174	Inspection & Rehabilitation of Sewer and Storm Piping for Pascagoula
175	Relocate Pascagoula WWTP out of surge area
176	Re-establish benchmarks Pascagoula city-wide
177	Pascagoula brown water system study
178	Pascagoula Beach Blvd. Restoration (Boardwalk, beach, and marsh addition along Pascagoula front beach)
179	11th St Bulkhead Rehab
180	Pascagoula main drainage system restoration including additional wetland side storage. City-wide retention/detention system. Drain barrier valve system.
181	C. Byrd Road Drainage

Table 14.

Jackson County Stakeholder Input: Public Workshops

Item#	Name
182	Ebb and flow of Intracoastal veins from the MS Sound to rebuild property with the erosion in the bayous near potential project #66.
183	Use jetties to prevent sediment flow clogging channels
184	Cedar Point/West River-Restore beaches, sand, work, sediment management in this area
185	Ecosystem restoration along Hwy 90, Jackson County
186	Dredge/clear area in front of beachfront outfalls.
187	Hydraulic lifting boardwalk/sidewalk as component of seawall/boardwalk improvements.

Table 15.

Jackson County Stakeholder Input: Additional Input from Regional Workshops

188	Improve the Jackson-county seawall. Provide additional county-wide seawall construction, boardwalks, beach construction, marsh construction, or a combination of these elements
189	Gautier improvements to drainage. Same as B.
190	Gautier, drainage improvements. Same as C
191	Bayou Outlets on the Mississippi Sound that require actions to remove deposited siltation
192	Gautier improvements to drainage. Same as D.
193	Dredge Davis & Simmons Bayous to include all connecting bayous to help prevent flooding.
194	Rebuild and enlarge Marsh Island
195	Divert water from Escatawpa River into Bayou Cumbest to restore freshwater flow to the bayou and improve water quality.

Table 3-1 presents a synopsis of system-wide and county problems and related needs identified by stakeholders during the workshops and public meetings. These problems and related needs are the basis for the plan formulation process.

Table 16
Examples of Stakeholder Input: Coordination with Local Communities

Stakeholder Identified Problems	Stakeholder Identified Needs
• Loss of life and human injury due to ineffective communication • Insufficient capacity at storm shelters	• Coastal Mississippi Hurricane Evacuation Plan
• Storm surge damages and environmental degradation due to development in low lying areas	• Wetland Area Buyouts
• Erosion and intrusion of salt water	• Barrier Island Restoration • Restore or enhance Mississippi Oyster Reefs • Freshwater Diversion
• Erosion and storm damage	• Widen beaches, jump start dunes (Hancock, Harrison, and Jackson Counties)
• Storm surge flooding caused damage to structures and infrastructure	• Provide protection for public facilities • Surge gates along Biloxi and St Louis Bays • Seawalls, levees and ring levees (Forrest Heights Levee, etc.) • Hurricane and Storm Damage Reduction at population centers (Gautier, Ocean Springs, etc.) • Floodproof Existing Infrastructure
• Storm surge caused sedimentation in wetland areas	• Restore wetland functions (Grand Bay Swamp, Hancock County Marsh, etc.) • Restoration of Pine Savannah • Complete snagging and clearing to increase flood water conveyance

Additional details on specific problems are provided within the appropriate appendices. For storm damage reduction and erosion control formulation and screening processes, these discussions are contained in the Engineering Appendix. For ecosystem restoration and saltwater intrusion reduction formulation and screening processes, these discussions are contained in the Environmental Appendix. The results of each evaluation and screening process are summarized in the following chapters, and are presented as a Comprehensive Plan of "tentative recommendations" in the Main Report.

2.2 Opportunities

Comprehensive, ***system-wide opportunities*** were identified during the MsCIP planning process to guide the development and evaluation of solutions to the region's water resource problems. An overall theme of Comprehensive Plan opportunities is not merely to reverse the harm done by the hurricanes of 2005, but as importantly to promote the long-term future sustainability of physical,

human, and environmental resources within the study area. Comprehensive, system-wide opportunities include:

- Assist in sustainable redevelopment of hurricane damaged physical, environmental, and human resources within the MsCIP study area;
- Reduce the susceptibility of residential, commercial, and public structures and infrastructure to hurricane induced storm damages within the three-county (Hancock, Harrison, and Jackson) MsCIP study area;
- Assist in the recovery and long-term sustainability of coastal wetlands that support important fish and wildlife resources within the study area;
- Accelerate the recovery and assist in the long-term sustainability of maritime forest environments that suffered hurricane induced damages;
- Restore barrier island environments that suffered hurricane induced storm damages in a manner that promotes long-term sustainability of their fish and wildlife resources;
- Reduce saltwater intrusion within the Mississippi Sound coastal environment;
- Assist in the recovery of coastal ecosystems and infrastructure damaged by erosion during the hurricane events of 2005 and support programs that promote long-term erosion reduction and limit erosion potential during future hurricane events.

2.3 Planning Goals and Objectives

In response to the Federal Goal, as established by Congress, the following goals were established for the MsCIP by the Corps of Engineers Project Development Team (PDT), cooperating agencies and affected public. The system-wide goals established for this study were developed in clear recognition of the linkages between structural and nonstructural storm damage reduction and ecosystem restoration opportunities. System-wide goals are intended to address the coastal landscape of the entire Gulf Region, including the area specifically evaluated in the LaCPR program. MsCIP system-wide goals identified in the Comprehensive Plan effort include the following:

- Identify measures to minimize risk to loss of life and safety caused by hurricane and storm surge;
- Recommend cost-effective measures for restoration of nationally and regionally significant environmental resources within a context of long-term sustainability;
- Recommend cost-effective measures to reduce damages from hurricanes and storms without encouraging re-development in high-risk areas;
- Recommend cost-effective measures to mitigate damages caused by saltwater intrusion into nationally significant ecosystems;
- Recommend cost-effective measures to restore eroded coastal resources as part of a system-wide approach to develop a resilient coastline;
- Identify other water resource related programs and activities integral to the development of a comprehensive system-wide plan.

The system-wide objectives established for this study provide specific targets to measure progress towards achieving the comprehensive goals outlined above. Projects formulated as part of the Comprehensive Plan were evaluated based on their ability to contribute to achieving the targets established in these objectives. System-wide objectives include the following:

- Reduce loss of life caused by hurricane and storm surge by 100%;
- Reduce damages caused by hurricane and storm surge by $150M-$200M annually;
- Restore 10,000 acres of fish and wildlife habitat including coastal forests, coastal wetlands, wet pine savannah, submerged aquatic sea grasses, oyster reefs, and beaches and dunes by the year 2040;
- Manage seasonal salinities within the western Mississippi Sound such that optimal conditions for oyster growth (surrogate for other aquatic resources, 15 ppt during summer months) are achieved on an annual basis by 2015;
- Reduce erosion to barrier islands, mainland, and interior bay shorelines by 50%;
- Create opportunities for collaboration with local, state, and Federal agencies to facilitate implementation of programs and activities that maximize the use of resources in achieving the comprehensive goal.

2.3.1 Planning Considerations: Environmental Justice

On February 11, 1994, President Clinton issued EO 12898, *Federal Actions to Address Environmental Justice in Minority and Low-Income Populations*. The EO is designed to focus attention of Federal agencies on the human health and environmental conditions in minority communities and low-income communities. Environmental Justice analyses are performed to identify potential disproportionately high and adverse impacts from proposed actions and to identify alternatives that might mitigate these impacts.

2.3.1.1 Historic and Existing Conditions

Data from the U.S Department of Commerce, Census of Population and Housing were used for this Environmental Justice analysis. The population in 1990 for Mississippi was 2,573,216. Minority populations included in the census are identified as Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and other Pacific Islander, Hispanic, of two or more races, and other. Mississippi is only second to the District of Columbia as having the largest Black or African American population. Poverty status, used in this coastal Mississippi report to define low-income status, is reported as the number of persons with income below poverty level. The 2005 Census defines the poverty level as $9,973 of annual income, or less, for an individual, and $19,971 of annual income, or less, for a family of four. In 2005, Mississippi ranked number one out of the 50 states for individuals living below the poverty level in the past 12 months. Unfortunately, Mississippi had 21.3% of its population living in poverty in 2005.

Coastal Mississippi has a lower percentage of minority residents than the State of Mississippi and the U.S. In 2000 (the most up-to-date data available), 79.6 percent of the population was white and 16.3 percent was black. All other racial groups combined totaled approximately 4.1 percent of the population, while 2.2 percent were of Hispanic origin. In Mississippi, 61.4 percent of the population was white, 36.3 percent was black, 2.3 percent was of another minority racial group, and 1.4 percent was of Hispanic origin. For the U.S., 75.1 percent of the population was white, 12.3 percent was black, and 12.6 percent was of other minority racial groups. Approximately 12.5 percent of the U.S. population was Hispanic.

The Census Bureau bases the poverty status of families and individuals on 48 threshold variables, including income, family size, number of family members under the age of 18 and over the age of 65, and amount spent on food. In 1997, approximately 14.6 percent of the residents were classified as living in poverty, lower than the State of Mississippi but slightly higher than the poverty rate for the U.S. as a whole.

2.3.1.2 Post-Hurricane Conditions

As of 2006, the population in Mississippi was 2,910,540 – of this 135,940 individuals live in Jackson County, 193,810 live in Harrison County, and at this time a population count for Hancock County was not available. Hurricane Katrina drew focus on the number of residents unable to flee the Gulf coast due to lack of funds. There is a longstanding legacy of unfair and disproportionate harmful exposures to low income, predominantly African American communities in much of Mississippi. Predominantly in the Biloxi area but also in other coastal Mississippi communities, there was a large population of Asian Americans that depended upon fishing for their livelihood. Adverse impacts from Hurricane Katrina have resulted in a large number of these individuals leaving the area.

Environmental Justices have resulted from years of industrial activity and waste disposal practices that hit these communities harder than higher income, predominantly white communities. Impacted areas, such as superfund facilities, are located more often in low-income areas and therefore are at greater risk to post-Katrina exposure. As clean-up proceeds and rebuilding begins, every effort must be made to remedy these environmental injustices through full clean-up, fair rebuilding practices, and full partnership with affected communities. Over 30,000 families are being helped through Administration on Children and Families Temporary Assistance for Needy Families (TANF) program by the provision of short-term, non-recurrent cash benefits to families who traveled to another State from the disaster designated States. The hurricane-damaged States of Mississippi, Louisiana, and Alabama also received additional funding for the TANF program to provide assistance and work opportunities to needy families ($69 million for loan forgiveness and $25 million in contingency funds for State Welfare Programs.)

Counties along the Mississippi Gulf coast lost a sizeable share of their white residents and homeowners immediately following Hurricane Katrina, while other Gulf Coast metropolitan areas, especially those that gained residents, experienced little overall shifts in their demographic profiles. Coastal counties of Mississippi, which include Gulfport-Biloxi and Pascagoula metropolitan areas, in contrast to New Orleans, were left with a population that had a larger share of minority residents, a lower level of homeownership, and no significant decline in poverty. In essence, while the poor and less well-off residents of New Orleans bore the greatest brunt of Katrina, the storm had a more egalitarian effect on the population of coastal Mississippi. Our examination of the data for other hurricane impacted areas in the Gulf Coast region reveals that while a great deal of population shifting had occurred, only minor changes have taken place in the race and ethnic, economic and socio-demographic profiles for most of these areas.

Each and every measure or alternative examined in the MsCIP study was evaluated for its potential for adverse impacts to minority and/or low-income populations, in adherence with EO 12898. In no case was there any identified negative impact to any of these communities in regards to human health and environmental conditions, from any proposed actions or projects.

Because no plans for structural or non-structural protection of residences or businesses, either in-place or as acquisition and relocation have been vetted by community leaders or the public at more than a concept level, it is impossible to say whether or not any of these measures, as ultimately acted on over the long-term, would genuinely have a significant effect, either positive or negative, on low-income or minority populations.

In fact, the realities of living in a high hazard area, which grows more hazardous as one approaches the shoreline, will supersede the effect of any plans or projects pursued under any outside authority. The reality is that most low-income populations, some of whom are also minorities, will have a hard time rebuilding in high hazard areas simply due to the cost of homeowners or business insurance, which will be a requirement of the vast majority of lending institutions. In the more than two years since the hurricanes of 2005, the majority of rebuilding has been undertaken by those that can self-

insure their homes or businesses, and also afford to rebuild with their own resources, something the vast majority of low income families cannot do. Therefore, the economic nature of communities along the coast of Mississippi is being changed largely by the economics of those that can afford to rebuild and insure their properties, versus those that cannot.

And, while some structural measures might protect areas in which low-income residents might rebuild, those measures would only provide damage reduction for surge events, and not wind. The cost of insurance against wind damage, which would continue to be a requirement of lending institutions, may continue to drive the economics of whether one can or cannot afford to rebuild traditional residences or businesses, within the highest hazard zones.

Non-structural measures intended for acquisition and removal of the most risky structures would tend to affect all residents or businesses located in those zones, low-income and high-income alike. However, well-armored structures, such as high-rise concrete complexes, would advisedly be the most survivable of those that might exist in the most high hazard zones. But, the choice of income level of those that would be able to afford to live in those complexes, will also likely be driven by the economics of those that can or cannot afford to do so. Whether or not some of those complexes can afford to contain apartments that have low rental rates, will be a choice of local government, which controls zoning ordnances and land-use and development decisions. Ultimately, the plan adopted for the Mississippi coast will not be a plan forced on them by the Corps or other Federal agencies, but a plan coordinated, discussed, and finally adopted by the numerous entities and individuals that will live with that plan, the residents and local government of coastal Mississippi.

3 DISCUSSION ON TECHNICAL ANALYSES: PLANNING AND ENGINEERING METHODOLOGIES AND APPROACHES

The technical analyses undertaken by the MsCIP study team involved the development of methodologies and application of models, over a broad spectrum of disciplines. These include economics, environmental resources, plan risk evaluation and decision-making, coastal engineering, design and cost estimating, real estate, geotechnical investigations, Geographic Information Systems (GIS) application, saltwater/freshwater interface and saltwater intrusion remediation analysis, erosion and sediment transport analysis, sediment source analysis, hydrology and hydraulics, public involvement, and plan formulation.

Details on each of these technical functions and evaluative efforts are given in each of their respective appendices; however, a general discussion of the process each engaged in, in the development of measures and alternatives, is provided in following sections of this report.

3.1 Planning Models

Planning models used in the development, evaluation, and screening of measures, are provided in Table 17, below. A more complete discussion on all the models used throughout this study, as well as quality control and quality assurance procedures can be found in the Modeling Appendix.

Table 17.

MsCIP Planning Models

Model	Description/Purpose	Use in MsCIP
Spatial Decision Support System (SDSS)	GIS based decision system to identify & evaluate potential sites	Selection of potential Wetland restoration sites
AL/MS Gulf Coast Tidal Fringe Hydrogeomorphic Model (HGM)	Perform functional assessment of tidal fringe wetlands	Evaluate positive/negative impacts to tidal fringe wetlands
MS Wet Pine Savannah HGM Model	Perform functional assessment of wet pine savannah habitats	Evaluate positive/negative impacts to wet pine savannah habitats
Functional Habitat Unit (FHI) Spreadsheet	Assess the environmental Values of beach and dune habitat	Evaluate positive/negative impacts to beach and dune habitats

3.2 Environmental Resources Analysis and Evaluation

The analysis of existing and future "without-project" resources, and the development, evaluation, and screening of measures and alternatives dealing with ecosystem degradation and restoration, are discussed in general terms below, and in more detail in the Environmental Appendix.

The environmental team initially defined the overall comprehensive natural system and its condition after the hurricane season of 2005. This detailed discussion is found in Chapter 1 of the Environmental Appendix. A comprehensive list of ecosystem-related problem areas consisting of single or multiple problems associated within a given site was compiled with assistance from members of the public, state, local, and other Federal agencies, representatives of industry and commerce, and resource agencies concerned with study area resources, at a series of open meetings and on-site meetings. These areas were first identified as having been caused or exacerbated by the 2005 hurricane events identified with: a) coastal erosion; b) damage to fish and wildlife resources; and c) saltwater intrusion. The vast areas initially identified for study of ecosystem damage are shown in Figures 2 - 4. The areas are color designated based on their ability to be restorable. The red designation shows areas that are highly likely to be able to be restored to their historical habitats and in contrast the blue designation shows areas that are possible but very difficult to be able to be restored.

After an initial screening of problem areas to determine their link to the hurricanes of 2005, a list of potential problem-solving measures was developed for each problem area. This list of problem areas and sites damaged by the hurricanes of 2005 was then screened based on the input of the inter-disciplinary study team's understanding of each site's ability to either heal on its own, unaided by human intervention, or:

- by its national and/or regional significance in regards to the type of ecosystem it represents;
- the need for assistance to restore vital hydrologic links;
- the need to manually remove blockages created by hurricane-deposited debris that was impacting function;
- the need to remove excess sediment deposited by the hurricanes that had changed the nature of the land's surface and resulted in degraded function and value;
- the need to remove invasive species that had entered the area since the hurricanes and caused displacement of native plant species (and potentially wildlife depending on native species), degrading function of the ecosystem; or

- the need to plant native species vital to restoration of a significant ecosystem and restoration of its functions and values.

The following four models were utilized by the MsCIP environmental PDT to evaluate existing and future without-project conditions within the three-county study area:

- Mississippi and Alabama Gulf Coast Tidal Fringe Hydrogeomorphic (HGM) model;
- Wet Pine Savannah HGM model,
- SDSS; and
- Functional Habitat Index (FHI) Model.

The methodology used for riparian and coastal wetlands is the HGM, developed by the USEPA, NOAA, Corps, and USFWS, calibrated for wetlands ecosystems found in coastal Mississippi, as used in many prior studies (Schaffer 2007). HGM is a science-based quantitative and replicable methodology that establishes functions ands values at a variety of sites and reference points that are then used to establish functional values for sites within the area be analyzed. HGM was applied at a landscape-level, using numerous reference sites in the area in the establishment of without-project conditions. The HGM model was used for the functional assessment of tidal fringe wetlands and wet pine savannahs within the study area.

Because HGM has not been calibrated for use in coastal maritime forest analysis in this area, an alternative methodology was used for the small number of beach, dune, and/or coastal maritime forest sites evaluated. The methodology chosen for this application was FHI. Functional production was quantified as an output that the fauna could potentially use. Functions evaluated in the matrix included substrates, habitat types, stabilization, and vegetation. In order to reduce subjectivity, the output was identified as an indirect or direct benefit. The “No Action” effort for a given project still has a FHI score even though there is no work proposed for the area. The FHI tables quantify expected biological output by linking biophysical benefits (termed functions) to specific restoration activities. The term biophysical, in this case, refers to the living and non-living components and processes of the ecosphere. Adding all of these outputs together from the table, and then multiplying by the acreage, provides an FHI score. A FHI model was used in the assessment of existing and future without-project conditions for coastal dune environments. This model is based on collaboration between resource agencies involved in past restoration projects.

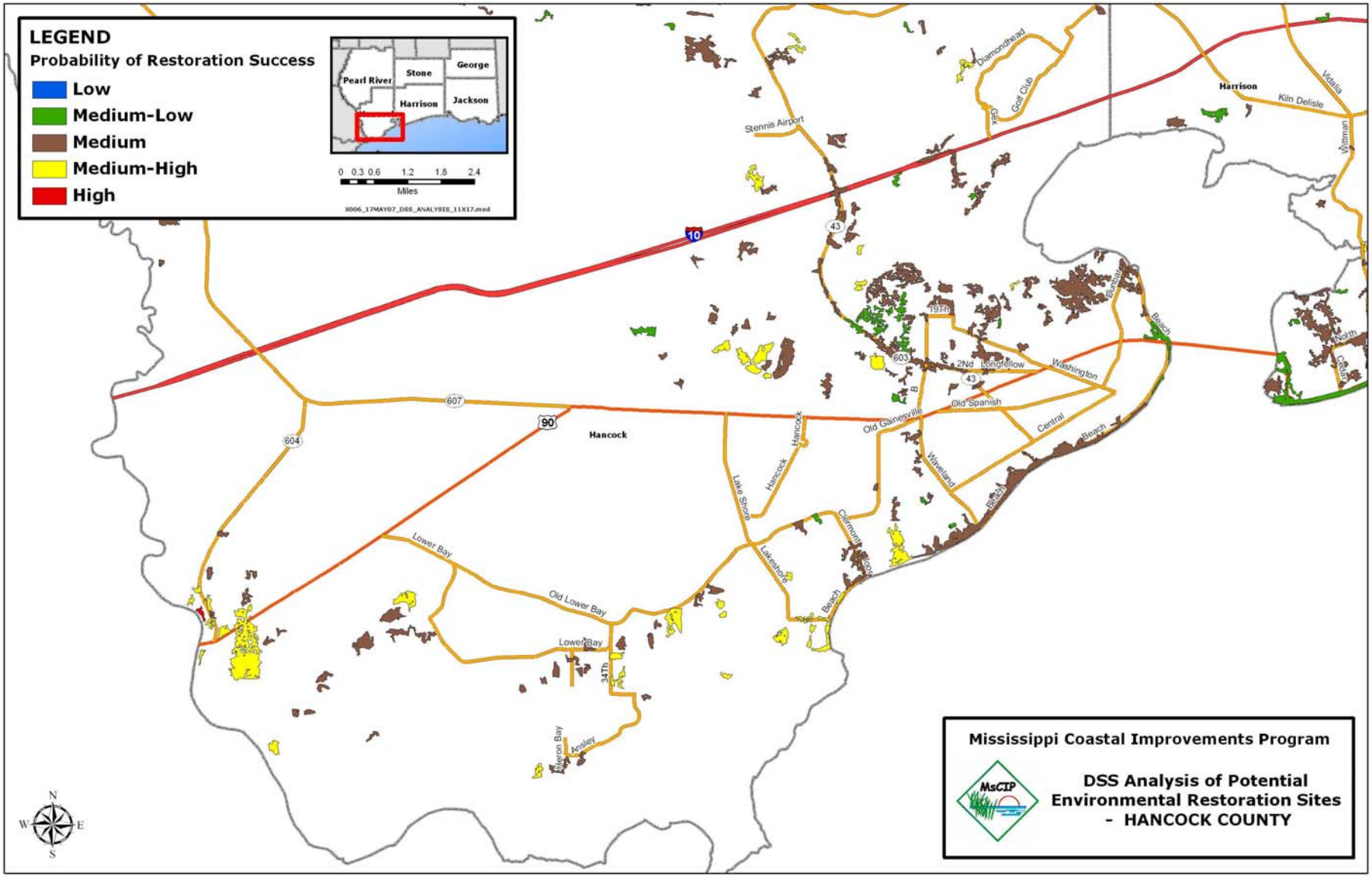
The SDSS tool allowed the Corps, Mobile District, working in cooperation with the USFWS and MDMR, to identify and prioritize potential wetland restoration areas throughout coastal Mississippi. A subset of potential restoration sites were identified by the SDSS tool and then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS. This interagency team allowed us to both confirm the accuracy of the SDSS results and to collect additional on-site information pertinent to restoration efforts. There are some major benefits in using the SDSS approach to wetland restoration. First, it allows for the relatively rapid assessment of the large number of restoration sites across the wide study area. Second, potential sites can be evaluated and restored in a watershed or landscape context, which allows us to comprehensively evaluate the overall natural system. This approach can maximize the benefits of wetland restoration, as opposed to simply restoring wetlands where convenient or where property is available. Essentially use of this SDSS tool allowed the MsCIP environmental PDT to assess the entire coastline as a holistic natural system; thus, the team was more effectively able to analyze needs in coastal Mississippi.

The SDSS effort resulted in the following products:

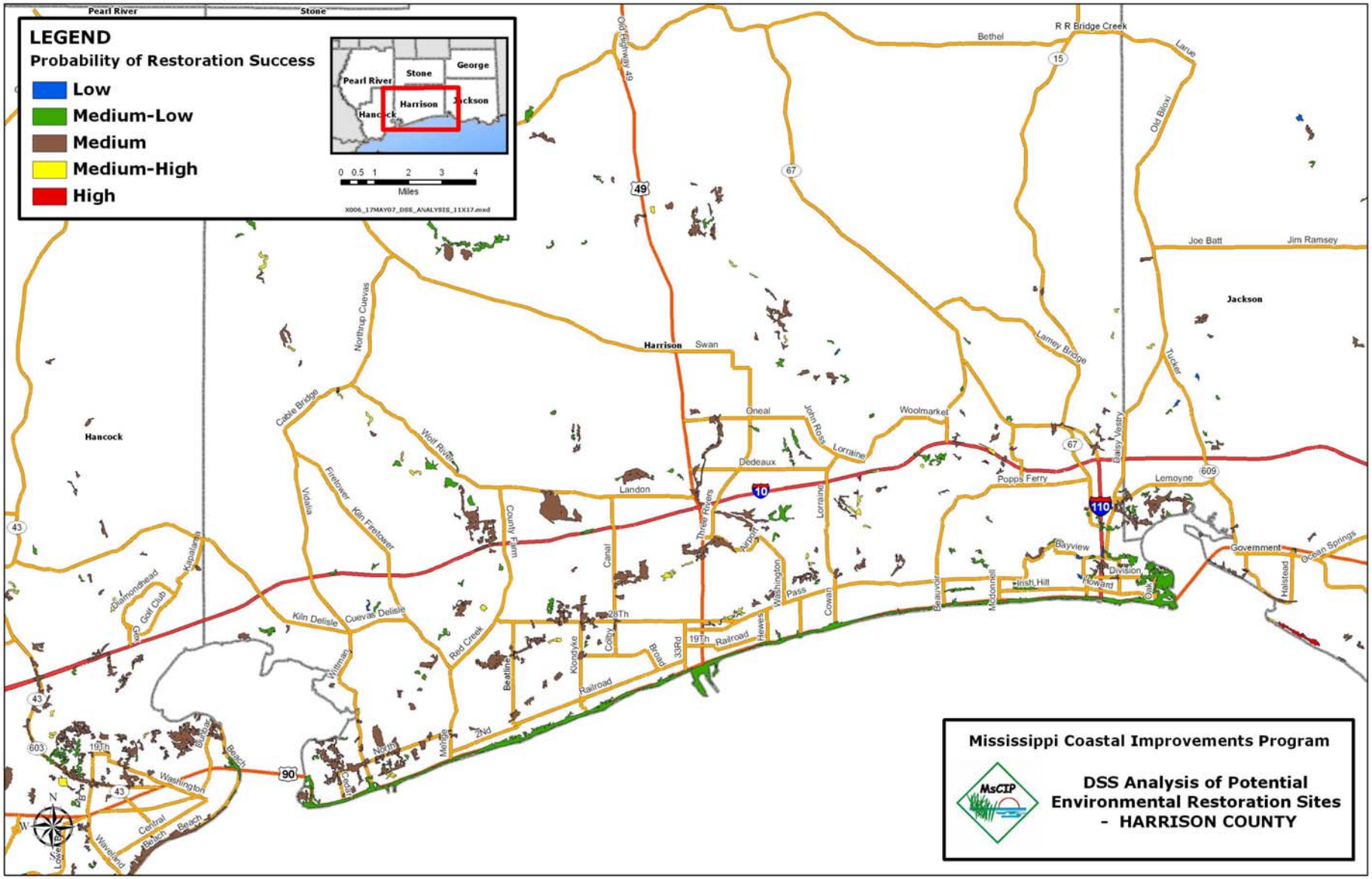
1. A ModelBuilder based SDSS tool, which can be subsequently edited and applied to other areas along coastal Mississippi in the future as funding becomes available;

2. Maps, such as aerial photography, topographic, soil layers, etc., depicting areas in the study region that have a high probability of being successfully restored into wetland functions that buffer and/or store stormwater, and provide suitable habitat for fish and wildlife; and

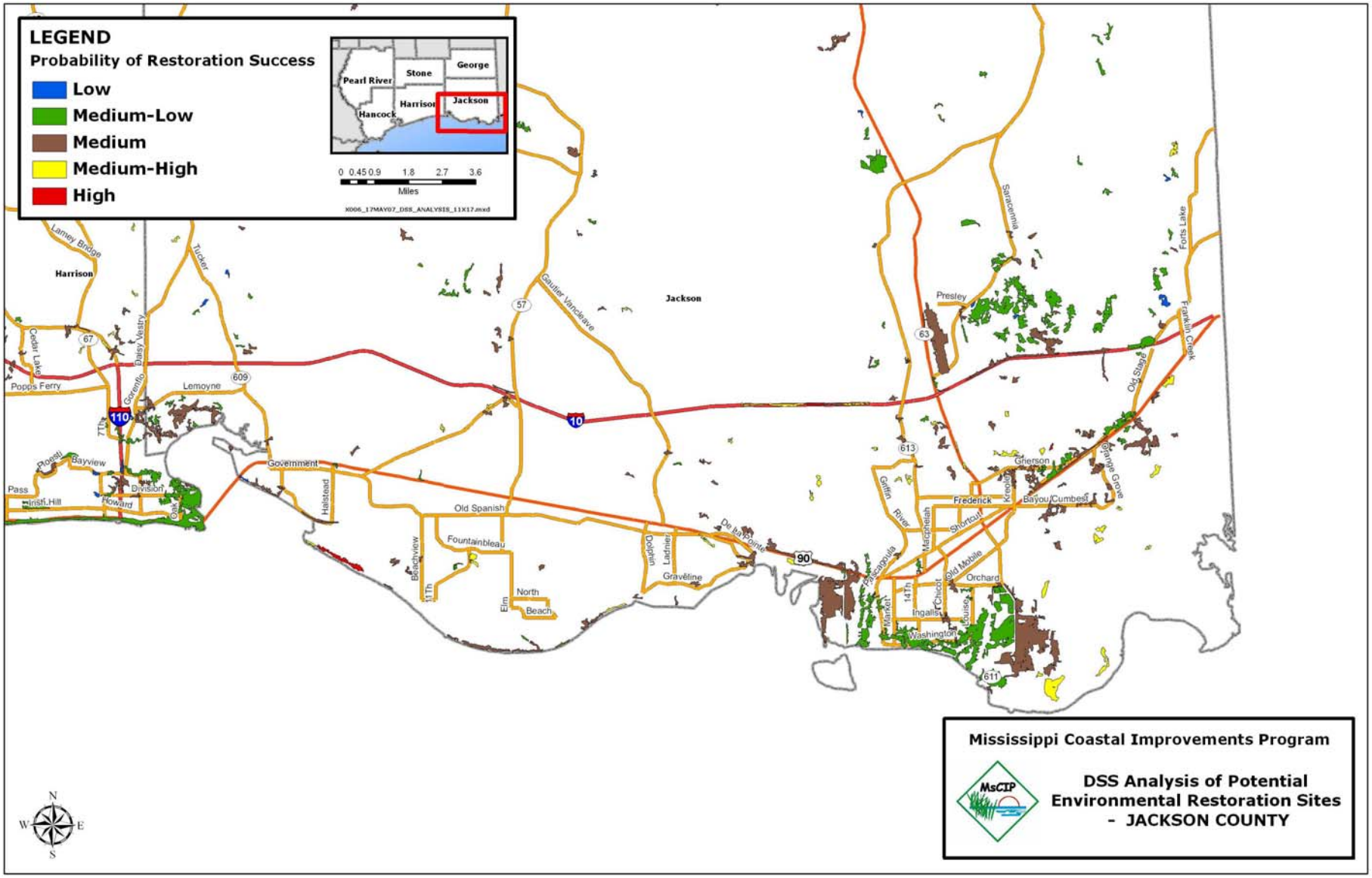
3. Photograph documentation and data sheets containing information on ground-truthed potential restoration sites.



1 **Figure 2. Hancock County Ecosystem Resources**



1 **Figure 3. Harrison County Ecosystem Resources**



1 **Figure 4. Jackson County Ecosystem Resources**

A FHI model was used in the assessment of existing and future without-project conditions for coastal maritime/beach-dune environments. This model is based on its use in the Corps' 2003 Section 204: Beneficial Use of Dredged Material at Deer Island, Harrison County, Mississippi Combined Planning and Design Report. The end product of the without-project conditions analysis was a set of functional scores for each problem area or site, which are presented in the Environmental Appendix.

A cost-effectiveness analysis was conducted for each of the measures and alternatives that were formulated for ecosystem restoration. The analyses followed the methodologies established in the Corps Institute for Water Resources (IWR) publications, Evaluation of Environmental Investment Procedures Manual, Interim: Cost-Effectiveness and Incremental Analyses, May 1995, IWR Report #95-R-1 and Cost Effectiveness Analysis for Environmental Measuring: Nine Easy Steps, October 1994, IWR Report 94-PS-2. The nine steps outlined in the cited IWR report have become the standard practice for identifying what are known as "Best Buy" ecosystem restoration measures, or those measures that yield the greatest 'bang for the buck' at various levels of output.

The IWR Measure model was developed based on these nine steps and is the preferred Corps model for the evaluation for ecosystem restoration measures. For the MsCIP Comprehensive Report and Integrated Programmatic EIS, Congressional Authority stated, "…but shall not perform an incremental benefit-cost analysis to identify the recommended project…." Following this authorization, only the first five steps of the nine easy steps, which are bolded below, were used in the IWR Plan evaluation, resulting in the identification of cost-effective plans for restoration purposes. The nine steps are:

- Formulation of combinations:
  Step 1 - Display Outputs and Costs
  Step 2 – Identify Combinable Management Measures
  Step 3 – Calculate Outputs and Costs

- Cost-Effective Analysis:
  Step 4 – Eliminate Economically Inefficient Solutions
  Step 5 – Eliminate Economically Ineffective Solutions

- Development of Incremental Cost Curve
  Step 6 – Calculate average costs
  Step 7 – Recalculate average costs for additional output

- Incremental Cost Analysis:
  Step 8 – Calculate incremental costs
  Step 9 – Compare successive outputs and incremental costs

3.3 Engineering Analyses

This section describes in very general terms the methods used to evaluate various elements and attributes of a "lines of defense concept". This concept involves multiple lines that include structural, environmental, and nonstructural features to accomplish the planning objectives. The lines are arranged in increasing levels of risk reduction from off-shore to in-shore up to the maximum possible intensity storm event that the team evaluated as possible for coastal Mississippi. This concept would utilize existing barriers such as the barrier islands, roadways, and railroad embankments as shown in Figure 5. Detailed descriptions of objectives, methods, and results are described in the Engineering Appendix.

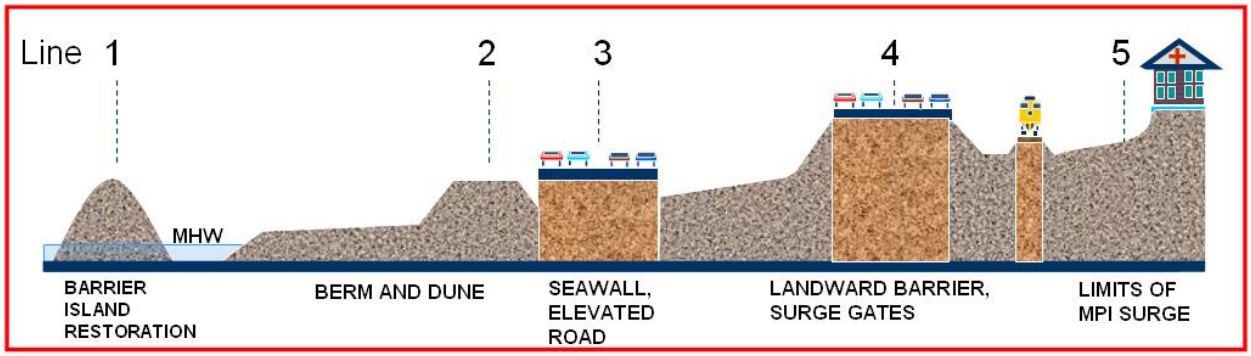


Figure 5 Lines of Defense Concept

3.3.1 Coastal Process Modeling

The purpose of this analysis is to evaluate the physical performance of the beach and dune system for anticipated future without-project and alternative with project conditions and to estimate the economic costs and benefits of each. The coastal processes modeling analysis employed the engineering-economic model Beach-fx (Gravens et al. 2007). Beach-fx relies on a shore response database to evaluate the beach and dune line of defense (line of defense two). The beach and dune analysis was evaluated considering the environmental forcing as characterized by plausible variants of the 71 historical tropical storm events that impacted the study area between 1886 and 2001.

The models applied to evaluate beach profile response to storms and project induced shoreline change are SBEACH (Larson and Kraus 1989) and GENESIS (Hanson and Kraus 1989). SBEACH is a numerical model for simulating storm-induced beach change that has been applied at numerous projects. SBEACH takes as input the storm time series (wave heights, wave periods, and total water elevations) and the initial profile definition, as well as other descriptors of the beach (e.g., grain size) and model parameters, and produces as output, the estimated beach profile at the end of the storm, as well as cross-shore profiles of erosion, maximum wave height, and total water elevation including wave setup. This information is extracted from the SBEACH output by post-processing routines and stored in the shore response database (SRD). The storm time series input is derived from a pre-computed surge response database developed by the Dredging Research Program (DRP) and the Wave Information Studies (WIS) database.

3.3.1.1 Hurricane Surge Modeling

A team of Corps of Engineers, FEMA, NOAA, private sector and academic researchers have been working toward the definition of a new system for estimating hurricane inundation probabilities. The findings and recommendations of this Risk Assessment Group are documented in a White Paper on Estimating Hurricane Inundation Probabilities (Resio 2007). The approach recommended by the group was a modified Joint Probability Method (JPM) referred to as the JPM with Optimal Sampling (JPM-OS). Generally, the approach involves wind and pressure field analysis and modeling; offshore and nearshore wave modeling, and storm surge modeling. For a full description, see Resio (2007). The general modeling approach is illustrated in Figure 6.

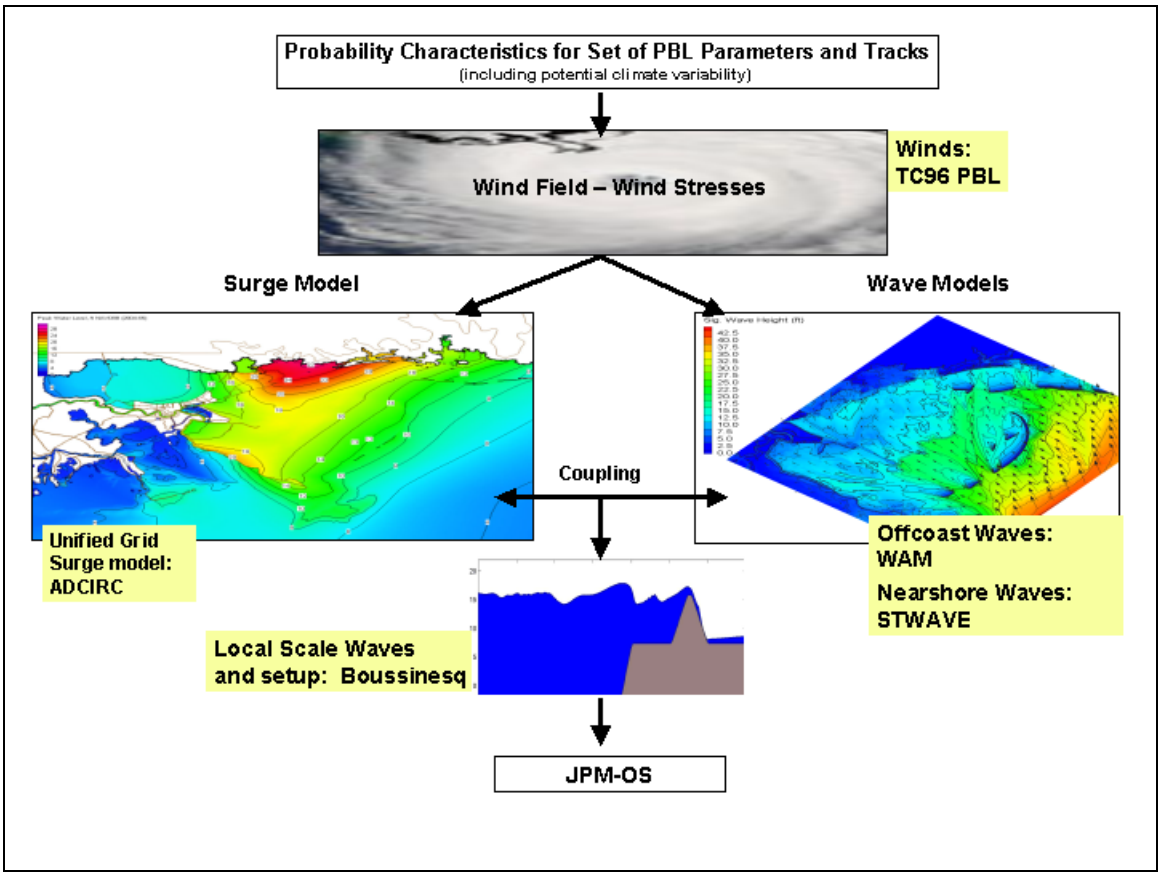


Figure 6. Diagram of modeling system for coastal inundation applications

Tropical cyclone surface wind and pressure fields were computed using the Planetary Boundary Layer Model, a.k.a. the TC-96 model. The wind and atmospheric wave fields were applied in (a) STWAVE to generate offshore and nearshore wave spectra and (b) ADCIRC generate bulk sea surge identities. These models were used iteratively to account for nearshore radiation stress transformation, and the resulting surge stage signature was modified for local shore feature effects based on limited application of the Boussinesq model COULWAVE.

Resulting storm surge surface envelopes were statistically sampled to derive surge stage-frequency relationships at a number of locations along the Mississippi Coastline. These relationships describe the stage for events with an annual chance of occurrence between 1 in 25 (or 4%) and 1 in 1000 (0.1%).

3.3.1.2 Stage-Frequency Curves

Stage-frequency curves are a foundational product for the present storm damage reduction design and analyses. The stage-frequency curves are the primary engineering inputs to economic flood damage analyses, and represent the static water surface elevation for non-structural flood damage reduction measures and levee crest height determination.

Stage-frequency curves describe the annual chance of occurrence of the surge still water elevation. The curves are composite curves, composed of both observed information (USACE tide gage observations at Gulfport, Biloxi, and Pascagoula) for more common events, and synthetic information (surge envelopes derived from statistical analysis of historic storm properties and imposition of those properties on the coastal environment through hydrodynamic wave and surge

models) for more rare events. The composite and synthetic portions of the curves were joined graphically. Given the focus on hurricane surge damage Curves were developed for 62 locations in the vicinity of the coastline, and another 18 locations in Mississippi Sound in the vicinity of the Barrier Islands. Stage frequency curves with uncertainty were developed for the without project condition; for the Line of Defense 3 condition; and for the Line of Defense 4 condition.

Uncertainty to plus and minus one standard deviation about the observed portion of the stage-frequency curves was developed using the method of order statistics. Uncertainty to one standard deviation about the synthetic portion of the stage frequency curve was based on a Gumbel distribution. Uncertainty limits were also joined graphically.

3.3.1.3 Flood Damage Reduction Analyses

The Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) program uses risk and uncertainty analysis methods for evaluating flood damage and flood damage reduction alternatives. The program relies on hydrologic, hydraulic, and economic data input. Uncertainties in these data are input and used by the model for computing expected annual damages. Version 1.2.3b dated August 2007 was used. This is a customized version of the modeling platform which provides for input of user-specified stage-frequency uncertainty. The Engineering Appendix describes the model and it's application.

FDA models were developed for each coastal Mississippi county: Hancock, Harrison, and Jackson counties). Each county represents a planning unit, and each was further delineated into planning sub-units (PSU). There are ten PSU's in Hancock County, 19 in Harrison County, and 26 in Jackson County.

3.3.1.4 Levee Crest Elevation Determination

Levee heights were initially established based on interpretation of early hydrodynamic model output. A range of heights were conceptually designed and cost-height function was developed. The adequacy of a given levee height is related to social acceptability, cost-effectiveness, the desired level of protection, and local hydraulic and geotechnical performance requirements.

Hydraulic performance for purposes herein is predicated on limiting the average overtopping flow rate to a given threshold. The adopted threshold, based on application of limited mean estimates of coincident frequency significant wave height, peak period, and still water elevations, is 0.01 cubic feet per second per foot of levee. Wave heights, periods, and still water surface elevation frequency functions were provided by ERDC based on the hydrodynamic modeling program output. Such estimates are based on consultation with New Orleans District and are considered preliminary in accordance with draft levee certification regulations. Where required, wave properties are translated to the levee toe using the CEDAS program, which is also used to determine the required crest freeboard above the still water elevation for overtopping. Hydraulic performance evaluations are ongoing and are contained in Section 2.14 of the Engineering Appendix.

3.3.1.5 Regional Sediment Budget

This study evaluated the existing regional sediment transport magnitudes and directions for the Mississippi and Alabama barrier islands fronting Mississippi Sound and the mainland coast, including an analysis of historical long-term barrier island migration. A conceptual sediment budget was developed through a review of existing studies and is included in Section 2.12 of the Engineering Appendix. This budget formed the framework for the historical and calculated sediment budgets. Next, a historical sediment budget was developed through analysis of bathymetric and shoreline position change through time in consideration of engineering activities (navigation channel

construction, etc.) and significant storm events were also documented. A calculated sediment budget was developed based on STWAVE and GENESIS modeling for the Gulf and Bay shorelines of the barrier islands as well as the mainland coast. The final sediment budget was formulated from all these intermediate budgets.

3.3.1.6 Wetlands, Landscape Features, and Storm Surge

A literature review that documents studies that have measured and modeled storm surge elevations with the goal of understanding how landscape features and vegetation modify the surge elevation was conducted. A sensitivity study of a degraded and restored Biloxi marsh utilizing STWAVE was also performed.

3.3.1.7 Interior Drainage

Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee at the locations shown above. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. A typical section is shown below in Figure 7.

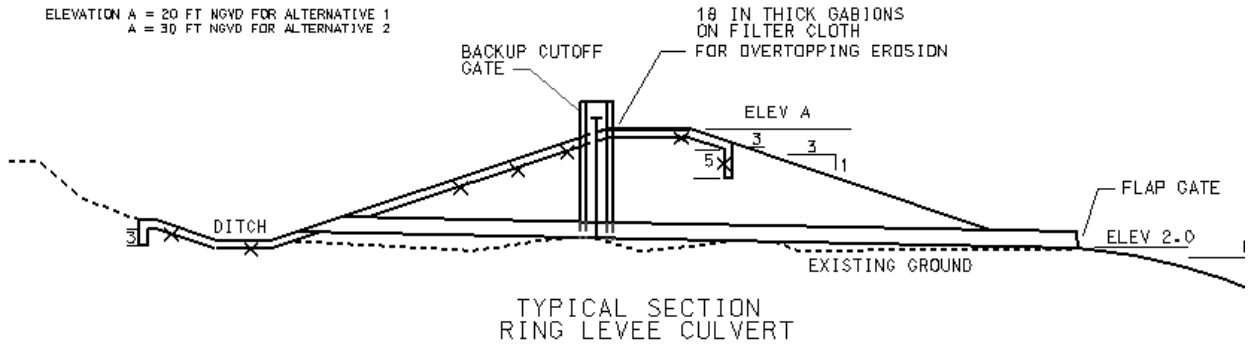


Figure 7. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the leveed areas into major sub-basins and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number. The variation in soil types, hydrologic soil groups, and major sub-basins was accounted for.

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico" US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is "National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)", R.W. Schoner and S.

Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report, therefore the exact extent of the ponding for extreme events is not precisely defined. The design rationale is based on the minimum facility concept, and economic tradeoffs between induced flooding and pumping provisions were not examined. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

3.3.1.8 Structural Damage Reduction - Engineering

Hurricanes are commonly recurring hazards for coastal Mississippi. The central Gulf coast region has one of the highest rates of occurrence in the U.S.. Development along the Mississippi coastline at relatively low elevations in many areas has created a landscape that is highly susceptible to storm damage. The two bays that divide the coastline of the three counties also aggravates the potential for inland flooding due to storm surge. The influence that landfall location for hurricanes may impart on storm surge is based on physical reasons and dictates why western Mississippi might register higher stages for a given hurricane than elsewhere along the Mississippi Coast. While the central coast of Mississippi has the highest topography, major hurricanes such as Camille in 1969 and Katrina in 2005 still produced surges that devastated this highly developed area. Approximately half of the coast of Mississippi including all of Harrison County has man-made beaches with high-value real estate immediately landward of the beaches. Essentially all of the structures facing the Sound were completely destroyed in Katrina.

Sea level rise and land surface subsidence have been taken into account as part of this study and the two together are reported as “relative sea level rise”, which accounts for both as a single value. Both factors play into the gradual rise in sea level compared to the land surface, over the period of analysis, or planning horizon.

The MSCIP Study incorporated many geotechnical considerations into the structural and environmental appendices of the report. All embankments in support of the various lines of defense were modeled for alignment footprint and quantities using Microstation’s CADD 3D and INROADS software. The basic design templates assumed side slopes of 1 vertical to 3 horizontal with a 15 foot crest for normal embankments and some greater than 75 feet in support of major roads. Access through the levees was provided by earthen ramps where the embankment heights were small relative to the existing ground and a small elevation gradient could be accommodated. Areas where the levee height differentials were too great or site conflicts prevented access ramps, then tunnels with closure gates were provided. All utility removals and reinstallations excavations were incorporated into the cost estimate for the individual feature. Materials to be used in the embankment and levee structures were assumed to be obtained from commercial sources with 10 miles of any given project. No formal geotechnical investigations were performed for this study. Geotechnical investigations will be performed for any project carried forward for feasibility design.

3.4 Non-structural Analysis

The nonstructural analysis for this study was performed as directed by Section 73 of the WRDA of 1974, and as prescribed in ER1105-2-100 and the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (March 1983). Section 73 specifically requires consideration of nonstructural alternatives in all flood damage reduction studies. These alternatives can be considered independently or in combination with other measures.

All nonstructural measures reduce flood damages without significantly altering the nature or extent of flooding. Damage reduction from nonstructural measures is accomplished by changing the use made of the floodplains, or by accommodating existing uses to the flood hazard. Examples are flood proofing, relocation of structures, flood warning and preparedness systems (including associated emergency measures), and regulation of floodplain uses.

The foundation of the technical analyses for nonstructural formulation was based upon five primary sources of data and associated models:

1) Tax assessor's databases from the three counties (Jackson, Harrison, and Hancock) that were further refined by the Mobile PDT,

2) FEMA databases for the National Flood Insurance Program that included Flood Insurance Rate Mapping, post Katrina damage assessments and GIS mapping, FEMA's model of the Advisory Base Flood Elevation mapping and associated topographic GIS layers,

3) The FEMA HAZUS model and databases for damageable structures in the project area,

4) Information and data gleaned from NOAA post-Katrina reports, and

5) Information on historic districts and buildings located in the project area from the National Park Service. Other databases from local communities and the US Census were used to describe local conditions, public buildings, housing resources, and current land use regulations (i.e. zoning, NFIP and building codes).

The nonstructural analysis was based in part upon research of proven nonstructural methods applied within coastal areas of the USA and determination of the relative surge inundation and wave hazards of the various coastal areas. Field observations of the damages to elevated and non-elevated structures and community facilities supported several aspects of the formulation process. FEMA data and flood zone mapping for the National Flood Insurance Program and post-Katrina damage reports supplied information on the location and extent of high-hazard flood zones that defined the division between areas suitable (safe) for floodproofing by elevation and those areas only suitable for permanent acquisition.

Several established computer programs were used to collect and analyze the parcel data and GIS mapping from the above sources including Microsoft Excel, Microsoft Access, and ESRI ArcMap Versions 9.1 and 9.2. These computer programs were used to create the database spreadsheets that supported the formulation of the various nonstructural measures and plans as well as the basis for the nonstructural cost models. The ArcMap programs were used to create the nonstructural graphic plans for the various measures and combinations of measures displayed in the Nonstructural Appendix.

The formulation and analysis of applicable nonstructural measures was based upon the Corps' Engineering Regulation 1105-2-100, The Corps Planning Manual (IWR Report 96-R-21), applicable sections of Corps regulations regarding real estate acquisitions (ER 405-1-12 and CFR, Title 49, Part 24) and public buildings and facilities relocations (EFARS Appendix Q - Relocations, Alterations, Vacations and Abandonments October 1984), provisions of the Uniform Act (PL 91-646) and various floodproofing regulations from the FEMA National Flood Insurance Program as well as applicable sections of the Mississippi State Code (Title 17-1-17) regarding local land use, zoning and regulation capabilities.

3.5 Economic Analysis

This section describes the methodology for the evaluation of economic impacts of potential solutions for the Mississippi Gulf Coast under the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Report. It is intended to be an outline of the process used to determine the economic impacts that are fully detailed throughout this report and in the Economic Appendix. The methodology was developed to seamlessly fit into the six step planning process and current Corps guidance. The six step planning process, as defined by the Engineering Regulation (ER) 1105-2-100; Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council 1983), referred to as the P&G, is:

1. Identify Problems and Opportunities
2. Inventory and Forecast Conditions
3. Develop Alternatives
4. Evaluate Alternatives
5. Compare Alternatives
6. Select the Recommended Plan

The Mississippi Gulf Coast is a complex system that is made up of a diverse blend of ecological and human habitats. Given those complexities, a fluid and flexible process was needed to evaluate and aggregate the benefits of potential measures and measures. The process incorporates data collection, forecasting techniques, scenario planning, cost effective evaluation using state of the art modeling techniques, and the communication of both benefits and risks associated with potential measures and measures. Figure 8 outlines the process used for this analysis.

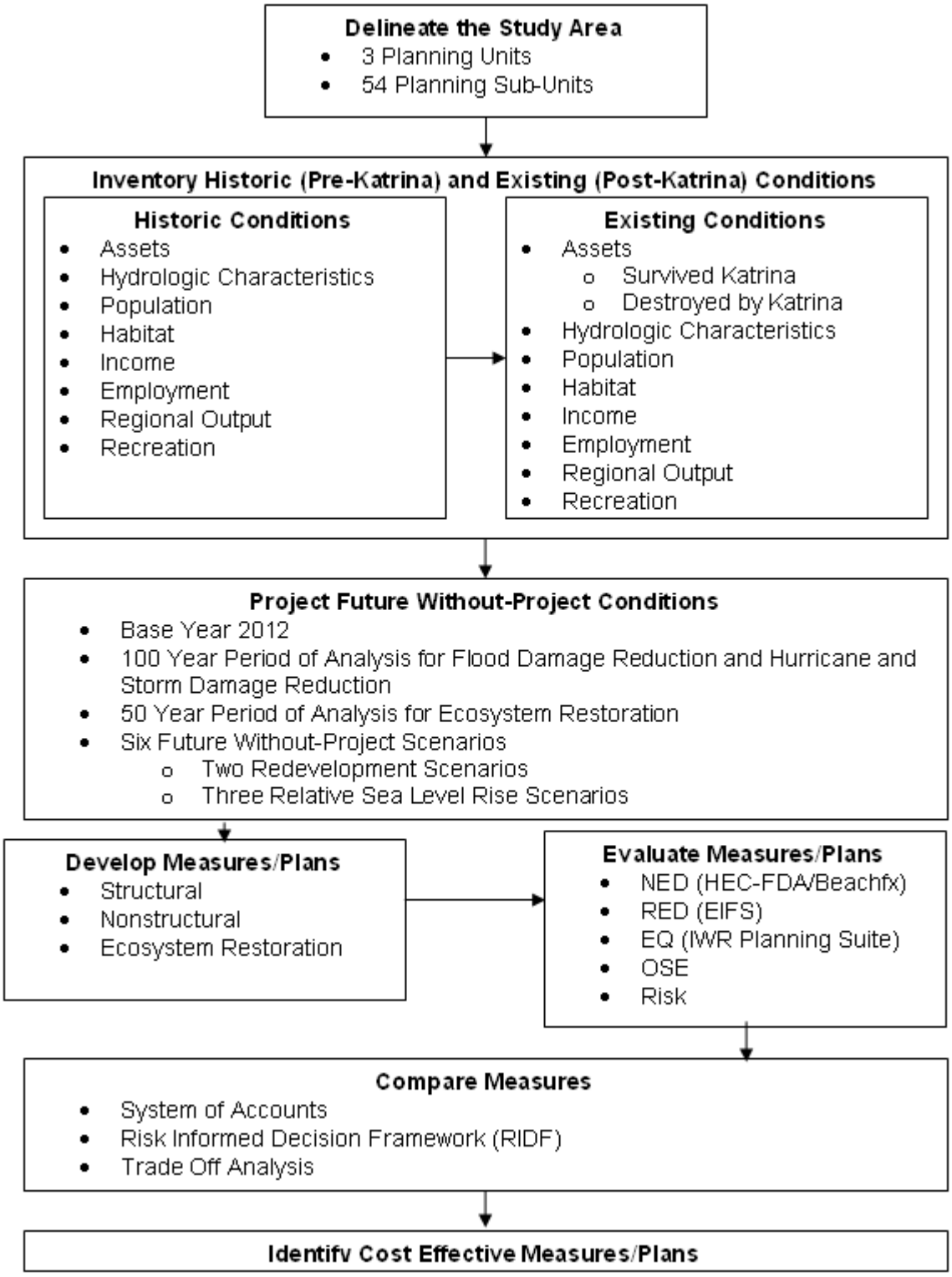


Figure 8. Overview of Economic Methodology

The first step in the process was to delineate the study area. The overarching study area, as defined by Congress, is the three coastal counties in Mississippi; Hancock, Harrison and Jackson from west to east respectively. For purposes of system wide evaluation and aggregating benefits, the study

area was divided into four planning zones, three planning units, and fifty-four sub-planning units. These are described in more detail in the following section.

Once the planning zones, planning units, and planning sub-units were identified, the next step was inventorying the economic, social, and environmental characteristics of the area. Data from Local, State, and Federal government agencies was utilized to determine the Historic (Pre-Hurricane Katrina) Condition, including data from the U.S. Census Bureau, the Federal Emergency Management Agency (FEMA), U.S. Fish and Wildlife, the Mississippi Emergency Management Agency (MEMA), the Mississippi Governor's Recovery Office, County Tax Assessors, previously conducted Corps of Engineers studies conducted in the area, and other valuable data sources. Historic data included economic structures (structures, content, and critical infrastructure), social and regional indicators (population, income, and employment), topographic and hydrologic characteristics, acreage of habitat, and etc.

With the historic data serving as a foundation, the next step was to determine the impacts of surge inundation from Hurricane Katrina. The team developed an inventorying methodology that was a combination of sampling and field verification. PDT members drove every street within the fifty-four planning sub-units over the course of four months from June to October, 2006, for purposes of determining the existing (Post-Hurricane Katrina) conditions and characteristics of structures. The findings of this work were put into a structure database that included over 200,000 tax parcels, 138,000 of which contained structures. Hydrologic programming was used to evaluate the surge inundation of each planning sub-unit and a combination of ESRI's ArcMap 9.1 Geographical Information System (GIS) data and ground truthing was used for habitat evaluation.

Six future with-out project scenarios were developed, based on the existing condition characteristics, for the evaluation of future without-project conditions. The six scenarios were evaluated over a 100-year period of analysis from the base year 2012 (2012-2111) and using the FY07 federal discount rate of four-and-seven-eighths (4.875) percent. The six future scenarios include two redevelopment scenarios (residential and mixed-residential and commercial) and three relative sea level rise scenarios (existing sea level, moderate relative sea level rise, and high relative sea level rise) for a total of six different future scenarios. Scenario one is a residential redevelopment with no relative sea level rise over the period of analysis, scenario two is a mixed residential and commercial redevelopment with no relative sea level rise, scenario three is a residential redevelopment with a maximum relative sea level rise depending on location of 2.0-feet over the period of analysis, scenario four is a mixed residential and commercial redevelopment and a maximum relative sea level rise of a 2.0-foot, scenario five is a residential redevelopment with a relative sea level rise depending on location of 3.4-feet, and scenario six is a mixed residential and commercial redevelopment with a maximum relative sea level rise depending on location of 3.4-feet. The detailed evaluation of these scenarios is outlined in the Economics Appendix, and a technical description of the calculation of relative sea level can be found in the Engineering Appendix.

The next step, identified as step three in the planning process, was to develop measures that relate to the planning objectives for this study. A measure is something that can be implemented to directly address a problem within the study area. Some examples of measures include levees and acquisitions for flood damage reduction, beach and dune construction for flood damage reduction and ecosystem restoration, excavation and planting of native species for ecosystem restoration. These measures can be stand alone or may be able to be combined like a system.

For the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Report, multiple measures were developed under structural, nonstructural, and ecosystem restoration categories. The project delivery team applied a screening process based on engineering, environmental, and economic feasibility to narrow the list of viable measures.

The result of the screening was a list of measures that were fully evaluated as compared to the future without-project conditions. These measures were evaluated using the four systems of accounts, outlined in ER 1105-2-100, which include National Economic Development (NED) benefits, Regional Economic Development (RED) benefits, Environmental Quality benefits, and Other Social Effects (OSE). Evaluations of the various metrics that make up these four accounts were conducted using multiple economic programs, expert opinion, and other sources where available. The main economic programs used for the evaluation of measures include the Corps of Engineers Flood Inventory Tool (CEFIT), the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) program, the Beach-fx program, the Institute for Water Resources (IWR) Planning Suite, and the Economic Impact Forecasting System (EIFS). Outputs from these programs were carried forward for the comparison of the measures.

The final two steps of the process include a comparison of measures/plans and the identification of cost effective plans. A comparison of the evaluated measures was conducted using the System of Accounts (SOA) table and the RIDF process developed specifically for the MsCIP and LaCPR studies.

3.6 Geographic Information Systems (GIS) Approach and Analyses

During the MsCIP Comprehensive Study, several Geographic Information System (GIS) software components were used. The GIS software used was created by ESRI and include: ArcGIS, ArcIMS, ArcReader, ArcGlobe, and ArcSDE. ArcGIS is used for analysis of geospatial data; this software allows the user to overlay data and perform analysis on the data. ArcIMS is used in displaying GIS data on the internet; this software allows users to view and query data without having to purchase software or need training to run the software. ArcReader is a GIS component that allows users to look at data on their local computers without having to purchase software and requires very little training. ArcGlobe is the GIS component that allows users to view data in 3D and is great to use when dealing with depths and heights. ArcSDE is the GIS component that is used to store and organize geospatial data.

3.7 Real Estate Analyses

Real estate costs are an important part of evaluating and comparing different measures to solve a problem. The real estate analysis includes descriptions of the minimum real estate requirements for different measures, estates to be acquired for the alternatives, Land costs to include Easements, Rights-of-way, Relocations and Disposal or borrow areas (LERRD's), and schedules for real estate activities. The real estate analysis was conducted in accordance with Corps' Guidance from Engineer Regulations 405-1-12, and from the Code of Federal Regulations, Title 49, Part 24. Other supporting guidance can be found in the attached Real Estate Appendix.

The real estate analysis for this study required a search of the local public records at local tax and county clerk's offices, to obtain data about owners and the types of properties that would be impacted by potential measures. The analysis includes the proposed acquisition of any land rights in privately owned lands that would be required for the building of a structure like a levee, and any other real estate requirements appropriate for the project construction. The acquisition of land rights may be either a partial or complete purchase of a parcel or tract of land, and in an easement or fee simple interest. Relocation assistance for landowners or tenants when structures are impacted is also included in the analysis. For the nonstructural buyout measures, fee simple purchase of lands and structures along with relocation assistance to displaced persons is recommended. Any such

acquisitions of real estate interests and/or relocation assistance for displaced persons are governed by Public Law 91-646.

An assessment was also made of which public facilities would need to be relocated for each measure, including roads, pipelines, utilities, and bridges. The Real Estate Appendix includes information as to the costs and land requirements whether the Government or the local Sponsor would be responsible for the relocation. More detailed investigations of items such as land for borrow areas, pipeline routes, staging areas, etc., will be conducted in a future feasibility study, or studies, if authorized by Congress.

Structural measures, as well as potential Nonstructural buy-out and Ecosystem Restoration sites, all have real estate requirements. Although some measures overlap, each could be constructed as a stand-alone project, and requires a separate real estate cost estimate. The total estimated cost includes land and any associated improvements, relocation payments, and administrative costs to acquire lands and provide relocation assistance services.

The Project Delivery Team (PDT) obtained tax databases for 2005 from the tax assessors' offices in Jackson, Harrison, and Hancock Counties. The team linked this information with GIS “footprints” of the measures to aid in sorting and querying of large amounts of data. These queries were imported into spreadsheets for use by economics, cost engineering, and environmental team members.

Due to the magnitude of the study involving evaluation of approximately 75,000 parcels, a number of assumptions were made in compiling the Real Estate costs. The average number of potentially impacted parcels for the individual interior barrier measures varied anywhere from 320 to over 1,700 parcels. The process originally began by looking at what percentage of each individual parcel might be impacted by the construction of a measure. As changes occurred and more measures were added, it became necessary to discontinue the parcel by parcel analysis and instead make determinations to estimate subsequent real estate requirements based on a percentage factor. Assumptions were also made for when an entire parcel needed to be acquired, and what percentage of structures on a parcel would potentially be impacted by a given measure.

While costs are based on assessed values from the 2005 tax year, an appraiser completed a market study using approximately 135 comparable sales from the three coastal counties. All of the sales used occurred in the first quarter of 2007. From these sales an "adjustment factor" for each county was established. It was found that post Katrina real estate values were approximately double the pre-Katrina values, and the adjustment factors for each county ranged from 1.75 - 2.50 percent. For planning purposes, this adjustment factor was used to bring the assessed values more in line with 2007 "market values".

A Real Estate Supplement (RES) will be prepared for each authorized component once the real estate requirements have been sufficiently identified during a Pre-construction, Engineering, and Design phase (PED). The RES will provide updated information as to final real estate requirements for a particular component and will include updated real estate values and costs. A Real Estate Relocation Plan for displaced individuals and businesses would also be prepared during PED. The Relocation Plan will investigate the availability of replacement housing within a specified radius and any unique or unusual problems that should be considered.

3.8 Costs Estimating Analysis

Rough order magnitude cost estimates have been developed for each of the tentatively selected plan components and comparative alternatives. All cost estimates for a specific plan component/alternative concept have been developed to the same level of detail and include the same level of uncertainty with regard to the precision of the estimate. As discussed below some

estimates are considered to be more advanced in that a selected design may have been available to use in developing the estimate.

In general the cost estimates for structural options are based on conceptual designs. To proceed with initial cost estimates, the structural options were conceptually designed to the selected elevations (i.e. 20 feet, 30 feet, or 40 feet) as described in previous paragraphs. These initial elevations selected for each component of the lines of defense are assumed to bracket a wide range of potential storms with corresponding surge elevations. Using these preliminary designs, rough order of magnitude cost estimates were completed for each of the structural options. These cost estimates can used to develop cost curves for future use to estimate costs after final design elevations are selected. Also, these cost curves, can be used in future studies to select varied levels of risk reduction based on risk assessments as well as taking into account future estimates of sea level rise. Cost estimates include not only the construction costs, but also any real estate and/or environmental costs as appropriate. In some cases the costs of environmental mitigation have been assumed to equal the cost of purchase of lands in mitigation banks. Additional detail is necessary before fully developed costs estimates can be developed. As discussed below, the team has included in the estimate a factor for uncertainity with regards to a number of factors (contingency percentages). Costs for plans and specifications have been included where applicable.

Costs for all the environmental restoration options are also estimated at the same rough order of magnitude type estimate, however unlike the structural options, each option had a selected design and no cost curves are developed. Costs for environmental restoration features are based to the maximum extent on prior efforts by the Mobile District in the Mississippi area (i.e. dredging costs for sand placement on barrier islands; costs for acquiring and installing specific vegetation species). Costs for plans and specifications, monitoring and any additional studies have been included where applicable.

Non-structural costs were generated from spreadsheet summaries of the tens of thousands of real estate parcels assigned to the 54 economic reaches based on available data from county tax data bases. All non-real estate contract costs (demolition or flood proofing) for inclusion into these spreadsheets were completed by cost estimators familiar with these activities and acquisition costs were provided by real estate specialists.

A specific analysis of the uncertainties of the cost estimates is being performed to best define the risks associated with the level of cost estimating used for this effort.

3.8.1 Uncertainty as Related to Construction Costs

Even though a Cost Risk Analysis was not developed for the total project cost estimate, some uncertainties were identified and addressed in developing the Construction Contingency. Such uncertainties identified included (a) lack of geotechnical information, (b) physical size and complexity of project, (c) a number of features of the project not being of conventional design, (d) contract requirements, (e) economy shifts, market forecast, (f) quantities not available; assumptions made based on historical information, (g) exclusion of hazardous, toxic, and radiological waste assessments and escalation cost, and (h) no detailed project scheduling.

Contingency in the construction cost estimates represents an allowance for elements within the project scope that are not included in the detailed estimate. This contingency allowance provides a level of confidence that the cost estimate will not overrun due to unpredicted events. Contingency is not intended to cover such factors as estimating allowances, change in scope, inaccurate projections of inflations, unanticipated regulatory standards, and other external factors (bad weather, strikes, labor disputes).

Based on review of identified uncertainties and the project delivery team's (PDT) judgment, the assumed **risk level** is considered higher than normal. Therefore, a Contingency of 25% was used throughout the cost estimate. Even though ER 110-2-1302 identifies Contingencies at 20% for projects greater than $10,000,000 for recon/feasibility phase, it was determined and agreed upon by the PDT that a higher rate should be used primarily due to higher risk than normal, degree of confidence lower than normal, and many features of the project not being of conventional design.

3.8.2 Uncertainty Relating to the Delineation of the High-hazard Areas for Real Estate Acquisitions

Numerous factors contribute to the uncertainty in Real Estate cost estimates. Estimates were made based on proposed project footprints for which plans and specifications are not finalized. Consequently there may be some variance, either higher or lower, in the total number of parcels impacted for a particular option. It is likely that a parcel which may be considered to be partially impacted by project construction could in fact be avoided when plans and specifications are completed. In addition, the real estate land cost is based on tax values with an adjustment factor for 2007 applied to bring the valuations of parcels in line with market values. Additional adjustments may be required to remain current with market conditions and values as project construction is scheduled.

There may also be a variance in the number of structures projected as being impacted since the footprint of actual structures was not available during the data analysis. Assumptions were made based on the "percentage of impact" to the parcel where a structure was shown in the tax data base. The county data bases, appeared to have a mix of pre-storm and post-storm data which mostly affected structure values. If the tax data included a structure value, an assumption was made that a structure is in existence. However, a site inspection is necessary to confirm the actual existence of a structure. Similarly, a parcel assumed to be vacant as per tax information could have a structure at the actual time of acquisition.

The number of relocations under P.L. 91-646 that are projected relates directly to the number impacted structures, and will increase or decrease proportionately with any increase or reduction in the number of structures impacted. An average cost was used across the project for a "relocation" payment with no distinction being made between relocation of an individual or business. Before implementation of acquisition, a relocation plan will need to be completed to gather more specific information and to prepare a more refined cost estimate.

Administrative costs used in the estimate are based on historical costs per tract for other projects. Although none have been as large as the MsCIP, they are thought to be a sound basis for this project. A contingency of 25% was used throughout for each cost estimate prepared.

3.8.3 Uncertainty as Related to Non-structural Costs

The uncertainties related to the delineation of the high-hazard zones would affect the number of tax parcels selected for permanent acquisition versus floodproofing by elevation. In all cases, parcels lying along that line of demarcation between the two measures would be either permanent acquisition or floodproofing by elevation, therefore any differences in cost could be expressed as the average cost difference between the two measures. In the formulation of the accelerated High Hazard Area Risk Reduction Plan the average homeowner payment for acquisition was calculated to be $143,000. The average cost estimate to raise an existing structure up to 6 feet was $140,000 – a difference of $3,000 between the two measures for any structure along the demarcation line.

The differences in the number of parcels allocated to one or the other of the two measures would affect the relative amounts of cost allocated between the project accounts. Since the lines

delineating the various zones may have not exactly matched the parcel boundaries, there is some inherent inaccuracy in the accumulation of the affected parcels by the GIS database in one or the other of the two categories of measures included in the plan.

The uncertainty surrounding the delineation of the high-hazard areas along the Mississippi coast is based upon three primary components: 1) the accuracy of the FEMA geographic information system (GIS) layer that delineated the VE Zone (Velocity Elevation Zone) on the Flood Insurance Rate Maps for the three counties and municipal areas along the coast, 2) the accuracy of the GIS layer delineated by FEMA in their post-Katrina report regarding the catastrophic damage zone where damages to insured structures exceeded 50%, and 3) the accuracy of a GIS-generated polygon depicting a 800-foot wide buffer zone in Jackson County that mimicked the damage areas observed in Hancock and Harrison counties.

The GIS layers used in the Nonstructural Appendix to delineate the VE and catastrophic zones were taken from FEMA published data. Considering the scales used on FEMA National Flood Insurance Program mapping and the dates of the flood insurance rate maps from which the GIS layers are taken (1970's) it's likely that there are inherent inaccuracies in the GIS layers. Any inaccuracies that may have been inherent in that data have been carried into the Corps document. The construction of the 800-foot wide buffer area was generated and whatever inaccuracies are imbedded in that layer are also within the report database.

3.9 Communication and Collaboration

Collaborative planning requires that the Corps move beyond the Corps interest and embrace solutions that reflect the full range of the national Federal interest. In an effort to fully embrace this, concept steps have been taken to involve all applicable state and Federal agencies in the development of the various measures being considered. The USFWS and NPS have assigned specific individuals to be on staff at the District as they participate on the PDT. Other agencies have identified specific individuals to represent their agencies on all team efforts. Further, the environmental PDT has been communicating on-going effort to the resource agencies. Measures that have been developed relate to activities that cross all boundaries of the Federal government. In particular, plans for the systematic restoration of the Mississippi barrier islands have been developed jointly by the NPS, USGS, NOAA, EPA and the Corps. Collaboration with the State of Mississippi is a critical building block of the MsCIP as we move forward with the long-term restoration of the coast. Elements of this collaboration including sharing personnel and data have resulted in the development of a comprehensive restoration strategy.

Communication among all the stakeholders has been a critical element of the MsCIP. From the inception, the importance of communication is evident with the hiring of a specialty firm to assist in the development of the stakeholder base and the dissemination of information. Group Solutions Inc. has employed a number of innovative techniques to assist in obtaining participation from the largest number of stakeholders possible. The MsCIP communication plan includes the use of public workshops and meetings, meetings with special interest groups including NGOs, web based meetings, and extensive use of the internet to facilitate communication. As a result of the extent of the damage from the hurricanes, a large number of stakeholders have been displaced and every effort has been undertaken to reach these individuals as well as those currently residing along the coast. Although a large amount of effort has been taken to reach the stakeholders (over 30 meetings since April 2006), we are still not satisfied with the participation and will continue to take additional steps as the comprehensive plan develops.

3.9.1 Regional Sediment Management (RSM)

Regional Sediment Management uses the understanding of sediment dynamics (inputs, outputs, movement) to manage sediment resources towards implementing environmental restoration, conservation, and preservation while reducing coastal erosion, storm damages, and associated costs of sediment management. The MsCIP study team is building on RSM relationships, technology, data, and tools; likewise, the RSM program is benefiting from the extension of these relationships, technology, data and tools as well as lessons learned through MSCIP. Prior to the MsCIP project, data and information were lacking along coastal Mississippi. The MsCIP project is providing valuable information and data, and is improving our understanding of the coastal processes, which occur along the Mississippi mainland shoreline as well as the barrier islands. Additionally, MsCIP project's coordination and relationships developed with other Federal agencies, sponsors, and stakeholders will enhance the RSM programs ability to coordinate and implement future RSM strategies in coastal Mississippi.

Formulation of measures and alternatives fully considered the opportunities of applying RSM. Measures formulated consistently considered the beneficial uses of sediment in the larger ecosystem, as well as ways by which sediment delivery or re-allocation could be enhanced to areas of greatest need. This objective was carried through the formulation, evaluation, screening, and selection process.

The State of Mississippi as part of Gulf of Mexico Alliance has acknowledged that sediment resources are integral to accomplishing many restoration initiatives. It is also recognized that there is a need for a better understanding of regional sediment systems and processes to inform decisions about projects and actions that use or affect sediment resources. Mississippi is actively involved in the development of a Gulf Regional Sediment Management Master Plan as an implementation action for the Gulf Alliance Conservation and Restoration Workgroup. The regional sediment management plan will also help link sources of sediment with sediment needs, provide a basis for assessing competing needs for sediment, and foster more cost effective sediment management.

3.9.2 Public and Agency Involvement in the Planning Process

The Corps' 6-step planning process is a structured approach to problem solving that provides a rational framework for sound decision making. The 6 steps consists of: identifying problems and opportunities; inventorying and forecasting conditions; formulating alternative plans; evaluating alternative plans; comparing alternative plans; and selecting a plan. The MsCIP team has made every effort to involve the public and agencies throughout the entire Interim and Comprehensive Plan development. Immediately following Hurricane Katrina, members of the MsCIP team were openly communicating with state, federal, and local agencies regarding their concerns, obstacles, hurricane-related problems, needs, and opportunities. Agencies, educational institutions, and interested individuals have been contacted via phone, e-mail, or public notice, to solicit input, ideas, and constraints to the plan formulation process. A website was developed and maintained as a way of disseminating information and receiving public comments regarding potential issues and their concerns. Over 60 Federal, State and local government agency representatives and other community leaders from business and industry gathered in Biloxi on April 7, 2006 to identify early needs, opportunities and recommendations for the MsCIP process. Many other public and agency meetings have been held in Harrison, Jackson and Hancock Counties to examine a broad range of potential coastal protection options and solicit input on designing comprehensive improvements. Comments received from these meetings have led the team to revise some of the initial proposed measures. Existing and future conditions were identified and projected in coastal Mississippi by Corps, MDMR, USFWS, and the NPS members. On May 7, 2007, the MsCIP team held a public workshop to present additional environmental, structural and non-structural measures. Input provided from these meetings was used during further formulation of the comprehensive plan.

3.9.2.1 Initial Coordination by Mobile District Team

The hurricanes of 2005 caused numerous deaths and untold injuries to local residents and visitors to the area, extensive damage to environmental resources, homes, businesses and industries. Soon after Hurricane Katrina struck coastal Mississippi, the Mobile District made and received contact with local government officials, agencies, and the public regarding the impacts of the storm and conditions on the coast. This interaction was encouraged by the existing working relationships established during the normal water resource activities conducted by the Mobile District and the state and local governments. After the MsCIP authorization, Mobile District multi-disciplined project teams went to each coastal Mississippi county and municipal area to assess damages and needs first hand identifying needs and formulating ideas and opportunities.

3.9.3 Public and Agency Involvement Process

The MsCIP team places a high value on public and agency involvement during development of the Interim and Comprehensive Plans. Participation from Federal and state agencies, local governments, and stakeholders was obtained through an on-going and engaging series of public scoping meetings, public input meetings, agency and stakeholder meetings, web-casts, on-line auditoriums, Federal principals group, vertical teams, regional coordination meetings, in-house USFWS and NPS personnel, MDMR personnel, non-structural road shows, on-site meetings and multi-participant plan formulation.

3.9.4 Public Input and Review of Planning Options: Round One

Planning solutions to water resource problems is not an activity just for engineers and scientists. It also involves homeowners, businesses, environmental advocates, interest groups, and other members of the public as well as people from Federal, State, regional and local agencies. Citizens have the right to participate meaningfully in public decision making processes, and to be informed about the bases for those decisions. In addition, public participation will undoubtedly lead to better decisions. The wisdom needed to solve complex problems is not limited to the technical experts in public agencies. Early and continuing participation by a diversity of interests, including project sponsors, customers, partners and other stakeholders, can provide essential information and insights. Public participation also increases confidence in the planning process and acceptance of its resulting decisions. The following sections show how the public was involved early and often during the MsCIP planning process.

3.9.4.1 Regional Coordination Workshop

A highly interactive Regional Coordination Workshop was held in Biloxi, MS, on April 7, 2006 for a group of state, municipal, county, NGOs, and agency officials. Approximately 200 participants were invited to attend the workshop through letters, e-mails and phone contacts. Approximately 75 individuals participated representing a spectrum of participant groups invited. Participants were asked to provide the Corps guiding principles for MsCIP direction and specific projects that should be included within the two plans (i.e. Interim and Comprehensive) for Congress. Over a hundred ideas were generated at the workshop. The ideas ranged from small local projects to coastal-wide submissions. The MsCIP Team reviewed these ideas or potential projects for consideration as near-term projects in the Interim Report or actions to be considered in the Final Report.

3.9.4.2 Public Workshops

Following the Regional Coordination Workshop, the Corps held 3 Public Workshops; April 10, 12, and 13, 2006. One workshop was held in each of the 3 coastal Mississippi counties, Jackson, Harrison, and Hancock. Invitations to participate in Public Workshops were made through a Mobile District Public Notice sent to standard environmental coordination mailing list, Mobile District press

releases sent to the media, and by Mobile staff contacts. We asked state, county and local officials to help get word of the workshops out to the public.

The purpose of the workshops was to review the ideas already gathered from previous involvement activities and gather additional ideas for inclusion in the MsCIP reports and plans. The workshops



were interactive and non-confrontational. Public participants were polled on project direction and the important principles of recovery that should be used in the plans. The public was invited to review the ideas already submitted and to add additional ideas or creative combinations of existing ideas to the list. Input could be provided via a network of PCs and structured questions. Alternative input opportunities for those uncomfortable or unable to respond via PC were also provided. Comment cards, post-it notes for maps, and a court reporter were available to capture ideas. From the Public Workshops, the list of MsCIP ideas grew to over 180. Again the MsCIP Team reviewed these ideas or potential projects for consideration as near-term projects in the Interim Report or actions to be considered in the Final Comprehensive Report. It should be noted that the residents of coastal Mississippi have been through a terrific ordeal. In some cases, their lives have returned to normal while in others the recovery process is just beginning. These conditions made acquiring public input difficult. Frequent comments were made that people were generally "tired of the storm and tired of meetings about the storm." In spite of that, needs and opportunities for specific areas were gathered from the public.

3.9.4.3 Website and Webcast

As discussed previously, the website (www.MSCIP.usace.army.mil) was established and maintained as a repository of MsCIP information and a different vehicle to allow interested public and agencies to provide comments and ideas including those who were displaced from there homes or could not attend the workshop opportunities. A webcast was created and provided on April 18, 2006 to allow those that could not attend the public workshops and online alternative for participating in the project. The webcast had conference call participation for all callers, a video and PowerPoint presentation delivered through a special webcast, polling, and a question and answer portion with Mobile District staff fielding questions.

3.9.5 Coordination with LaCPR

The MsCIP team took a systematic and regional integration approach with the Louisiana Coastal Protection and Restoration (LaCPR) study team. For a detailed account of this approach, please see the Main Report.

3.9.6 Public Input and Review of Planning Options: Round Two

3.9.6.1 Regional Coordination Workshop

The Round Two, Regional Coordination Workshop was held in Biloxi on April 26, 2006 with similar participants as Round One. The purpose of the Round Two Regional Coordination Workshop was to review the planning options that emerged from the Round One workshops. Prior to the workshop, participants were provided via the MsCIP website a list of ideas that emerged Round One and the screening criteria to be used to recommend near-term projects for inclusion in the Interim Report or retain them for evaluation in the Final Report. There was general understanding of the concept of near-term projects that can be implemented quickly to help in the immediate recovery of coastal Mississippi while the Comprehensive Plan is being developed. The screening criteria and their application to the potential projects were discussed. The Mobile District presented a preliminary, by-county, list of projects to be potentially recommended in the Interim Report. The potential near-term projects were discussed and none recommended for Interim Report received objection. However, participants requested review of a limited number of additional projects for inclusion in the Interim Report. As a result of this discussion, additional projects were considered and at least one additional potential near-term project (Jackson Marsh Restoration) was recommended for the Interim Report. No potential projects were deleted from consideration in the MSCIP, simply deferred to consideration in the Comprehensive Analysis and Final Report. Using these recommendations, the MsCIP team then began developing the structural lines of defense concepts. The MsCIP environmental and non-structural team analyzed environmental benefits anticipated from restoration while the other team assessed flood-proofing techniques.

3.9.6.2 Public Workshops

The Round Two, Public Workshops were held May 1, 2, and 4, 2006. The purpose of the Round Two Public Workshops was to review the planning options that emerged from the Round One workshops and discuss recommendations for near-term projects to be recommended in the Interim Report. The Mobile District presented a by-county list of projects to be potentially recommended in the Interim Report and the screening criteria for selecting those projects. None of the projects recommended for Interim Report received objection. However, participants requested and received clarification regarding why specific potential projects were not recommended as near-term projects. No potential projects were deleted from consideration in the MSCIP, simply deferred to consideration in the Comprehensive Analysis and Final Report. The MsCIP team had another public workshop on December 19, 2006 to present general ongoing efforts and to discuss conceptual solutions for coastal Mississippi. On April 5, 2007, the MsCIP team then presented detailed plans for environmental, non-structural, and structural plans to protect coastal Mississippi from future storms.

3.9.6.3 Web-site and Webcast

A Round Two webcast was created and provided on May 3, 18 to allow those that could not attend the public workshops and online alternative for participating in the project.

3.9.7 Public Scoping

Public and agency involvement has been a critical, early, and continuing part of the MsCIP project. Public and agency involvement accomplished to date has been a multi-step, and multi-component process. Persons and organizations having a potential interest in the proposed action, including minority, low-income, disadvantaged, and Native American groups, have been urged to participate in the environmental impact analysis process.

Scoping can lay a firm foundation for the rest of the decision-making process. Scoping is often the first contact between project planners and the public. The MsCIP team held many meetings prior to the actual formal Public Scoping meeting on 19 December 2006. These initial meetings were held due to the accelerated timeframe involved in preparing the 6-Month MsCIP Interim Report. At the December Public Scoping meeting, individuals presented their concerns to the MsCIP team and also to each other. The issues brought forth included concerns regarding construction of levees, preservation of the natural environment, impacts to natural resources especially wetlands regulatory permits for wetland fill, future growth, potential future storms, and etc. Possibilities and clarifications on initial thoughts were discussed during the Public Scoping meeting. This scoping process led the MsCIP team to think about the proposal early on, in order to explain it to the public and affected agencies. The participants were able to respond with their own concerns about significant issues. Incorporation of public and resource agency input will likely reduce the need for changes after the draft documentation is finished, because it reduces the chances of overlooking a significant issue or reasonable alternative.

4 PLANNING CONSTRAINTS

There are a number of issues that constrain the development of certain potential measures that might be used to address the identified problem set. Planning constraints are limited to laws and regulations that constrain the planning process. Among these include:

- Measures developed must not negatively impact the resources within the NPS's Gulf Islands National Seashore, particularly with respects from those constraints created by inclusion of Horn and Petit Bois Islands as Wilderness Areas;
- Measures developed must avoid, minimize, or mitigate any negative impacts to T&E species identified as residing within areas potentially impacted by study recommendations;
- Measures developed must be consistent with State of Mississippi Coastal Management Plan;
- Measures developed must meet the guidelines directed at maintenance of State Water Quality standards;
- Measures must be consistent with provisions of CWA;
- Measures must be consistent with provisions of NHPA;
- Measures must be consistent with Clean Air Act (CAA);
- Measures must be consistent with the ESA and the Fish and Wildlife Coordination Act (FWCA);
- Measures must be consistent with CBRA;
- Measures must be consistent with EO – Environmental Justice and Protection of Children; and
- Measures must be consistent with the Magnuson-Stevens Fishery Conservation and Management Act as amended by the Sustainable Fisheries Act of 1996.

5 INVENTORY AND FORECAST OF FUTURE CONDITIONS/RESOURCES

As mentioned earlier, six future "no-action" scenarios were developed to evaluate the impacts of plan components over time. The six scenarios were evaluated over a 100-year period of analysis

and include two redevelopment, and four sea-level rise scenarios. The first redevelopment scenario assumes the residential and commercial rebuilding that existed before Katrina will be built back as the same type (residential or commercial). The second rebuilding scenario assumes that a majority of the waterfront properties destroyed will be built back as commercial (i.e. high-rise condominiums). The three relative sea level rise scenarios are comprised of existing sea level, a moderate relative sea level rise, and high relative sea level rise. Scenario one is a residential redevelopment with no relative sea level rise over the 100-year period of analysis. Scenario two is a mixed residential and commercial redevelopment with no relative sea level rise, scenario three is a residential redevelopment with a maximum relative sea level rise depending on location of 2.0-feet over the period of analysis, scenario four is a mixed residential and commercial redevelopment and a maximum relative sea level rise of a 2.0-foot, scenario five is a residential redevelopment with a relative sea level rise depending on location of 3.4-feet, and scenario six is a mixed residential and commercial redevelopment with a maximum relative sea level rise depending on location of 3.4-feet. The detailed evaluation of these scenarios is outlined below, and a technical description of the calculation of relative sea level can be found in the Engineering Appendix.

The first round of inventory and forecast indicated that several future conditions scenarios should be revised. Key among these was the uncertainty of forecasts of future re-development and relative sea level rise. Future relative sea level rise is an especially important factor in defining conditions of the barrier islands, estuarine circulations, water quality, etc. A detailed discussion of relative sea level rise has been provided earlier in this report. As discussed earlier, this was accommodated by the inclusion of sensitivity analysis for both factors, to determine what effect alternative future scenarios might have on benefits, costs, and other considerations, under each scenario.

5.1 Forecasting of Future Re-development: Scenarios

The Mississippi Coast is rebuilding from the aftermath of the storms of 2005. Due to numerous factors (i.e. insurance payments, business opportunities, etc.), the exact rate at which re-development will continue to occur is not known. For this study an approximation was made based on the following assumptions:

- The structures destroyed as a result of Hurricane Katrina will be rebuilt and the population will return to at least pre-Katrina levels.
- Full redevelopment of structures will occur by 2012. Redevelopment is defined as the building back structures that existed before Hurricane Katrina, not development that occurs on land that was undeveloped.
- Redevelopment of the study area could take the form of residential redevelopment (exactly the way it was pre-Hurricane Katrina) or a mixture of commercial/condominium and residential redevelopment.
- FEMA guidelines require minimum heights that the first floor elevation must be built to in order to be included in the National Flood Insurance Program (NFIP). For the purposes of the redevelopment projected in this report, houses that will be rebuilt before the start of 2009 are assumed to be rebuilt to the Pre-Hurricane Katrina Base Flood Elevation (BFE) and those that are rebuilt between 2009 and 2011 will be rebuilt to the Advisory Base Flood Elevation (ABFE) as existed May 2007.
- The surge damage characteristics (by depth) of structures vary by the type of construction and are assumed to be similar to those in the New Orleans area (where this type of data is available). It is also assumed that the duration of surge inundation is approximately 24 hours, which is considered a short-term duration. The depth-to-damage relationships are explained in more detail in the Economic Appendix.

- A depreciated replacement cost of structures was used unless a structure was destroyed fifty percent or more due to surge from Hurricane Katrina. For those structures damaged fifty-percent or more and must be rebuilt, the full replacement cost was used to denote the value in the structure inventory.

Redevelopment is anticipated to occur as follows:

Table 18.

Redevelopment Assumptions

Assumptions of Structure Redevelopment by Year

Year	Percent Redeveloped	Height of Redevelopment
2005	N/A	Hurricane Katrina Landfall (August 29th)
2006	10%	Pre-Hurricane Katrina Base Flood Elevations
2007	25%	Pre-Hurricane Katrina Base Flood Elevations
2008	40%	Pre-Hurricane Katrina Base Flood Elevations
2009	60%	Advisory Base Flood Elevations
2010	80%	Advisory Base Flood Elevations
2011	100%	Advisory Base Flood Elevations
2012	Full Redevelopment	Base Year

5.2 Forecasting of Relative Sea Level Rise: Scenarios

In addition to redevelopment, relative sea level rise could also impact solutions (and decisions) to the water resource problems being evaluated along the Mississippi coast. The following scenarios were evaluated to account for relative sea level rise:

- Baseline. This is the current condition (or existing sea level) from where all other scenarios would be measured. This condition, although unlikely, must assume no further sea level rise (or land subsidence)
- Medium. This scenario assumes a relative sea level rise of about 2.4 feet over the 100-year period of analysis and is consistent with current Corps policy.
- Increased. This scenario assumes a relative sea level rise of about 3.4 feet over the 100-year period of analysis. This represents a reasonable upper bound of what could happen over the life of the project.

Because the scenarios are so wide-ranging geographically, and so dramatic in some reaches and not in others, one may need to examine the detailed results of the potential damage functions contained in the Economic Appendix to see what effect adding two feet, for instance, has on the number of structures that would be inundated in a given area, for a given event, and of a given frequency in 2012, versus those that would be inundated in Reach X for an event of a given frequency in 2111 (i.e., illustrating the differences over the 100-year planning horizon). There are few general statements, or statements that apply to the entire coast, that can be made for relative sea level rise. The single statement that applies is that sea level rise over the period of analysis, be it 50-year (used for evaluation of ecosystem restoration measures) or 100-year (used for storm damage reduction measures), would cause more damage over time, for an event of a given frequency. This is illustrated in Figure 9, below, which shows the increase in average annual damages for Hancock County, using 3 relative sea level rise scenarios.

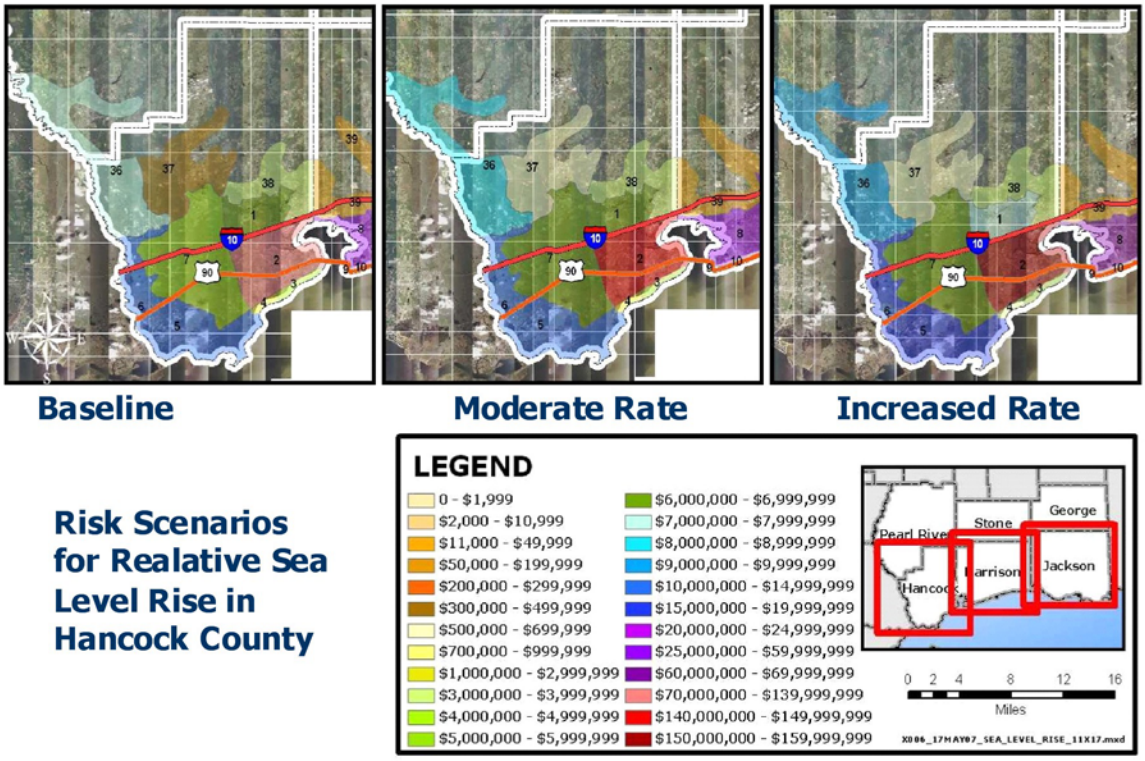


Figure 9 – Hancock County Annual Average Surge Damages by Sea Level Rise Scenario

It should be noted that the global debate over sea level rise is ongoing and the Corps will continue to design using the most up to date data available.

5.3 Preliminary Screening of Problem Areas

Following the initial identification of sites and problem areas, a preliminary screening analysis was conducted. Key to the success of this effort was the need to screen problem areas or sites that did not satisfy a link to:

- The problem being caused or exacerbated by the hurricanes of 2005;
- Based on the professional judgment of the study team that the problem area could not recover on its own;
- Congress' provided areas of investigation (storm damage reduction, erosion, fish and wildlife preservation [ecosystem restoration], saltwater intrusion, or related water resource issues;
- Ecosystem significance (scarcity of resource), from a national or regional perspective; and
- Being technically or environmentally feasible.
- Already being addressed by others.

The list of problem areas and sites screened as part of this process are shown in Table 19 below.

Table 19

Preliminary Screened List of Problem Areas

#	Name	Problem_Resolution/Status
1	Coastal Mississippi Hurricane Evacuation Plan	1. FEMA "Intergrated Public Alert and Warning System" update 2. State of MS. "Comperhensive Emergency Management Plan" update
2	Coastal Mississippi Artificial Reef Project for Remediation of 2005 Hurricane Damage	Mississippi Department of Marine Resources
5	USE selected levels of rip-rap instead of bulkheads for erosion control	Local Govermental Intities
7	Provide 100 acres of oyster reef restoration	MsCIP Interim & Comprehensive - Partnership with MDMR
8	Work with State to authorize transfer of development rights in state statutes	State of MS
9	Include repair standards in building codes	Local Govermental Intities
10	Dredge access channels to existing public marine industry and recreational boating	1. USCG clearing dredging tidal channels 2. FEMA evaluating remaining channels for debris and sediment removal
13	Form a monitroing network network that will survive and function throughout a major storm to provide data that is critical to emergency managers	FEMA "Intergrated Public Alert and Warning System" update
14	Provide an incentive for replacing failing septic systems in rural areas to improve water quality along bayous and bays.	1. Section 592 Program 2. State Regional Water and Wastewater Authority
17	Complete snagging/clearing, etc. to restore the capacity of existing drainage.	1. MsCIP, four Interim projects and recommendation for Forrest Heights 2. Jackson County Permitted for six drainage ways 3. FEMA evaluating remaining channels for debris and sediment removal
18	Repair existing bulkheads or other structural drainage components that were damaged during the storm to reduce future failures during similar events.	1. MsCIP, two Interim projects- Jackson Marsh, Courhouse Road 2. FCCE, Harrison County Beach project 3. City of Pascagoula has repaired
19	Maximize Beneficial Use of Dredge Materials	1. MsCIP Barrier Island recommendation 2. FCCE, Harrison County Beach project
20	Consider brown water system to minimize demand on ground and surface waters and limit saltwater intrusion.	USEPA
21	Re-establish Benchmark Information Coastal-wide	FEMA
22	Relocate wastewater treatment facilities out of the surge-prone areas	State Regional Water and Wastewater Authority
23	Inspect and Rehabilitate Wastewater and Piping Systems	State Regional Water and Wastewater Authority
28	Barrier Isalands - Remove hazardous materials	Other
30	Barrier Islands - Protect From Spills	Other
31	Barrier Islands - Evaluate Sediment Transport - Ensure sand minimg does not Impact Islands	1. MsCIP Barrier Island recommendation 2. MsCIP/ERDC Sediment Budget evaluation

#	Name	Problem_Resolution/Status
34	Partnership Efforts with Louisiana to Marsh Island Areas	LaCPR Comprehensive
37	Provide protection for public facility (i.e., WW treatment plants).	1. State of MS Regional Water & Wastewater Authority via FDA funds. 2. MsCIP LOD-4 recommendation
38	Bay St. Louis Downtown HSDR	MsCIP Interim Project
39	Cowand Point Seawall Erosion Control	MsCIP Interim Project
40	Hancock County Beach Ecosystem Restoration and HSDR	MsCIP Interim Project
41	Clermont Harbor Seawall HSDR and Erosion Control	MsCIP Interim Project
42	Hancock County Comprehensive HSD - Ecosystem Restoration	MsCIP Interim & Comprehensive Echosystem Restoration Recommendation
43	Jackson Wetland Restoration	MsCIP Interim Project
44	Bayou Caddy Shore Protection and Ecosystem Restoration	MsCIP Interim Project
46	Lakeshore Beach Ecosystem Restoration	State of MS - Environmental Concerns - Potential SAVs
48	Hancock County Communities Flood Damage Reduction	MsCIP Interim Project
49	WhiteÆs Road Evacuation Route Protection	State of MS. "Comperhensive Emergency Management Plan" update
55	Restore more natural freshwater flows by closing the MRGO	USACE-MVN is funded to close MRGO
56	Remove storm debris (i.e., demolition debris carried in by surge retreat) from aquatic environments. Restore traditional shrimping and fishing areas rendered un-trawlable by storm debris.	1. City of Pascagoula funded to construct Boardwalk 2. MsCIP to construct Beach along entire sound-front from city park westward 3. MsCIP Environmental Restoration recommendation
57	Ferries to Temporarily Replace Bridges.	State of Mississippi, Bridges Repaied
59	Restore Hancock County Beaches to Pre-Katrina conditions	1. MsCIP Interim Project Dunes Only
60	Widen Hancock County Beaches, jump-start dunes	1. MsCIP Interim Project Dunes Only
61	Preserve Bayou Caddy Area	MsCIP Interim Project
62	Protect Hancock County wetlands from filling for development	1. MsCIP Envronmental restoration recommendation 2. MsCIP Regulatory Collaboration
63	Construct a N/S rail link connecting Port Beinville Industrial Park to the Norfolk and Southern Railroad through Stennis Buffer. Hurricanes cause CSXT rail outages which cost > $20,000/day	State of Mississippi and Congressional Representatives
64	Open the east Pearl River channel so it can be used by commercial marine traffic from Port Bienville	USCG

#	Name	Problem_Resolution/Status
66	Mississippi Coastal Pump Station Inundation Protection	1. State of MS Regional Water & Wastewater Authority via FDA funds. 2. MsCIP LOD-4 recommendation
68	Mississippi Coastal Barrier Island Restoration	MsCIP & NPS Barrier Island restoration recommendation
69	Mississippi Coastal Improvement and Hurricane Storm Damage Reduction Program	Mississippi Department of Marine Resources
70	WhiteÆs Road Evacuation Route Protection	FEMA evaluating remaining channels for debris and sediment removal
71	WhiteÆs Road Evacuation Route Protection	FEMA evaluating remaining channels for debris and sediment removal
72	Harrison County Beach Ecosystem Restoration and Erosion Control	MsCIP Interim Project
73	Long Beach Harbor HSDR	Harrison County Beach Authority
74	Highway 90 û Rodeburg to St. Charles St. HSDR and Flood Control	State of Mississippi DOT
75	Pass Christian Harbor HSDR	Harrison County Beach Authority
78	Gulfport Commercial Harbor	State of Mississippi Port Authority
80	Turkey Creek Flood Damage Reduction	1. MsCIP Forrest Heights Levee Recommendation 2. MsCIP Regulatory Collaboration 3. MsCIP Interim Project at Long Beach
81	North Gulfport Interior Drainage	1. FEMA evaluating remaining channels for debris and sediment removal 2. MsCIP Interim Project at Long Beach
82	Long Beach Interior Drainage HSDR (includes Canals 2 - 3)	MsCIP Interim Project
83	Harrison County Industrial Seaway Harbor of Refuge	State of Mississippi
85	Courthouse Road Wetlands Ecosystem Restoration and Preservation	MsCIP Interim Project
91	Extend South Side of Deer Island. Extend 200 yards to repair breach in island and restore original footprint of island.	SAM FCCE Project
92	Deer Island enhancements. Cap shell middens on western side of the island and restore top soil in maritime live oak forest	Section 528 Construction General & FCCE Funds
93	New Sewage Treatment Plant in Woolmarket Lagoon Area - Move the Woolmarket Lagoon to north of I10 north of the area. would protect the citizens by moving the sewage from the flood prone areas:	State Regional Water and Wastewater Authority
94	Flood-Proof Existing Infrastructure	State Regional Water and Wastewater Authority
95	Enhance Lee and Bayview Docks for commercial shrimpers.	Other Local and State Entities
96	Enhance Maine Street Docks for commercial shrimpers.	Other Local and State Entities
98	Develop Concrete Staging Center in Industrial Canal. Develop Harrison county industrial canal artificial reef staging area to stockpile concrete debris for oyster reef and other useful projects.	MDMR and MsCIP Comprehensive - Partnership with State

#	Name	Problem_Resolution/Status
99	Restore or enhance Mississippi oyster reefs.	Mississippi Department of Marine Resources
100	Open hw 90 Bridges quickly	State of Mississippi DOT - Bridges are Open
101	Utilize HW 90 bridge as artificial reef material	State of Mississippi DOT
103	Economic Development of Downtowns. Orderly expansion of municipal harbors along with revitalization of downtowns would provide green space; non-water dependent retail, and a manageable beach blvd. (NOT HW 90).	State of Mississippi, Governors Renewal Initiative State of Mississippi Port Authority State of Mississippi DOT Alternate Hwy 90 proposal
105	Complete the purchase of “optional” Cat Island for inclusion into Gulf Islands Nationals Seashore	National Park Service
106	Rebuild the Harrison County boardwalk with concrete to accommodate pedestrians, BICYCLES, and possibly street vendors.	Harrison County Beach Authority
107	Provide inland marine vessel storm shelter location with adequate moorings.	State and Local Entities
113	Reconsider dioxin cleanup on navy base post Katrina.	USEPA
114	Long Beach Interior Drainage HSDR (includes ôCanals 2 - 3)	MsCIP Interim Project
115	Reduce toxic exposure which exacerbates storm damage – Dioxin, Creosote, Titanium Dioxide, Gypsum.	FEMA evaluating area regarding hazardous materials
116	Turkey Creek watershed Greenway	MsCIP Comprehensive Future Studies and Gulf Coast Trails
117	Forrest Height Levee :- Restore; Vegetate with native species; Footbridges; Nature trail atop	1. MsCIP Forrest Heights Levee Recommendation 2. Rivers, Trails and Conservation Assistance Program
118	Dredge shoaled channels hinfering storm evacuation	FEMA evaluating remaining channels for debris and sediment removal
119	Dredge shoaled marinas	US Coast Guard
120	Deer Island re-nourishment of south side.	SAM Project Section 528
122	Possibly add height to the existing beach elevation and redevelop lost dune vegetation.	1. MsCIP Interim Project 2. SAM FCCE Harrison County Beach Restoration Project 3. MsCIP Comprehensive, LOD 2
123	Flood-proof low-lying sewer treatment plants. Lift stations and wells and their electrical and electronic controls.	State of Mississippi Regional Water and Wastewater Authority
128	Shearwater Bridge Erosion Control	MsCIP Interim Project
131	Pascagoula Beach Blvd. Restoration	MsCIP Interim Project
133	Beach Boulevard Erosion Control	MsCIP interim Beach Project
135	Chicot Road Flood Damage Reduction	City of Pascagoula
138	Upper Bayou Cassotte Flood Damage Reduction	MsCIP Interim Project
142	Greenwood Island Ecosystem Restoration	State of Mississippi
146	Old Spanish Trail Comprehensive Flood Damage Reduction/Drainage	1. MsCIP Comprehensive - Non-Structural/SDSS for further evaluation

#	Name	Problem_Resolution/Status
		2. FEMA evaluating remaining channels for debris and sediment removal
147	Old Spanish Trail Comprehensive Flood Damage Reduction	FEMA evaluating remaining channels for debris and sediment removal
148	Old Spanish Trail Comprehensive Flood Damage Reduction	1. MsCIP Interim Project 2. NRCS Recovery Project
150	Franklin Creek Floodplain Restoration/Franklin Creek and Pecan Hydrology Project	MsCIP Interim Project
152	Gautier Hurricane Storm Damage Reduction and Ecosystem Restoration/Ladnir Rd	1. MsCIP Interim Project 2. Coast Guard Dredging Project 3. FEMA evaluating remaining channels for debris and sediment removal
153	Bayou Chico Beach HSDR/Bayou Chico Bulkhead Rehabilitation	Local Governmental Entities
154	Round Island Ecosystem Restoration/Round Island Lighthouse Relocation	State of MS
155	Upper Old Fort Bayou Comprehensive Flood Damage Reduction/ C. Byrd Road Drainage	1. MsCIP Comprehensive - Non-Structural/SDSS for further evaluation 2. FEMA evaluating remaining channels for debris and sediment removal
156	Upper Old Fort Bayou Comprehensive Flood Damage Reduction/ C. Byrd Road Drainage	1. MsCIP Comprehensive - Nonstructural/SDSS 2. FEMA evaluating remaining channels for debris and sediment removal
157	Pascagoula beaches, offshore breakwater/dunes/reefs/marshes to dissipate wave energy	MsCIP Intreim Project
158	Restore natural drainage ways upper Bayou Castelle (vic Fishhawk Rd, Meadow Dale Dr., Longwod Dr, and Bayou Castelle Dr)	1. MsCIP Comprehensive - Nonstructural/SDSS 2. FEMA evaluating remaining channels for debris and sediment removal
159	Restore natural drainage ways upper Sioux Bayou (vic Laville Subdivision and Westgate Subdivision)	FEMA evaluating remaining channels for debris and sediment removal
160	Restore natural drainage ways upper Mary Walker Bayou (vic Northwood Hills, Rolling Meadows, and Bayou Oaks subdivisions)	FEMA evaluating remaining channels for debris and sediment removal
165	Pascagoula Beach Restoration. Dunes, grasses, trees, with intermittent pockets of sand beach	MsCIP Interim Project
166	W Land Lake Pascagoula. Dredge to recover retention qualities and install new drainage pipes to north.	FEMA evaluating remaining channels for debris and sediment removal
168	Study same as 58	FEMA evaluating remaining channels for debris and sediment removal
169	11th St Bridge and Drainage Canal. Bridge is failing and canal walls are caving in.	Jackson County Road Repair
170	Drainage improvements - same as 65	FEMA evaluating remaining channels for debris and sediment removal
171	Old Mobile Hwy Bridge Failing	Jackson County Road Repair

#	Name	Problem_Resolution/Status
172	Bridge at Old Mobile Highway and Hospital Road is Damaged	Jackson County Road Repair
173	Restore Bates St Drainage to Open Water	FEMA evaluating remaining channels for debris and sediment removal
174	Inspection & Rehabilitation of Sewer and Storm Piping for Pascagoula	MVK Section 592 Program
175	Relocate Pascagoula WWTP out of surge area	State of Mississippi Regional Water and Wastewater Authority
176	Re-establish benchmarks Pascagoula city-wide	FEMA
177	Pascagoula brown water system study	State of Mississippi Regional Water and Wastewater Authority
178	Pascagoula Beach Blvd. Restoration (Boardwalk, beach, and marsh addition along Pascagoula front beach)	1. MsCIP Interim Project 2. City of Pascagoula Renewal Project
179	11th St Bulkhead Rehab	City of Pascagoula
180	Pascagoula main drainage system restoration including additional wetland side storage. City-wide retention/detention system. Drain barrier valve system.	1. MVK Section 592 Program 2. State of Mississippi Regional Water and Wastewater Authority 3. MsCIP Comprehensive - Nonstructural/SDSS for wetland Evaluation
181	C. Byrd Road Drainage	1. MsCIP Comprehensive - Non-Structural/SDSS for further evaluation 2. FEMA evaluating remaining channels for debris and sediment removal
183	Use jetties to prevent sediment flow clogging channels	Local Governmental Entities
186	Dredge/clear area in front of beachfront outfalls.	1.MsCIP Interim at Pascagoula 2. MsCIP Comprehensive, LOD 2 at Ocean Springs
188	Improve the Jackson-county seawall. Provide additional county-wide seawall construction, boardwalks, beach construction, marsh construction, or a combination of these elements	1. Mississippi Rebuild Renew Initiative 2. MsCIP Interim Projects
189	Gautier improvements to drainage. Same as 158.	1. MsCIP Comprehensive - Nonstructural/SDSS 2. FEMA evaluating remaining channels for debris and sediment removal
190	Gautier, drainage improvements. Same as 159	1. MsCIP Comprehensive - Nonstructural/SDSS 2. FEMA evaluating remaining channels for debris and sediment removal
191	Bayou Outlets on the Mississippi Sound that require actions to remove deposited siltation	1. MsCIP Interim Project 2. Coast Guard Dredging Project 3. FEMA evaluating remaining channels for debris and sediment removal
192	Gautier improvements to drainage. Same as D.	FEMA evaluating remaining channels for debris and sediment removal
193	Dredge Davis & Simmons Bayous to include all connecting bayous to help prevent flooding.	FEMA evaluating remaining channels for debris and sediment removal
194	Rebuild and enlarge Marsh Island	State of Mississippi

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6 FORMULATION ROUND ONE

After narrowing the list of problem areas, the MsCIP study team developed potential problem-solving measures. The initial measures were developed independently within the structural, environmental, and nonstructural sub-teams and then later evaluated by the entire group. These potential measures were also solicited at each of the Regional Coordination, agency, and public workshops, and through detailed discussion with the entire study team. In order to not short-cut the planning process, and to ensure that good ideas were allowed to proceed through the process, a simple definition of a potential *measure* was provided to the team members, as "a feature or activity at a particular site". This definition was reiterated over and over to the formulators of measures, as the team progressed through this phase and following phases of formulation.

Formulation of measures to reduce storm damage, reduce coastal erosion, restore damaged ecosystems, or deal with saltwater intrusion, generally fell under the category of *Engineering solutions* in the case of the first two issues, or under the category of *Environmental solutions*, in the case of the last two issues.

6.1 Development of the No Action Plan

NEPA regulations (40 CFR 1502.14(d)) require that no action always be considered a viable alternative in any final array of plans. The no-action plan is the default choice. The planning process is built on the default assumption that the Corps should do nothing to address the problems and opportunities. The Corps should become involved in a project only if it is better for society than doing nothing. Hence, the planning process must convincingly demonstrate that involvement in some project is preferred over no action by the agency. In other words, one should not overlook the importance of the first decision to be made at this step, should something be done? The "no action" alternative is the same as the 'without project' condition described in more detail in the Main Report.

The most notable adverse changes that would occur as a result of no actions being taken are within the areas of flood damages and fish and wildlife. It is anticipated there would be little or no change within the existing soils, sediments, climate, air quality, water supply, and geology of coastal Mississippi. Due to the current rebuilding throughout the coast, slight increases in noise could occur during rebuilding construction activities. It is anticipated that these disturbances would be temporary and have only minor impacts to the community.

The wetland community will likely suffer the most significant impacts under the no action alternative. A large amount of exotic specie vegetation has been colonizing parts of coastal Mississippi following the storms of 2005. Hurricane Katrina left extensive debris fields and sedimentation in the area destroying many native trees and vegetation. Due to the loss of the native species, this area has experienced a severe infestation of the invasive Chinese Tallow tree, which is invading the marshes and adjacent flatwoods. The native species of wetland vegetation act as filters removing pollution from runoff, and allow these areas to act as natural buffers improving water quality, storing floodwaters, and reducing erosion. Exotic species, however, outcompete the native vegetation so that it negatively alters the hydrology of the wetlands, reduces the available food source for fish and wildlife, and degrades the entire wetland community by impeding the natural biogeochemical process. Exotic vegetation would continue to persist under the no action alternative, and eventually worsen.

It is anticipated there would be a slight recovery of the vegetation within various habitats such as dune plants, emergent marshes, and pine savannah wetlands under the no action alternative, but these areas would also generally degrade over time. Further fragmentation of once contiguous

wildlife corridors in the northern reaches of the study area will also continue to occur as new development continues to move further away from the coast.

Tidal habitat for fish and wildlife (i.e. barrier islands, marsh habitat, wet pine savannah, etc.) may also be adversely impacted under the no action alternative. Many marine species depend on sea grass beds that were destroyed during Hurricane Katrina for foraging opportunities and cover. An increase in saltwater intrusion will continue to degrade the estuarine environment of the Mississippi Sound. Examples of the species that are dependent on this type of habitat are oysters, shrimp, crabs, finfish, coastal shore birds, and sea birds.

Many threatened and endangered species (i.e. Sandhill Crane, piping plover, etc.) could also be adversely impacted under the no action plan. Their continuing loss of habitat could occur as development and further degradation occurs.

With no Federal action, the city's municipal services would not likely be relocated and the badly damaged or uninhabitable structures would have to be reconstructed in the same area as funding becomes available. It would also likely result in changes to existing land uses. The city of Biloxi in Harrison County is experiencing record number building permit requests for waterfront development, such as condominiums and commercial businesses. In fact, the number of building permit requests has increased to about six times more than prior to Hurricane Katrina. While over time the building rate should level off, building is still likely to continue under the no action plan, even into areas that are not suitable to support development.

Significant impacts to the cultural resources would likely occur under the no action alternative. Archaeological and architectural studies along the Mississippi Gulf Coast have documented the destruction caused by natural forces, most notably hurricanes. Standing structures are often the most dramatic and visible witnesses to this destruction. However, prehistoric and historic archaeological sites are also extremely vulnerable. Shell middens, found along the immediate shoreline and within coastal marshes and estuaries, often are flipped and re-deposited by the storm surge and wave action of hurricanes. This effectively destroys much of the value of the sites. Historic Indian villages and historic town sites, such as those along the bluff on Bay St. Louis, could be destroyed by continued exposure to wave action. In addition, post storm activities offer many more mechanisms for site destruction. These include clearing of timber by use of skidders and other heavy equipment, debris removal, and reconstruction. The destructiveness of these activities is well documented from the years following hurricane Camille which struck the area in 1969. Hurricane Katrina has been documented to have destroyed a vast majority of the standing historic properties within Hancock County, and a large number of those within Harrison and Jackson Counties. Future storms will likely continue this trend under the no action alternative. For a more detailed discussion on storm surge damages, please see the Economic Appendix.

6.2 Development of Storm Damage Reduction and Erosion Reduction Measures

Examples of preliminary measures for storm damage reduction, supplied by the study team, agencies, and public, included:

- Levees, seawalls, or embankments (barriers to surge);
- Gates, berms, and breakwaters (barriers to surge);
- Elevating structures (elevation above inundated area);
- Acquisition and removal from high-risk areas (removal from high-risk inundation zones);

- Zoning and Building Code modification (removal of the most damageable or critical infrastructure or services from highest risk areas);
- Floodplain Management (removal of the most damageable or critical infrastructure or services from highest risk areas);
- Moving back from the shoreline (removal of the most at-risk development, most damageable or critical infrastructure, or services from highest risk areas);

Examples of preliminary measures for erosion reduction, supplied by the study team and public, included:

- Placement of additional sand;
- Placement of harder erosion-control features, such as shell materials, construction debris, rubble, stone, geo-textiles;
- Supply of additional sand to littoral zone;
- Reduction of sand-robbing activities in the near-shore or barrier island zones.

Additional measures were added later, as more factual information became available, and as more input was provided and more technical results became available.

6.3 Development of Ecosystem Restoration, Preservation of Fish and Wildlife and Saltwater Intrusion Reduction Measures

Examples of preliminary measures for ecosystem restoration and fish and wildlife preservation, supplied by the study team and public, included:

- Removal of sediment and/or debris, choking streams and estuaries;
- Re-grading to historic conditions and topography;
- Removal of invasive species;
- Removal of dead vegetation, deadfalls, and other vegetation that interferes with natural functions;
- Planting of native species in areas in which those species were killed by the hurricanes; and
- Filling of drainage channels that interfere with natural functions.

Examples of preliminary measures for saltwater intrusion (actually encroachment into a freshwater body) reduction, supplied by the study team and public, included:

- Reallocation of freshwater supply by re-regulation of reservoirs and
- Diversion of freshwater sources to direct more freshwater into areas of critical need.

The list of potential measures that applies to each site was crafted to that specific site based on its characteristics. More detail is provided on the list of potential measures within its appropriate appendix.

Formulation of these preliminary measures was also based on consideration of both what resources it would reduce damages to (i.e. - targeted developed areas of the coast or targeted ecosystem

features), as well as the potential negative outcomes it might cause (i.e. - induced flooding). All of the structural measures were also formulated in such a way that they could be laid out as either stand-alone concepts, or as components of a multi-featured plan for a given area (i.e. – structural, nonstructural, or ecosystem restoration plan).

6.4 Evaluation of Measures: General Discussion

Each problem area or site was then evaluated to determine the level of effort required for more detailed development of solutions, the need for more rigorous technical analyses (such as detailed modeling), the need for more detailed environmental analysis related to its implementation and long-term effects, such as the potential for impacts to sensitive, threatened or endangered species or habitats, and a host of other factors. Evaluation at this phase of study was based on discussion between study team members and technical experts, on the results of preliminary modeling of potential storm surge, for instance, or, in the case of ecosystem restoration, calculation of potential improvement output, to determine the relative potential damage reduction or environmental output improvement achievable, and problems encountered or solved.

6.5 Evaluation of Storm Damage Reduction and Erosion Reduction Measures

Early evaluation indicated many areas of the coast that are not highly developed, and other areas that contain significant obstacles to formulation of structural measures. Many areas were found to be extremely difficult to reduce damages when using structural measures, compared to areas such as those in certain areas of Harrison County, where the entire coastline is densely developed, but have lesser degrees of environmental resource concentration. Many outlying areas were found to require individual means to achieve storm damage reduction.

Almost any problem area or site along the Mississippi coastline was found to have environmental considerations that required adjustment or modification of formulated structural measures to address those concerns. However, in Jackson County, the Pascagoula River system separates the city of Pascagoula from most of the coast to the west. This river system with its vast marshes areas is one of the last major free-flowing rivers in the southeast, and has numerous environmental resource concerns. In the western portion of the state, extensive mashes create other concerns along with the Pearl River that separates Mississippi from Louisiana. Other technical issues also made structural damage reduction in these areas problematic.

Review of the coastline in Mississippi using aerial photographs, topographic maps, LIDAR surveys, and storm inundation data revealed that natural topography could play a major role in forming storm barriers. Other features such as the offshore barrier islands, extensive beaches in many areas, and existing beach-front roadways were also determined to have a substantial role in potential damage reduction. The modeling also indicated that the high ground followed by the CSX Railway crossing the entire state near the coast, functioned as a barrier to surge during Katrina, and thus, should be considered as a potential inland barrier during future events.

Review of the inundation maps generated during the surge modeling of Katrina and other events also indicated that the extensive low-lying areas associated with two bays that extend inland from the coast would require more refined methods than a simple barrier, to solve the surge inundation issue. It was apparent that any continuous storm protection systems would have to consider these as breaks in the line. Closing off rivers and bays with surge gates have been used in Europe to protect inland areas and different designs of gate structure had to be evaluated and considered in the development of comprehensive plans for coastal Mississippi.

6.6 Evaluation of Ecosystem Restoration and Saltwater Intrusion Reduction Measures

The following four models were utilized by the MsCIP environmental PDT to evaluate the performance of potential ecosystem restoration measures:

- Mississippi and Alabama Gulf Coast Tidal Fringe HGM;
- Wet Pine Savannah HGM;
- FHI Model for Evaluation of Coastal Maritime Forest/Beach-Dune Habitat; and
- GIS-tool Wetland Restoration SDSS Model.

The HGM and FHI models are discussed in more detail in the Environmental Appendix.

In addition to HGM and FHI, a SDSS model, which related areas of hydric soils and other factors related to long-term survivability of a wetlands resource, was also used as a formulation, evaluation, and ultimately, screening tool. The SDSS model scales and combines multiple GIS layers for the purpose of identifying and evaluating potential wetland restoration sites within the three coastal counties. The results of the model were used in conjunction with local expertise to evaluate potential wetland restoration areas.

The results of the HGM modeling were used for functional assessment of existing and future "without-project", and also preliminary "with-project" measure assessment, of both tidal fringe wetlands and wet pine savannahs habitats. The tidal fringe HGM model was also used to evaluate impacts to tidal fringe wetlands that would result from levee alignments including various ring levee alignments. The functional assessments helped to determine mitigation requirements for unavoidable wetland impacts by structural components of the comprehensive plan. The wet pine savannah HGM allowed the team to assess impacts to wet pine savannah habitats at several of the recommended environmental sites.

The results of the FHI modeling was used for functional assessment of existing and future "without-project", and also preliminary "with-project" measure assessment, of all potential coastal maritime forests/beach-dune habitat restoration measures.

Future with-project condition scores, established by the study team's modeling analysis of the specific functions that would be modified, either positively or negatively, at each site, plus "No-Action", existing and future "without-project" score, are shown in the Environmental Appendix, by site or problem area.

Evaluation of saltwater intrusion reduction methods involved the investigation of freshwater diversion measures at several locations. These would divert freshwater from the Mississippi River or other sources as a mechanism to promote a reverse of the recent increases in salinity in the Mississippi Sound/Biloxi marshes areas. This would support fresher marshes and oyster reef health and productivity, thus enhancing both their economic value and the ecological services they provide.

In an effort to initiate the proper evaluation of freshwater diversions, a water quality model (WQM), which is based on the CE-QUAL-ICM water quality model code, is coupled to output from a three-dimensional hydrodynamic model of the region, which is based on the CH3D hydrodynamic model. The version of CH3D with sigma coordinate in the vertical dimension is being used. The model grid extends seaward beyond the Chandeleur Islands and includes Mobile Bay, Lake Borgne, Lake Pontchartrain, the Inner Harbor Navigation Channel of New Orleans and the Mississippi River Gulf Outlet Channel. Predicted water quality constituents, including nutrients, phytoplankton, dissolved

oxygen, temperature, salinity, and underwater light intensity were evaluated for several scenarios and compared to modeled existing baseline conditions to assess relative changes.

The WQM was applied at three locations: (1) a diversion of freshwater flow from the Mississippi River at Bonnet Carre' spillway, (2) a diversion of freshwater flow from the Mississippi River at Violet Marsh, and (3) a diversion of all of the Escatawpa River flow into Grand Bay. The modeled release of water at the Bonnet Carre' diversion was varied by month, and the Violet Marsh model was designed to have a constant flow. The Escatawpa diversion was modeled after the flow that occurred in the Escatawpa River during 1998. The WQM was applied for the period April through September 1998. The hydrology model was run with the same conditions as used for the base conditions used in the WQM calibrations for 1998 except that the additional freshwater flows were introduced.

6.7 Comparing Measures: Formulation Round One

Each preliminary measure (potential solution, activity, or feature) for each problem area or site was then compared to other measures developed for that site or problem area. Again, comparison at this phase of study was based on discussion between study team members and technical experts, to determine the *relative* potential damage reduction or environmental output achievable, and problems encountered or solved, particularly in comparison with the "No-Action" Plan, or the condition in which no action is taken to solve as problem or provide the means for improvement of a given degraded condition or set of circumstances.

Comparison of structural and non-structural damage reduction measures, and erosion control measures, was done by comparison of their relative ability to reduce damages, with consideration given as to their potential environmental mitigation requirements or negative impacts, potential costs, and other potential issues. Comparison of ecosystem restoration measures, and saltwater intrusion measures, by the means discussed in the immediately preceding sections, was done by comparison of their relative ability to achieve the previously-discussed criteria, as well as their potential costs, and potential environmental outputs as compared to the "No-Action" Plan.

6.8 Screening Measures: Formulation Round One

6.8.1 Initial Screening Criteria

After the preliminary screening of problem areas and sites, and development and evaluation of measures was developed for each problem area, the list of problem areas and sites was then screened based on the input of the inter-disciplinary study team's understanding of each site's potential to meet a variety of criteria.

For storm damage reduction or erosion reduction, the site or problem area had to have:

- **Technical feasibility** (i.e., will a given measure provide a sound technical solution to the identified problem(s)?), and thus, at least one technically-feasible solution from the above list;
- **Environmental feasibility** (i.e., will a given measure provide a sound solution to the identified problem(s), without creating environmental resource problem of its own?), and;
- There were identified some potentially **cost-effective** solutions to the identified problem suite.

For ecosystem restoration or saltwater intrusion reduction, the site or problem area had to be identified as having:

- no ability to either heal on its own, unaided by human intervention, or;
- national and/or regional significance in regards to the type of ecosystem it represents;
- the need for assistance to restore vital hydrologic links;
- the potential need to manually remove blockages created by hurricane-deposited debris that was impacting function;
- the potential need to remove excess sediment deposited by the hurricanes that had changed the nature of the land's surface and resulted in degraded function and value;
- the potential need to remove invasive species that had entered the area since the hurricanes and caused displacement of native plant species (and potentially wildlife depending on native species), degrading function of the ecosystem;
- or the potential need for planting of native species vital to restoration of a significant ecosystem and restoration of its functions and values.

6.8.2 Screening of Preliminary Measures

The MsCIP planning process required this screening process to "weed out" unproductive measures, or those that did not meet the planning objectives. Application of the screening criteria above resulted in the screening of a large number of less significant areas, as well as many that the study team determined were capable of recovery on their own.

Additionally, as more technical and environmental data became available, more judgment is able to be applied as to the relative value of any given measure, when compared to others applied to that same site or problem area. Preliminary analysis again indicated that there were many solutions or measures that were *obviously* cost-prohibitive, unequivocally environmentally damaging, or simply technically infeasible, when compared to other measures, when each problem area or site was evaluated individually.

Due to the large number of measures involved, and the fact that initial evaluation and screening was done on a case-by-case basis by the study team in the field or in discussion held for each site, no detailed discussion of each of them is contained here, although numerous preliminary measures and their evaluation, comparison, and screening are referenced in the Engineering and Environmental appendices.

The screened list of remaining ecosystem problem areas and sites was narrowed to the following:

- Restoration of barrier islands. Includes entire restoration of the MS barrier islands including littoral placement, re-vegetation, and restoration of Submerged Aquatic Vegetation.
- Restoration of Dune habitat. Using dune barriers along the MS coast as either an ecosystem restoration measure, or in combination with dune use as a storm damage reduction barrier.
- Reduction of saltwater intrusion by restoring fresh water flows from the Escatawpa, Pearl, and Mississippi Rivers.
- Restoration of coastal Mississippi wetlands and forests by evaluating historical wetland areas, frequently flooded populated areas, and current wetland and forest areas degraded by the storms of 2005.

For damage reduction concepts, a structural "Lines of Defense" concept (see Figure 11) was developed that started with the offshore barrier islands and progressed inland to what could be considered the surge extent of the worst possible theoretical storm. This storm, labeled the

Maximum Possible Intensity (MPI) event would be used to define a line, based on ground surface elevation that the storm surge would not exceed. The lines of defense would be designed to provide increasing levels of protection as you transgressed inland. Some lines would not provide protection from large storms, and several areas of the coast could not be included in continuous line of defense. These areas would be either placed in a ring levee system or designated to a non-structural solution during the second round of evaluation.

Many types of structural and nonstructural protection were reviewed. Some examples of the types of measures that were screened out due to a lack of technical feasibility are identified below and depicted in Figure 10.

- Inflatable barriers,
- Concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall,
- Sliding panel gates, and
- Offshore breakwaters.
- Contiguous Barrier Island 'Wall'
- Galveston type Seawall

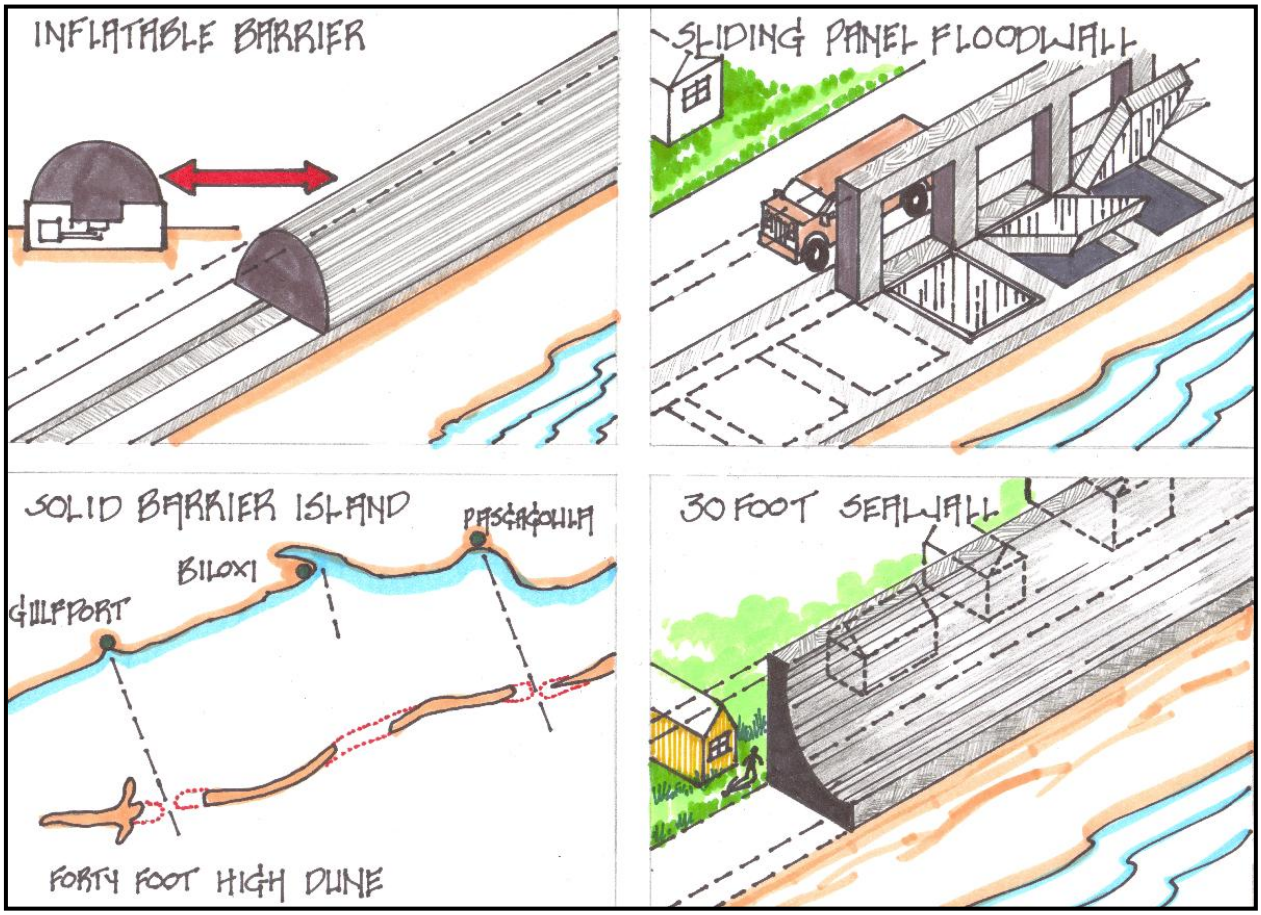


Figure 10 Preliminary Damage Reduction Measures Screened Out

The screened list of damage reduction concepts and/or alignments includes the following for further analyses and depicted in Figure 11:

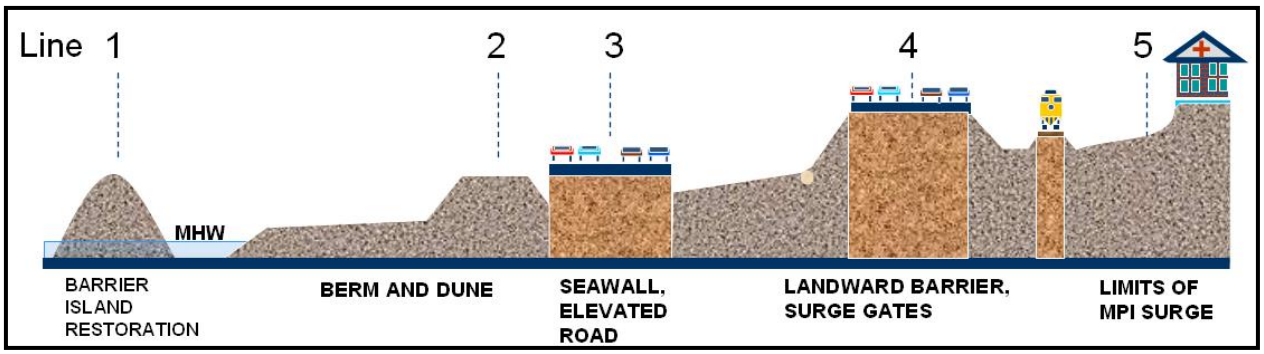


Figure 11 Lines of Defense Concept

First Line of Defense – Barrier Islands. The coastline of mainland Mississippi is bordered on the south by the Mississippi Sound, a shallow body of water that separates the coast from four barrier islands that lie several miles to the south. These barrier islands are located along a littoral drift zone that moves sand westward creating three elongated islands and then to the westward most island where littoral currents are not as well defined. From east to west, the islands are Petit Bois, Horn, Ship, and Cat. Ship Island has been breached by prior hurricanes and now is actually two small islands, West Ship Island and East Ship Island, with a shallow sand bar between the two. Since Hurricane Camille in 1969, this breach has existed with varying amounts of natural rebuilding between later storms. The western ends of both Petit Bois and Ship Islands have migrated to maintained navigation channels and the continuing littoral drift of the sand into the channels is causing an artificial termination of the migration. A new island has emerged on the west side of the channel from Petit Bois Island, created from the dredged sand coming from island that is disposed of on the west side of the channel. Soon after Hurricane Katrina, it was reported that many in Mississippi felt that if the islands had been in the condition that existed prior to Hurricane Camille, there would have been less damage along the coast from Hurricane Katrina. This idea was also included in the Mississippi Governor's Restoration Plan, which called for restoring the islands to a pre-Camille footprint. The idea was also included in the Mississippi Governor's Restoration Plan, which called for restoring the islands to pre-Camille footprint. This measure (identified as LOD-1) was selected to be carried forward for further analysis.

Second Line of Defense – Dunes along Existing Beaches. Essentially all the beaches along coastal Mississippi are man-made. Harrison County has the most beach-front with 26-miles extending from Biloxi Bay to St. Louis Bay. Hancock County has several miles of beach and Jackson County only a short length. In total, the beaches extend along less than half of the Mississippi coastline. Most of the dunes that previously existed along these beaches were destroyed by Katrina and much of the beach was damaged. Reconstruction of the dunes, where beaches exist, will likely provide reduction of damaging wave action from smaller storms.

The beaches, as situated immediately seaward of developed areas, provide a location where elevated dunes could be constructed to provide some protection from smaller hurricanes. This measure (identified as LOD-2) was selected to be carried forward for further analysis. First concepts would look at crest elevations of 10.0 and 15.0 feet above sea level (NAVD-88) as options for the all dunes.

Third Line of Defense – Raised Roadway or Seawall and Ring Levees. All of the beaches described in LOD-2 have a roadway landward (North) of the beach. These roads vary from local or county roads to US Highway 90, a major, four-lane, highway that extends across the entire Harrison County coast. The existing roadways vary in elevation from four to five feet above sea level (NAVD-88) in Jackson and Hancock County and up to about 15 feet above sea level in Harrison County. All

of these roads are evacuation routes and all have been damaged in past hurricanes. In a damaged or destroyed condition, these roads make re-entry to the area difficult after a hurricane has passed. Raising and using these roadways as barriers or having an associated seawall defines a portion of the 3rd line of defense (LOD-3) and will be carried forward for further analysis. This line will be the first hard engineered structure and will be initially evaluated at elevations 12.0, 18.0 and 24.0 feet above sea level and will be supplemented by nonstructural solutions such as the elevating or buying out of structures.

Fourth Line of Defense – Inland Barrier. To preserve the shoreline environment as much as possible, a 4th line of defense (LOD-4) for very large storms is envisioned that would be inland from the coast (and LOD-3). This line of defense would be the highest line and could be designed to contain a larger storm surge, such as the "Maximum Possible Intensity" (MPI) hurricane, and will also be supplemented by nonstructural solutions such as the elevating or buying out of structures. This line of defense was selected to be carried forward for further analysis. First efforts would model LOD-4 as an infinitely high barrier against storms varying from a Camille type storm up to the MPI.

Fifth Line of Defense – Maximum Surge Limit. This line of defense will be a line on a map that indicates the extent of surge resulting from the "Maximum Possible Intensity" storm. Structures that are situated or built above (North of) this line should not be inundated from surge by large storm events. This fifth line of defense (LOD-5) was selected to be carried forward for further analysis. Initial efforts would look at nonstructural plans to either build future or relocate existing emergency services such as hospitals, or police and fire stations.

The following figures (12 - 14) indicate the initial alignments of the lines of defense concepts.

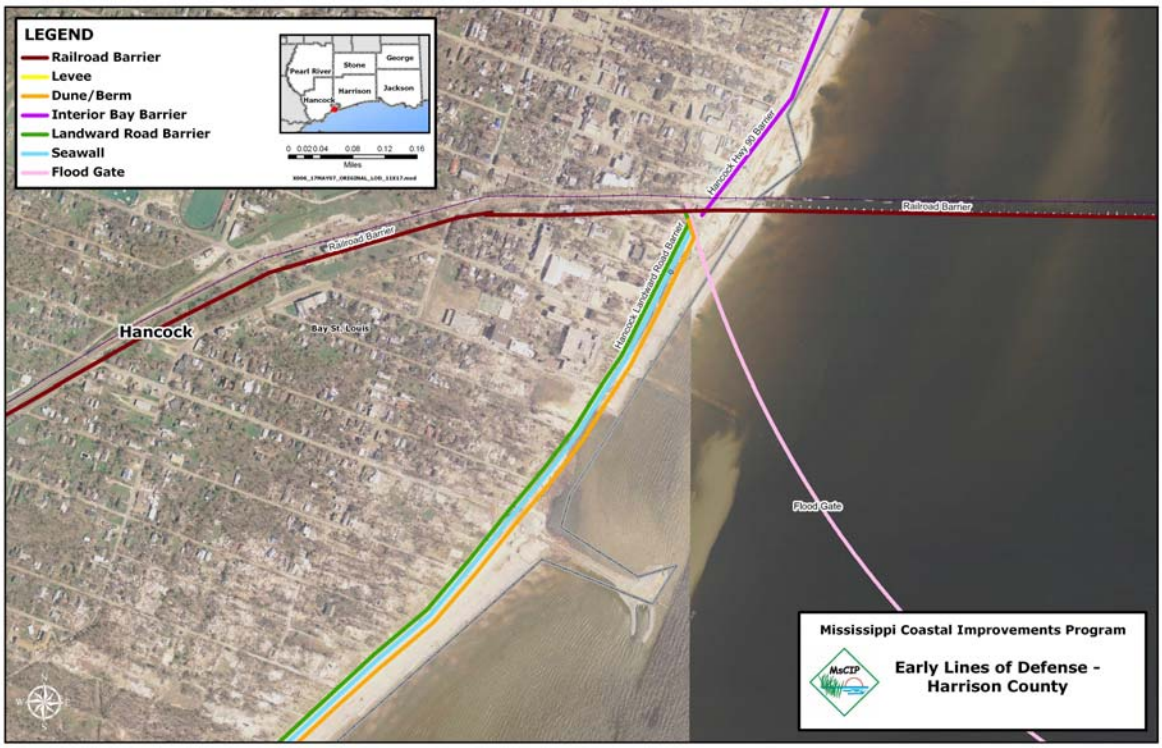


Figure 12 Initial Lines of Defense for Hancock County

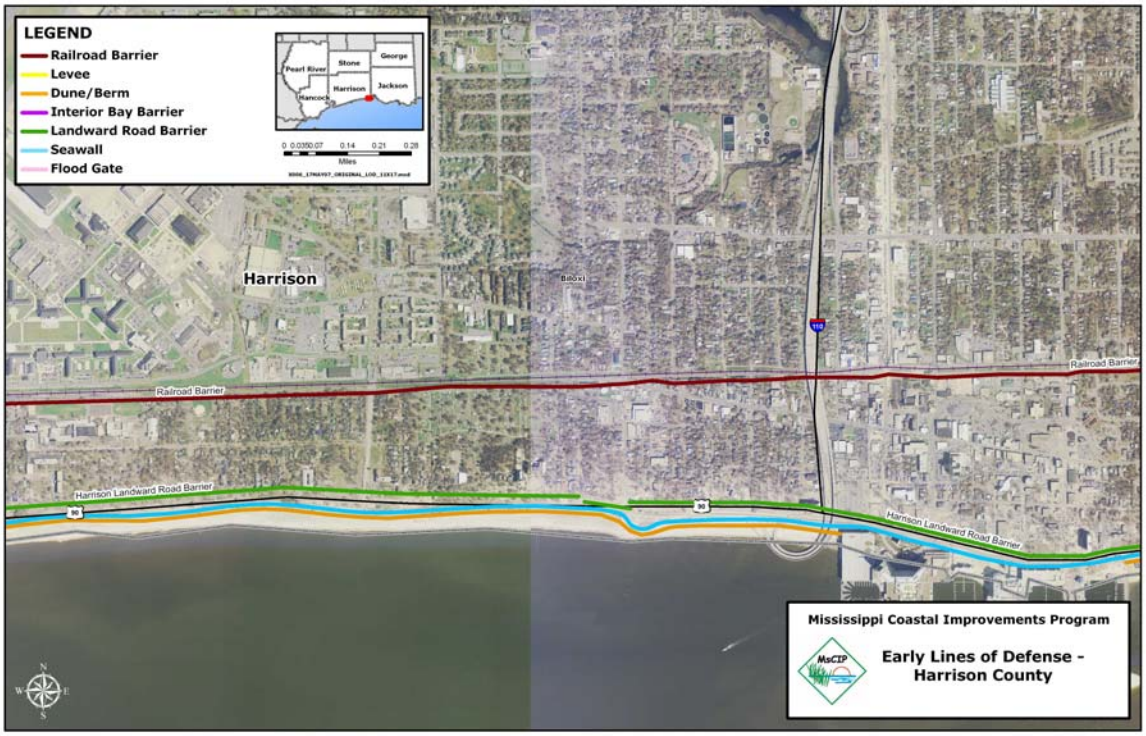


Figure 13 Initial Lines of Defense for Harrison County

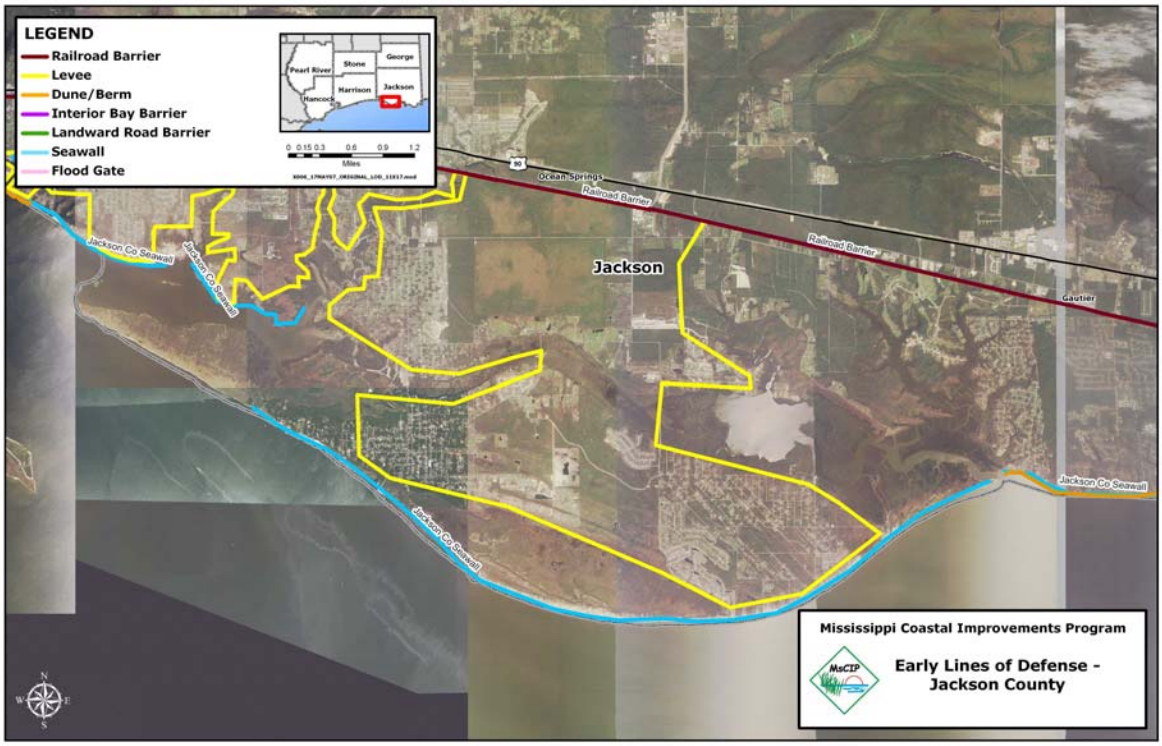


Figure 14 Initial Lines of Defense for Jackson County

Due to the relatively low elevations, type of construction, and the nature of storm surge throughout the coastal area, several preliminary nonstructural measures were also screened from further evaluations. These include:

- Elevating structures on fill material
- Dry floodproofing of residential structures (maximum protection is 3 feet), and
- Wet floodproofing of residential structures (elevating utilities)

Additional information on these measures can be found in the Engineering, Environmental, and Nonstructural Appendices.

7 RISK ASSESSMENT AND EDUCATION IN PLAN FORMULATION

7.1 Intro to Risk

The additional process of evaluating and appropriately integrating risk, uncertainty and consequences of potential actions in the plan formulation process used the following criteria of: a) identification, b) quantification, and c) characterization, of these factors. This process is summarized below.

7.1.1 Risk in Identification in Technical Analyses

Risk identification involved the selection of various parameters around which risk might be quantified. The first level of risk identification involved the selection of those parameters, by agreement of the study team, technical experts, and appropriately-trained risk-educated staff brought in to assist in this process, from the Corps Engineering Research and Development Center (ERDC).

Risk was initially identified for certain technical parameters, including stage (the depth to which water could rise during a surge event), frequency, wave height, first floor elevation of structures, structure value, and content value. Uncertainty was also accommodated by the evaluation of multiple storm tracks (paths), magnitudes (strength), and alignments, to ensure that the maximum number of potential conditions was incorporated into the assumptions that went into defining future without-, and with-project conditions.

7.1.2 Risk Identification in the Planning Process

In addition, to risks and uncertainties in technical parameters, numerous other factors were also identified as having the potential for risk, uncertainty, or consequences. These included risks associated with the potential for impacts to culture and historical properties, public service disruption, risk associated with long-term sustainability of measures, risk, uncertainty and potential consequences to individuals and families, and other societal issues.

Identification of factors that required assessment also included the definition of a unit of measure (or "metric") by which the factor would be judged, such as measuring risk of being off on an estimate of inundation depth by how many feet above or below the expected depth the technical expert could

consider that value to vary for a given storm; another example could be the amount of money that a damage estimate might vary for a given storm event.

Input on the factors found to be of most importance to the public and decision-makers was sought at public workshops set up to establish *which factors* were of importance, and also get input on which factors they found of *highest* importance. A full discussion on the selection of risk "metrics" and their discussion and selection by the public, is contained in the appendix on the RIDF process.

7.2 The Risk-Informed Decision Framework (RIDF) Process

The first step in the planning process is determining the problems, opportunities, and objectives which guide the study team in developing solutions. The next step involving risk is to structure the objectives using a hierarchical approach. For example, the study team considers many different risks associated with a flood event in an effort to develop and implement measures to minimize damages cause by storm surge. Residual risk is that portion of the total sum of all risks that still exists after a flood damage reduction project is implemented. Therefore, the overall objective guiding the selection of measures could be expressed as minimizing the residual risk from storm surge in terms of the economic, environmental and societal consequences associated with a flood event. This overall objective might be further divided into its component, or sub-objectives (i.e. - economic, environmental, and societal). These sub-objectives are incorporated into the planning process through measurable metrics that are used to compare the performance of each measure in an economic context (e.g., cost effectiveness), an environmental context (e.g., preservation of fish and wildlife habitat for ecological stability), or a social context (e.g., societal displacement). Successful planning requires giving careful attention to clearly describing and structuring the objectives for the study in detail. The next step involves developing metrics to represent the objectives. These metrics will then be used to calculate performance scores and ranks for the measures during the evaluation and comparison steps of the planning process.

7.2.1 Risk "Metric" Development

The MsCIP team developed metrics to be used in evaluating measures to accomplish the study objectives. If a measure did not meet the performance goals, it would either be screened out (dropped from further consideration) or taken back to the "drawing board" for refinement. The metrics themselves would be scored (or weighted) and ranked by various stakeholder groups, which would in turn aid decision makers in identifying a plan or plans to be recommended for implementation.

Evaluating measures by a large set of metrics can be complex and very time consuming. With this in mind, the study team selected an effective set of metrics that, while representing the best available information, would not be so large as to hinder the evaluation process.

The following criteria were used in selecting metrics to insure that they were:

- Scientifically verifiable. Meaning that two independent assessments would yield similar results.
- Cost-effective. The technology required to generate data for the metrics is economically feasible and does not require an intensive deployment of labor.
- Communicable. Are easy to communicate to a wide audience. The public would understand the scale and context, and be able to interpret the metric with little additional explanation.

- Changeable by human intervention. The metric would describe a dependent relationship between the outcome of the measure and those things that are under a decision-maker's control. Metrics that are independent of human action does little to help evaluate a measure.
- Credible. It would be perceived by most stakeholders as accurately measuring what it is intended to measure.
- Scalable. It would be directional in nature, whether qualitative (best, good, worst) or quantitative (dollars, acres, percent damaged), as appropriate.
- Relevant. It would reflect the priorities of the public and other stakeholders and enhance their ability to execute their stewardship responsibilities. There is no point assembling a metric no one cares about.
- Sensitive. The metric must be able to capture the minimum meaningful level of change, make the smallest distinctions that are still significant, and any uncertainty about the metric is easy to communicate.
- Minimally redundant. What the metric measures is not essentially reflected by another metric.
- Transparent. The use and development of the metric is readily apparent.

It is important to acknowledge here that there will be "conflicts" among metrics, resulting in the need to make tradeoffs. For example, a tradeoff exists between achieving any significant benefit from a project and minimizing cost. As a consequence of such "conflicts", a given measure may not take clear precedence over other measures in respect to every "metric" for evaluating performance. This may present a dilemma to decision-makers, who are trying to choose a single measure. It is important to place development of metrics prior to the development of measures because the "hard thinking" that goes into developing the metrics can create an improved set of measures. This permits stakeholders to focus on thinking about the objectives rather than anchoring themselves to their "favorite" measures.

Within a particular scenario, the amount of uncertainty surrounding metric values must be clarified. Metric values depend upon either a mathematical model, empirical data from a study, or expert opinion. All of these sources share varying degrees of uncertainty, presumably more so for expert opinion than for models and studies. Therefore, along with indicating the basic source of the metric values, it is also necessary to describe the assumptions that went into calculating the value. Estimates of the uncertainty for a metric should be quantified (e.g., in terms of the variance or range associated with the estimate). This quantification must be captured and integrated into the decision analysis in order to make risk-informed decisions.

An initial set of metrics were developed by the study team and then shared with several "focus" groups". They in turn helped to shape the final list of metrics, described and grouped by different accounts below.

Environmental Quality (EQ) Metrics

1) Tidal Habitat Restored - This metric measures (in acres) positive changes to the tidally-influenced wetlands that results from the implementation of a measure or plan. These are positive benefits from implementing a restoration plan or a combination of plans. Ecosystem components included in this metric are tidal wetlands (i.e., tidal fringes), associated threatened and endangered (T&E) and other species, associated essential fish and other tidal habitats (i.e. oysters, submerged aquatic vegetation), and related losses that require mitigation due from implementation of structural plans. There are 5 tidal wetland functions measured: wave energy attenuation (wave energy absorbed by wetland through landscape position, marsh width, and vegetation cover), biogeochemical cycling (receive, transform, and export nutrients through a wetland), nekton (swimming organisms)

utilization potential (whether wetland contains suitable habitat for nekton), provide habitat for tidal marsh dependent vertebrate wildlife, and maintain a characteristic tidal marsh plant community. Units for this metric are the percentage increase of quality fish and wildlife habitat in functional habitat units (FHI).

2) Tidal Habitat Lost - This metric measures adverse impacts to the tidally-influenced wetlands that results from the implementation of a measure or plan. Ecosystem components included in this metric are tidal wetlands (i.e., tidal fringes), associated threatened and endangered (T&E) and other species, associated essential fish and other tidal habitats (i.e. oysters, submerged aquatic vegetation), and related losses that require mitigation due from implementation of structural plans. There are 5 tidal wetland functions measured: wave energy attenuation (wave energy absorbed by wetland through landscape position, marsh width, and vegetation cover), biogeochemical cycling (receive, transform, and export nutrients through a wetland), nekton (swimming organisms) utilization potential (whether wetland contains suitable habitat for nekton), provide habitat for tidal marsh dependent vertebrate wildlife, and maintain a characteristic tidal marsh plant community. Units for this metric are also in acres.

3) Non-tidal Habitat Restored - This metric measures (as functional units) positive changes to the non-tidal ecosystem that result from the implementation of a measure or plan. These are positive benefits from implementing a restoration plan or a combination of plans. Ecosystem components included in this metric are maritime forests, beach nourishment, dune restoration and vegetation, and associated threatened, endangered and other species in non-tidal habitats. There are numerous functions provided by upland habitat: wildlife and birds (includes threatened and endangered species) roosting, nesting, and foraging utilization potential, wildlife corridors, sustainability of the Mississippi Flyway, restoration of the natural ecology and aesthetics of the area, and maintenance of plant community composition. Units for this metric are the percentage increase of quality fish and wildlife habitat in acres.

4) Non-tidal Habitat Lost- This metric measures (as functional units) adverse impacts to the non-tidal ecosystem that results from the implementation of a measure or plan. This has a negative impact of implementation of an array of alternatives as part of the comprehensive plan. Ecosystem components included in this metric are maritime forests, beach and dunes, threatened, endangered and other species and their non-tidal habitats, and related losses that require mitigation due to implementation of structural plans. There are numerous functions provided that will be evaluated and include: breaks in natural wildlife corridors, fragmentation of habitat, loss of critical habitat for threatened and endangered species, loss of foraging and roosting areas, loss of vegetation resulting in increased erosion, reduction in water quality and air quality. Units for this metric are the percentage decrease of quality fish and wildlife habitat in acres.

National Economic Development (NED) Metrics

5) Monetary Damages Reduced/Avoided (Expected Annual Damages) - The amount of storm damages reduced/avoided by a plan expressed as annualized dollars. Annualized dollars are calculated by comparing a future without a project in place versus a future with a project in place. Damages are calculated by using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. This metric has become standard practice in the evaluation of the value of measures with respect to estimating damages to assets (i.e., residential, commercial, and industrial infrastructure and their contents) over the period of analysis. For more detail about the HEC-FDA model see Economics Appendix.

6) Residual Damage – This metric describes what a plan does not account for (or what happens if a plan is exceeded). Residual damage is defined as the storm damage that is not prevented with the implemented plan in place (expressed as annualized dollars).

7) Cost to Implement Plan – The amount of money in dollars needed to implement the plan. This metric measures the cost in today's dollars to local and Federal governments to implement the recommended plan.

Other Social Effects (OSE) Metrics

These metrics focus on the preservation of people's quality of life. OSE metrics were developed to address impacts to cultural heritage and preservation of historical structures, disruptions to public service and infrastructure and impacts to personal effects.

8) Cultural and historical heritage impacts – This metric addresses impacts to social groups, church congregations, and groups with common heritages. This metric also includes impacts to aesthetics and the destruction of the human-created landscape such as historical structures. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

9) Public service and infrastructure disruptions – This metric includes disruptions to schools, fire and police service, access to hospitals, libraries and community centers, and use of roads, bridges, and utilities. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

10) Personal impacts – This metric includes loss of family possessions, photographs, and impacts to people's emotional and mental health. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

Regional Economic Development (RED) Metrics

The RED metrics measure both positive and negative impacts to the regional economy. Positive impacts are captured by impacts to sales volume, personal income and employment and negative impacts by local cost burdens. Sales volume, income and employment will be sub-metrics under RED, and will be equally weighted. This metric is termed Positive regional economic benefits and will combine these 3 sub-metrics. The local cost burdens metric is also a sub-metric under RED and will receive a weight equal to combined weighting of the positive metrics under regional economic benefits.

11) Local Cost Burdens – This metric represents the costs and burdens to the local governments due to implementing a measure. This includes cost-sharing requirements with the Federal government to implement the plan and local costs for ongoing operations and maintenance (O&M) related to the implemented plan. The local cost burdens may also include those associated with additional workforce needed to maintain features of an implemented plan. This metric will be based on a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

12) Positive regional economic benefits – Economic benefits to the region with regards to sales volume, income and employment. This metric was evaluated using the economic impact forecasting system (EIFS) model. This model is an economic analysis tool that given the inputs for a particular plan will assess potential impacts of sales volume change and personal income in dollars and regional employment change in number of jobs to the local economy. Uncertainty will be based on several factors such as population, implementation cost, and social behavior of people in the region. This metric will be based on a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

Risk Metrics

The following risk metrics serve as additional information to decision makers. They are a way to address extreme cases of uncertainty.

13) Long-term Sustainability of Plan – The risk that features associated with the recommended plan will not perform as intended (over time) due to factors such as cost, human behavior, technical level

of maintenance required, political concerns, resource availability, local funding per year, and operational reliability. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

14) Residual Risk – This metric describes what a plan does not account for (or what happens if a plan is exceeded). Residual risk is defined as the storm damage risk that remains with the implemented plan in place (expressed as annualized dollars). It accounts for the following factors: erosion, wildlife species, wildlife habitat, salt water intrusion, surge damages, drainage, wind, maximum probable intensity (MPI) plan (accounts for more intense storm), cultural heritage, and infrastructure. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

15) Consequences of Plan Failing – This criterion describes what happens if a plan does not work as intended. In other words, it describes consequences to humans and the environment due to a catastrophic failure of an implemented plan under design conditions or other sets of circumstances from a storm event. The greatest risk is risk of failure to structural measures, such as levees, flood gates, etc. Consequences and likelihood of failure vary depending on the line of defense. For example, risk of Line 2 failure is more likely, but consequences are relatively low; risk of Line 4 failure is highly unlikely, but consequences are very high. It includes the following factors: injuries to population, loss of infrastructure, loss of habitat, and loss of wildlife species. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

Once the 15 metrics were described, the study team developed the values associated with each measure. The team calculated the acres associated with each measure for the metrics within the Environmental Quality Account as discussed above. The NED metrics were developed through the use of the Corps' HEC-FDA program (further described in the Economics Appendix) and are expressed in dollars.

As mentioned above, the RED, OSE, and Risk metrics are based on a scale from 1-10. Guidelines for these metrics were given to the team to help provide consistency amongst the different measures and are defined in the following tables.

Table 20.

Regional Economic Development Scoring Definitions

Score	Local Cost Burdens	Regional Economic Benefits
1	All Local Government funds are exhausted to cover the cost-shared portion, an extremely large workforce must be hired to perform maintenance of plan features, and the plan results in increased support of the area infrastructure.	Little or no economic benefits, or increase in sales volume, income and employment to the region.
2	A very large percentage of local funds would be required for cost-share and a very large workforce must be hired to perform maintenance of plan features. The plan results in a large burden on local government to support the area infrastructure.	Very small economic benefits, and increases in sales volume, income and employment to the region.
3	A large percentage of local funds would be required for cost-share and a large workforce must be hired to perform maintenance of plan features. The plan results in a large burden on local government to support the area infrastructure.	Minor economic benefits, and increases in sales volume, income and employment to the region.
4	A significant percentage of local funds would be required for cost-share and maintenance support of plan features. Plan also puts a significant burden on local governments to maintain infrastructure.	Some economic benefits, and increases in sales volume, income and employment to the region.
5	A moderate percentage of local funds are required	Moderate economic benefits, and increases in sales

Score	Local Cost Burdens	Regional Economic Benefits
	for cost-share and maintenance support of plan features. Plan puts moderate burden on local governments to maintain infrastructure.	volume, income and employment to the region.
6	Some local funds are required for cost-share and maintenance support of plan features. Plan puts mild burden on local governments on infrastructure.	Significant economic benefits, and increases in sales volume, income and employment to the region.
7	A minor percentage of local funds are required for cost-share and maintenance support of plan features. Plan also puts a minor burden on local governments to maintain the infrastructure.	Large economic benefits, and increases in sales volume, income and employment to the region.
8	A very small percentage of local funds will be required for cost-share and maintenance support of plan features. Plan puts mild burden on local governments to maintain the infrastructure	Very large economic benefits, and increases in sales volume, income and employment to the region.
9	Extremely small disruption to local funding, infrastructure, or maintenance support of plan.	Extremely large economic benefits, and increases in sales volume, income and employment to the region.
10	No burden on Local Government to cost-share, operate and maintain plan features, or support infrastructure.	Tremendous economic benefits, and increases in sales volume, income and employment to the region.

Table 21

Other Social Effects Metric Scoring Definitions

Score	Cultural & Historical Heritage	Public Service Disruptions
1	Total Loss of Community and Cultural and Historical Heritage.	All Public Services are interrupted and are interrupted during all events that currently affect them; no police or fire service or schools that would be affected would be available; hospitals, libraries, etc., would remain closed indefinitely. Roads, bridges, utilities, and other infrastructure destroyed.
2	A portion of community exists but much of what is culturally and or historically significant would continue to be lost.	Significant Disruptions that last for weeks to months. Measure may provide a very small measure of improvement.
3	A portion of community exists but most of the Cultural and Historical Significance is lost.	Severe Interruptions to Public Services. Significant amount of damage to roads, bridges, and utilities.
4	Significant Losses, or Changes to - - - Historical Setting (i.e Aesthetics – view, Loss to Community Defining Landmarks and/or Structures, Change in Land Use (i.e : A complete change in how they use their community)	Very limited public services would still be provided. Hospital offers emergency services. Schools and other services may close. Road and Bridges damaged and could remain closed for moderate amount of time.
5	Moderate Loss to, or Change to Historical Setting (i.e Aesthetics – view, Loss to Community Defining Landmarks and/or Structures, Change in Land Use (i.e : An almost complete change in how they use their community)	Limited public services provided. Small portion or number of hospitals are able to operate. Schools and other services remain closed. Road and Bridges damaged but most are usable in a few weeks.
6	Low Chance of Loss to, or Change to Historical Setting (i.e Aesthetics – view, Loss to Community Defining Landmarks and/or Structures, Change in Land Use (i.e : Almost complete change in how they use their community)	Mild Disruption to public services. Most everything back to normal operations within 7 days
7	Divide Community Cohesiveness – Community still exists but functions separately. Some of cultural and historical essence and features are lost, but community may still retain some of what makes it culturally and historically significant.	Minor Disruption to public services. Most everything back to normal operations soon after the event.
8	Community Still Functions and retains Cultural and Historical Heritage Significances but Notable Changes are Be Community Still Functions and retains Cultural and Historical Heritage Significances but Subtle Changes may occur that do impact community integrity.	Very minor disruption to public services. Most everything back to normal operations soon after the event.

Score	Cultural & Historical Heritage	Public Service Disruptions
9	Community Still Functions and retains most Cultural and Historical Heritage Significance; There may be small, subtle changes.	Extremely small disruption to public services. All services back to normal operations within days.
10	Complete Preservation of Community values, historical significance, and cultural heritage.	No impacts to normal way of life. Virtually no impacts to public services.

Table 22.

OSE / Risk Metric Scoring Definitions

Score	Personal Impacts	Long-Term Sustainability
1	Total Loss of Family Possessions due to Continued Hurricane Occurrence or to Plan Implementation (i.e. Property and Livelihood, Irreplaceable Items, Sense of Security, Mental Stability & Emotional Well-being) – Everyday Life no longer exists - Numerous Persons would be affected by events and might require professional therapy; most persons would likely not overcome effects of events	Complete failure (lack of sustainability) of plan (i.e. - will not perform as intended (over time) due to factors such as cost, human behavior, technical level of maintenance required, political concerns, resource availability, local funding per year, and operational reliability), is a certainty, at some time within period of analysis.
2	Majority of Family Possessions Lost (i.e. Property and Livelihood, Irreplaceable Items, Sense of Security, Mental Stability & Emotional Well-being) – Everyday Life no longer exists - Numerous Persons would be affected by events and might require professional therapy; many persons would likely not overcome effects of events	Will almost certainly fail within lifetime of project due to some factor associated with sustaining the plan. The plan will likely not be politically supported for funding or be reliably and fully maintained during its intended project life. Human behavior will almost certainly interfere with project performance sometime during project life, very high technical level of maintenance will be required, and very high risk that plan will not be operated correctly during time of need.
3	Significant Amount of Family Possessions Lost (i.e. Property Severely Damaged, Livelihood Significantly Changed, Many Irreplaceable Items Lost, Sense of Security, Mental Stability & Emotional Well-being Significantly Altered – Everyday Life no longer exists - Many people would be affected by events and could require professional therapy; many would likely not overcome effects of events for a very long time	Plan failure highly likely within project life. Minimal political support and project sustainability highly unlikely (i.e. maintenance and funding). Human behavior will interfere with project performance sometime during project life, high technical level of maintenance will be required, and high risk that plan will not be operated correctly during time of need.
4	Moderate Amount of Family Possessions Lost (i.e. Property Damaged, Livelihood Changed, Some Irreplaceable Items Lost, Sense of Security, Mental Stability & Emotional Well-being Shaken – Everyday Life Changed - Many people would be affected by events and might require professional therapy; a significant number of people would likely not overcome effects of events; some would benefit from professional therapy	Plan could possibly fail within project life. Minimal political support resulting in reduced funding and/or maintenance abilities. Human behavior may negatively affect project performance, moderate technical level of maintenance is required, and moderate risk of plan not being operated correctly.
5	Some loss of personal possessions remains likely over period of analysis; livelihood may be changed; irreplaceable items might be lost; some loss of security; property damages do affect one's sense of well-being; life for most could be altered; some loss of family possessions remains likely	Plan should perform as intended over entire project life, but possibility exists that it would not be sustained. Plan may not get sufficient political support for either sustained funding or maintenance over the life of the project. Human behavior may negatively affect project performance, moderate technical level of maintenance is required, and moderate risk of plan not being operated correctly.
6	Some loss of personal possessions is somewhat likely over period of analysis; livelihood could be changed at some point; irreplaceable items could be lost; some would suffer from loss of security; property damages could potentially affect one's sense of well-being; life for some would be altered at some point;	Plan will likely perform as intended over entire project life. There is general political support to implement the plan, but there is a risk of funding and maintenance being interrupted over project life. Negative human behavior may have some effect on project performance, and technical maintenance is required. There is also a moderate risk of the plan not being operated correctly.
7	Some loss of personal possessions could happen during period of analysis; chance exists that livelihood could be changed; irreplaceable items could be lost, but chance	Plan will most likely perform as intended over entire project life. There is general political support to implement the plan, but there is a moderate risk of

Score	Personal Impacts	Long-Term Sustainability
	is not good; some might suffer from loss of security, but although shaken, overall emotional well-being is good for vast majority of period of analysis; property damages affecting one's sense of well-being is not likely; life for small number of people could be altered at some point; Family Possessions could be impacted but most would be recoverable.	funding and maintenance being interrupted over life of project. Negative human behavior has some effect on project performance, and a moderate level of technical maintenance is required. There also remains some risk of the plan not being operated correctly.
8	Some loss of personal possessions could happen during period of analysis; small chance exists that livelihood could be changed; irreplaceable items have low likelihood of being lost; sense of security would not be shaken for vast majority, overall emotional well-being is good to very good; property damages affecting one's sense of well-being is highly unlikely; Family Possessions might be impacted, but most would be recoverable.	Plan is very unlikely of not performing as intended over entire project life. There is general political support, but some issues could arise causing delay to fully implement the plan. There is low risk of funding and maintenance being interrupted over life of project. Negative human behavior has some effect on project performance, a low to moderate level of technical maintenance is required, and there is a low to moderate risk of plan not being operated correctly.
9	Very low likelihood that loss of personal possessions would happen during period of analysis; chance exists that livelihood could be changed; irreplaceable items could be lost, but chance is extremely unlikely; very few would suffer from loss of security; overall emotional well-being is very good to excellent for vast majority of period of analysis; property damages affecting one's sense of well-being is extremely unlikely; life for very small number of people could be altered at some point; family possessions impacted but most recoverable; Recovery is Immediate.	Plan will almost certainly perform as intended over entire project life. There is strong political support and will to implement the plan, and an extremely low risk of funding and maintenance being interrupted over life of project. Negative human behavior would have extremely low likelihood of having any effect on project performance, an extremely low technical level of maintenance is required, and an extremely low risk of plan not being operated correctly.
10	Complete preservation of family possessions (i.e. Property and Livelihood, Irreplaceable Items, Sense of Security Mental Stability & Emotional Well-being)	Plan will absolutely perform as intended over entire project life. It is fully politically supported, resources are more than adequate to maintain the project, human behavior will not negatively affect project performance, minimal to no maintenance required, extremely low risk of funding being interrupted, and extremely low risk of plan not being operated correctly.

Table 23

Risk Metric Scoring Definitions

Score	Consequence of Plan Failing	Residual Risk
1	Plan failure would result in extremely widespread and extensive injuries and large number of deaths; enormous number of structures destroyed, and almost all of remainder damaged significantly; community would suffer total loss of infrastructure; wildlife would suffer severely as result of plan failure; habitat loss would be extreme as result of plan failure	Tremendous residual risk; All or almost all damages and risks remain unaddressed; Risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion remain unabated; threats to cultural or historical heritage remain extremely high.
2	Plan failure would result in extremely widespread injuries and significant number of deaths; Very large number of structures destroyed, and most of remainder damaged significantly; total infrastructure loss, wildlife, and habitat loss throughout Coastal Mississippi	High to extremely high residual risk; almost all damages and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion remain unabated; threats to cultural or historical heritage remain very high.
3	Plan failure would result in widespread injuries, large number of deaths, and large number of structures destroyed, with many of remainder damaged; significant damage to infrastructure, and loss of wildlife; widespread habitat damage or loss would occur	High residual risk; vast majority of damages and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion remain high; threats to cultural or historical heritage remain high, and cultural heritage could be severely compromised.
4	Very numerous people would be injured; moderate to large number of deaths; fairly large number of structures destroyed, and some of remainder damaged	Moderate to high residual risk; majority of damages and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater

Score	Consequence of Plan Failing	Residual Risk
	significantly; loss of infrastructure would be moderate to highly significant; much wildlife would be impacted; habitat damage or loss would be moderate to highly significant	intrusion remain high; threats to cultural or historical heritage remain moderate to high, and cultural heritage could be compromised.
5	Numerous people could be injured; moderate number of deaths; fair number of structures destroyed, and some of remainder damaged; loss of infrastructure would be moderate, but would require significant amount of time for recovery; wildlife would be impacted, but much would recover; habitat damage or loss would be moderate	Moderate residual risk; much of damage and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion remain moderate, but for a significant number, risk is reduced; threats to cultural or historical heritage remain moderate, and little of cultural heritage would be compromised. Environmental habitat could suffer but most could be restored with minor effort.
6	Moderate to minimal number of injuries as a result of plan failure, small to moderate number of deaths; some structures destroyed, and some number of remainder damaged; still substantial potential impacts to infrastructure, but much would recover quickly; habitat damage or loss would be moderate to small	Small to moderate residual risk; some of damage and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion are at small to moderate risk, but significant amount of risk is reduced; threats to cultural or historical heritage would be small to moderate, and very little risk of cultural heritage being compromised. Environmental habitat could suffer but most could be restored with very little effort.
7	Minimal number of injuries as a result of plan failure, small number of deaths might result; small number of structures destroyed, some damaged; moderate potential impacts to infrastructure, but almost all would recover quickly; habitat damage or wildlife loss would be small, and could recover quickly, impacts to infrastructure would be minimal, and recovery of most would be rapid	Small amount of residual risk; some damage and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion are at small risk, but most risk is reduced; threats to cultural or historical heritage would be small, and almost no risk of cultural heritage being compromised. Limited risk of environmental habitat suffering, and that which did would be restored with very little effort.
8	Very small number of injuries would occur as a result of plan failure, very small number of deaths; minimal number of structures damaged or destroyed; minimal potential impacts to infrastructure, and almost all would recover quickly; habitat damage or wildlife loss would be very small, and would recover quickly, impacts to infrastructure would be minimal, and recovery of majority would be rapid	Very small amount of residual risk; very limited amount of remaining risk or potential damages would remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion are at very small risk; vast majority of risk is reduced; threats to cultural or historical heritage would be very small, and cultural heritage at very low risk of any compromise. Very limited risk of any environmental habitat suffering over project life, and that which did would be restored with very low effort.
9	Extremely small number of injuries would occur as a result of plan failure; Few to no deaths would result; very small number of structures, if any, destroyed, and small number of remainder damaged; minimal impacts to infrastructure, and all would recover quickly; habitat damage or wildlife loss would be extremely small, and would recover quickly; and recovery of majority would be rapid. No Injuries, very minimal infrastructures, wildlife, and habitat impacts	Extremely small amount of residual risk; extremely limited amount of remaining risk or potential damages would remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion are at extremely small risk; almost all risk is reduced; threats to cultural or historical heritage would be extremely small, with cultural heritage at almost no risk of compromise. Extremely limited risk of any environmental habitat suffering over project life.
10	Complete Performance of Plan No Impacts due to Failure	Almost no residual risk would remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion are almost non-existent; threats to cultural or historical heritage would be almost non-existent, with cultural heritage at no risk of temporary or permanent compromise. Almost no risk of any environmental habitat suffering significantly over project life.

Using these definitions, the planning team starting developing metrics for the different measures. These metrics were used to help refine the measures.

7.3 "Weighting" of Risk metrics by Stakeholders of coastal Mississippi

Three sequential "risk weighting" workshops were held in July, September, and December of 2007 with various stakeholder groups. The first workshop was used primarily to make sure that the stakeholders understood the RIDF process and that the metric definitions were sound and easily understood. At this workshop, the stakeholders were subjected to two different weighting (or scoring) techniques and their feedback helped to refine the process. This process was repeated at the September workshop, where the stakeholders used example metric data to aid their understanding of the measures. Again, feedback from this workshop allowed the team to finalize the weighting process and in the December, the stakeholders were able to see the actual data for the metrics associated with the final list of alternatives. The MsCIP weight elicitation workshops yielded 45 complete sets of weights on fifteen metrics. These initial weights were used to establish the importance of each factor as determined by the stakeholders, and are shown in Table 24. An exploratory data reduction technique called a cluster analysis was used to group stakeholders with similar preference patterns expressed through their allocation of weights to metrics. These results, as shown in Figure 15, enabled the MsCIP team to compare the different stakeholder preferences that exist for potential solutions. A more detailed description of how the weights of these metrics were developed can be found in the RIDF Appendix.

Table 24.

Point Allocation to Metrics

Cluster	Session	Tidal Habitat Restored	Tidal Habitat Lost	Non-Tidal Restored	Non-Tidal Lost	Damage Reduced	Residual Damage	Implementation Cost	Local Cost Burdens	Regional Benefits	Cultural Heritage	Disruptions	Personal Impacts	Sustainability	Consequences	Residual Risk
A	Business	1	1	1	1	35	3	5	5	5	4	2	2	15	16	4
A	Business	5	3	5	3	5	4	9	10	10	6	8	8	15	3	6
A	Federal	2	1	2	1	20	4	10	4	10	1	10	4	17	10	4
A	Local	2	2	2	2	7	7	12	24	10	5	10	5	5	2	5
A	Local	1	1	1	1	3	3	25	25	10	10	5	1	7	3	4
A	Local	1	2	1	2	13	8	1	12	13	1	8	5	12	12	9
A	Local	3	4	1	2	15	5	5	3	4	3	12	8	18	13	4
A	Local	1	1	1	1	20	8	12	9	10	6	7	2	15	5	2
A	Local	1	1	1	1	10	10	10	16	3	7	7	7	15	10	1
B	Business	8	6	6	2	15	6	10	8	8	8	5	7	4	3	4
B	Business	10	8	1	1	7	10	10	12	5	3	8	5	9	6	5
B	USACE	12	12	10	10	12	7	2	2	2	5	5	2	7	7	5
B	USACE	10	12	10	14	10	9	8	5	7	3	2	4	2	3	1
B	USACE	5	5	5	5	10	5	10	10	5	5	5	5	7	15	3
B	Federal	6	6	5	5	20	6	6	4	7	4	5	3	9	8	6
B	Federal	5	5	5	5	10	10	10	5	5	5	5	5	10	10	5
B	Federal	10	10	5	5	10	1	10	7	5	1	5	1	5	5	20
B	Local	1	10	1	10	10	12	18	1	8	4	8	3	1	12	1
B	Local	15	9	5	2	8	5	6	8	3	8	5	5	8	5	8

Cluster	Session	Tidal Habitat Restored	Tidal Habitat Lost	Non-Tidal Restored	Non-Tidal Lost	Damage Reduced	Residual Damage	Implementation Cost	Local Cost Burdens	Regional Benefits	Cultural Heritage	Disruptions	Personal Impacts	Sustainability	Consequences	Residual Risk
B	NGO	5	10	5	10	17	1	10	5	2	3	3	3	18	7	1
B	State	5	5	5	5	10	10	10	10	10	5	10	5	10	0	0
B	State	7	12	7	12	6	3	11	6	3	3	2	2	16	5	5
B	State	5	4	5	3	9	5	5	7	6	5	10	10	8	6	12
B	State	3	15	2	2	8	10	8	8	7	1	5	12	5	6	8
C	Business	8	30	1	1	5	1	10	10	9	5	5	3	10	1	1
C	USACE	11	12	11	12	5	7	6	6	4	2	3	2	9	8	2
C	Federal	12	12	12	12	5	5	3	3	2	5	5	5	10	5	4
C	Federal	10	10	12	15	4	4	1	1	1	15	1	1	5	15	5
C	NGO	16	16	11	11	4	3	3	1	1	2	1	1	18	8	4
C	NGO	10	20	5	20	6	3	5	3	5	2	5	2	5	8	1
C	State	12	15	11	13	9	1	10	9	2	2	1	2	10	2	1
C	State	8	15	8	16	5	5	5	10	2	5	4	4	8	3	2
C	State	15	20	10	10	5	0	10	0	3	2	3	2	10	10	0
C	State	15	15	5	5	5	5	5	5	5	5	10	10	4	4	2
D	Federal	15	20	15	15	10	5	1	2	3	4	2	4	1	1	2
D	Federal	30	25	12	8	1	1	1	1	1	1	1	1	7	5	5
D	Federal	50	1	20	2	6	5	2	2	1	2	2	2	2	1	2
D	NGO	14	20	14	20	1	1	1	3	7	2	1	1	5	8	2
D	NGO	14	25	15	24	2	1	3	2	1	2	2	3	2	3	1
D	State	5	15	2	40	1	10	5	1	1	2	1	1	10	1	5

1

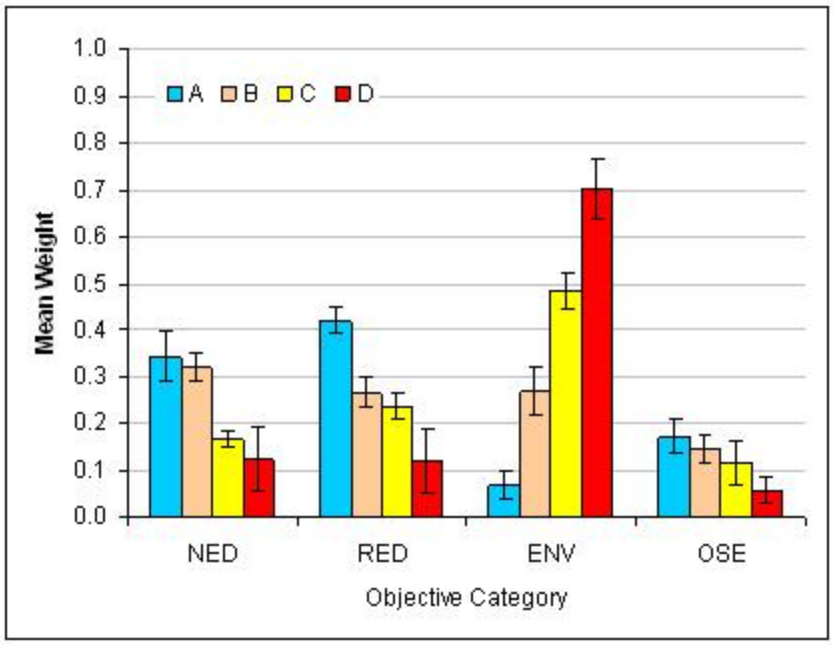


Figure 15. Stakeholder Weights for Clusters by Planning Objective

8 FORMULATION ROUND TWO

The refinement of measures consisted of modifying measures to achieve higher desired outputs (better benefits, more damage reduction, more ecosystem benefit), and to better serve the original intended purpose, based on feedback from modeling efforts or better data availability. This refinement process also included the development of data at a higher level of detail on remaining measures, and the development of data on additional areas of concern, such as cultural and environmental effects, for technical considerations not developed in detail in the first round of measure development, and for other factors.

If all of the earlier screening criteria were met, each remaining measure for a given problem area was then forwarded on for further analysis and to be evaluated and compared at a higher level of detail, in the next phase (Round Two) of analysis. This refinement process included the development of more detail in design, cost estimation, environmental components and potential impacts, potential damages prevented, site considerations, more detailed technical requirements, source material and source area considerations, variations in materials that could be used to solve the problem in a similar way, species benefits or impacts considerations, and many other technical, environmental, or economic issues.

The list of measures developed during this round by zone are presented in Table 25 below.

Table 25.

Round 2 Measures

Name (Measures screened during this round are in red)	Description
Offshore Zone	
Deer Island Restoration	Complete Restoration of Island back to its pre-Camille footprint
Increasing Islands Footprint (Option A)	Restore islands by sand dredged from off-shore
Placing River Sand in Littoral Zone (Option B)	Restore islands by placing dredged river sand in the littoral zone
Placing Off-shore Sand in Littoral Zone (Option C)	Restore islands by placing dredged sand in the littoral zone
Creating 2 FT Island Dunes with Beach Sand (Option D)	Restore islands by shaping existing beach sand into 2' high dunes
Creating 6 FT Island Dunes with Off-shore Sand (Opt E)	Restore islands by creating 6' high dunes with off-shore sand
Barrier Island No Action	
Barrier Island Restoration to Protect MS Sound Estuary	Study to recommend optimal solution to protect the MS Sound Estuary
Emergency Ship Island Restoration	Phased Advanced Engineering and Design to protect Ft. Mass. and Estuary
Sub Aquatic Vegatation Pilot Project	Tests various methods of planting SAVs in MS Sound
MS Sound Sub Aquatic Vegatation Restoration	Restore 4400 acres of lost SAVs in MS Sound using pilot results
Coastal Zone	
Hancock 40' Dune @ Elevated Roadway (Option A)	Dune adjacent to the seawall with a 40' crest at elevation 10
Hancock 50' Dune @ Elevated Roadway (Option B)	Dune adjacent to the seawall with a 50' crest at elevation 8
Hancock 20' Dune @ Elevated Roadway (Option C)	Dune adjacent to the seawall with a 20' crest at elevation 10
Hancock 30' Dune @ Elevated Roadway (Option D)	Dune adjacent to the seawall with a 30' crest at elevation 8
Hancock Dune Option A plus sea oats (Option E)	Like option A + plantings on toe of dunes
Hancock Dune Option B plus sea oats (Option F)	Like option B + plantings on toe of dunes
Hancock Dune Option C plus sea oats (Option G)	Like option C + plantings on toe of dunes
Hancock Dune Option D plus sea oats (Option H)	Like option D + plantings on toe of dunes
Hancock 55' Dune and beach berm (Option I)	Dune w/ 55' crest at elev. 10 & beach berm on south side
Hancock Dune Option I plus sea oats (Option J)	Like Option I but with plantings on toe of berm
Coastal Beach No Action	
Comprehensive 60' wide x 2' high Dune plus sea oats (Option K)	60' wide X 2' high berm with sea oats planted on 30" centers
Harrison 40' Dune @ Elevatied Roadway (Option A)	Dune adjacent to the seawall with a 40' crest at elevation 10
Harrison 50' Dune @ Elevated Roadway (Option B)	Dune adjacent to the seawall with a 50' crest at elevation 8
Harrison 20' Dune @ Elevated Roadway (Option C)	Dune adjacent to the seawall with a 20' crest at elevation 10
Harrison 30' Dune @ Elevated Roadway (Option D)	Dune adjacent to the seawall with a 30' crest at elevation 8
Harrison Dune Option A plus sea oats (Option E)	Like option A + plantings on toe of dunes
Harrison Dune Option B plus sea oats (Option F)	Like option B + plantings on toe of dunes
Harrison Option C plus sea oats (Option G)	Like option C + plantings on toe of dunes
Harrison Dune Option D plus sea oats (Option H)	Like option D + plantings on toe of dunes
Harrison 55' Dune and beach berm (Option I)	Dune w/ 55' crest at elev. 10 above datum and add beach berm
Harrison Dune Option I plus sea oats (Option J)	Like Option I but with plantings on toe of berm
Hancock Seawall/Elevated Roadway at Elevation 11	Seawall and Elevated Beach Road to Elevation 11
Harrison Seawall/Elevated Roadway at Elevation 16	Seawall and Elevated Beach Road to Elevation 16

Jackson Seawall/Elevated Roadway at Elevation 11	Seawall and Elevated Beach Road to Elevation 11
Biloxi Bay Surge Gate at Elevation 20	Required for LOD3 (same as LOD4 Biloxi Surge Barrier Option A)
St Louis Bay Surge Gate at Elevation 20	Required for LOD3 (same as LOD4 St Louis Bay Surge Option A)
Pearlington No Action	
Pearlington Nonstructural at ABFE (Reach 6)	Buyouts and/or rasing structures accounting for a 20' surge
Pearlington Ring Levee at Elev. 20 (Reach 6)	Ring levee around Pearlington 20' above datum (NAVD 88)
Pearlington Nonstructural for Elevation 20 (Reach 6)	Buyouts and/or rasing structures accounting for a 20' surge
Pearlington Ring Levee at Elev. 30 (Reach 6)	Ring levee around Pearlington 30' above datum (NAVD 88)
Pearlington Nonstructural for Elevation 30 (Reach 6)	Buyouts and/or rasing structures accounting for a 30' surge
ABFE Nonstructural for (Reach 5)	Includes everything in Reach 5
ABFE Nonstructural for (Reach 36)	Includes everything in Reach 36
Pearlington Ring Levee for up to a 'Moderate to Low Risk Event'	Ring levee around Pearlington designed for a 100-500 year event
Pearlington Nonstructural for up to a 'Moderate to Low Risk Event'	Nonstructural options for Pearlington to handle a 100-500 year event
Pearlington Ring Levee plus NS up to a 'Moderate to Low Risk Event'	Reach 5-6
Pearlington Ecosystem Restoration with NS Buyouts	Buyouts and Ecosystem Restoration of high risk properties
ABFE Nonstructural for Reaches 5,6,36)	Nonstructural buyouts / elevation of structures
Pearlington North Eco Restoration Plan - 1	76 Acres - residential infrastructure
Pearlington South Restoration Plan - 2	11 Acres - residential infrastructure
Port / West Ecosystem Restoration Plan - 3	49 Acres - residential infrastructure
Ansley Ecosystem Restoration Plan - 4	2024 Acres - residential infrastructure
Heron Bay Ecosystem Restoration Plan - 5	595 Acres - residential infrastructure
Bayou Caddy Ecosystem Restoration Plan - 8	362 Acres - residential / commercial infrastructure
Bay St. Louis / Waveland No Action	
ABFE Nonstructural for Reach 4	Nonstructural buyouts / elevation of structures
Clermont Harbor Ecosystem Restoration Plan - 9	210 Acres - residential infrastructure
ABFE Nonstructural for Reach 3	Nonstructural buyouts / elevation of structures
ABFE Nonstructural for Reaches 3,4	Nonstructural buyouts / elevation of structures
Henderson Point No Action	
Henderson Point Nonstructural for Reach 9	
Henderson Point B Accelerated Buyout	Nonstructural buyout of properties
Pass Christian Nonstructural for Reach 10	Nonstructural buyouts / elevation of structures
Pass Christian Beach Front Eco Restoration Plan - 20	21 Acres - Low forested drainage area / residential
Pass Christian Nonstructural for Reach 13	Nonstructural buyouts / elevation of structures
Pass Christian Nonstructural for Reach 15	Nonstructural buyouts / elevation of structures
Biloxi Front Beach Ecosystem Restoration Plan - 26	41 Acres South of Hwy 90 (commercial retail outlet)
Pass Christian Nonstructural for Reach 18	Nonstructural buyouts / elevation of structures
Nonstructural for Reaches 10,13,15,18	Nonstructural buyouts / elevation of structures
Ocean Springs No Action	
Ocean Springs Ring Levee at Elev. 20	Ring levee around Ocean Springs 20' above datum (NAVD 88)
Ocean Springs Nonstructural for Elevation 20	Buyouts and/or rasing structures accounting for a 20' surge

Ocean Springs Ring Levee at Elev. 30	Ring levee around Ocean Springs 30' above datum (NAVD 88)
Ocean Springs Nonstructural for Elevation 30	Buyouts and/or rasing structures accounting for a 30' surge
Ocean Springs Nonstructural for Reach 22	Nonstructural buyouts / elevation of structures
Ocean Springs Nonstructural for Reach 24	Nonstructural buyouts / elevation of structures
Nonstructural for Reaches 22,24	Nonstructural buyouts / elevation of structures
Gulf Park / Belle Fontaine No Action	
Pine Island Plan - 30	238 Acres - restore to emergent tidal marsh
Nonstructural for Reach 28	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 26	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 27	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 31	Nonstructural buyouts / elevation of structures
Gulf Park Estates Ring Levee at Elev. 20 (Option A)	Ring levee around Gulf Park Estates 20' above datum (NAVD 88)
Gulf Park Estates Alternate Ring Levee at Elev. 20 (Option C)	Ring levee around Gulf Park Estates 20' requires ABO plan
Gulf Park Estates Nonstructural for Elevation 20	Buyouts and/or rasing structures accounting for a 20' surge
Gulf Park Estates Ring Levee at Elev. 30 (Option B)	Ring levee around Gulf Park Estates 30' above datum (NAVD 88)
Gulf Park Estates Alternate Ring Levee at Elev. 30 (Option D)	Ring levee around Gulf Park Estates 30' require ABO plan
Gulf Park Estates Nonstructural for Elevation 30	Buyouts and/or rasing structures accounting for a 30' surge
Gulf Park Estates Nonstructrual ABO Plan	Nonstructural Advanced Buyout Plan for areas not in Ring Levee
Belle Fontaine Ring Levee at Elev. 20 (Option A)	Ring levee around Belle Fontaine 20' above datum (NAVD 88)
Belle Fontaine Alternate Ring Levee at Elev. 20 (Option C)	Ring levee around Belle Fontaine 20' require ABO plan
Belle Fontaine Nonstructural for Elevation 20	Buyouts and/or rasing structures accounting for a 20' surge
Belle Fontaine Ring Levee at Elev. 30 (Option B)	Ring levee around Belle Fontaine 30' above datum (NAVD 88)
Belle Fontaine Alternate Ring Levee at Elev. 30 (Option D)	Ring levee around Belle Fontaine 30' require ABO plan
Belle Fontaine Nonstructural for Elevation 30	Buyouts and/or rasing structures accounting for a 30' surge
Belle Fontaine Nonstructrual ABO Plan	Nonstructural Advanced Buyout Plan for areas not in Ring Levee
Belle Fontaine Ecosystem Restoration Plan - 31	1517 Acres (Contained in ABO area named Belle Fontaine)
Nonstructural for Reaches 26,27,28	Nonstructural buyouts / elevation of structures
Gautier No Action	
Nonstructural for Reach 29	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 30	Nonstructural buyouts / elevation of structures
Gautier Ring Levee at Elev. 20	Ring levee around Gautier 20' above datum (NAVD 88)
Gautier Nonstructural for Elevation 20	Buyouts and/or rasing structures accounting for a 20' surge
Gautier Ring Levee at Elev. 30	Ring levee around Gautier 30' above datum (NAVD 88)
Gautier Nonstructural for Elevation 30	Buyouts and/or rasing structures accounting for a 30' surge
Nonstructural for Reaches 29,30	Nonstructural buyouts / elevation of structures
Moss Point / Pascagoula No Action	
Pascagoula/Moss Point Ring Levee at Elev. 20 (Option A)	Ring levee around Pascagoula/Moss Point 20' above datum
Pascagoula / Washington St. Ring Levee at Elev. 20 (Option C)	Ring levee around Pascagoula/Washington Street @ 20'
Moss Point Alternate Ring Levee at Elev. 20 (Option E)	Ring levee around Moss Point 20' above datum (NAVD 88)
Washington St + Moss Point Alternate Ring Levee at	Ring levee around Washington St + Moss Point Alt at Elev 20

Elev. 20 (Opt G)	
Pascagoula / Moss Point Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Pascagoula/Moss Point Ring Levee at Elev. 30 (Option B)	Ring levee around Pascagoula/Moss Point 30' above datum
Pascagoula / Moss Point Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Pascagoula / Washington St. Ring Levee at Elev. 30 (Option D)	Ring levee around Pascagoula/Washington Street @ 30'
Moss Point Alternate Ring Levee at Elev. 30 (Option F)	Ring levee around Moss Point 30' above datum (NAVD 88)
Washington St + Moss Point Alternate Ring Levee at Elev. 30 (Opt H)	Ring levee around Washington St + Moss Point Alt at Elev 30
Nonstructural for Reach 54	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reach 53	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reach 52	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reach 51	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reaches 51,52,53, 54	Nonstructural buyouts / elevation of structures
Griffin Point Ecosystem Restoration Plan - 32	183 Acres - restore to emergent tidal marsh
Bayou Chico Ecosystem Restoration Plan - 33	259 Acres - restore to emergent tidal marsh
Grand Bay / Bayou Cumbest Ecosystem Restoration Plan - 34	1517 Acres (Contained in ABO area named Belle Fontaine)
Inland Zone	
Inland Zone No Action	
Inland Barrier A Levee at Elev. 20	3 County Levees at Elev. 20' plus surge gates
Inland Barrier D Levee at Elev. 20 with Roadway	3 County Levees at Elev. 20' plus surge gateswith roaway on top
Inland Barrier F Menge Ave. Levee at Elev. 20	3 County Levees at Elev. 20' with no Bay St. Louis Surge gate
Inland Barrier I Menge Ave. Levee at Elev. 20 w/ Roadway	3 County Levees at Elev. 20' with no Bay St. Louis Surge gate w/ roadway
Nonstructural at Inland Barrier Footprint for Elevation 20	Coast-wide Nonstructural comparison for inland barriers
Inland Barrier B Levee at Elev. 30	3 County Levees at Elev. 30' plus surge gates
Inland Barrier E Levee at Elev. 30 with Roadway	3 County Levees at Elev. 30' plus surge gateswith roaway on top
Inland Barrier G Menge Ave. Levee at Elev. 30	3 County Levees at Elev. 30' with no Bay St. Louis Surge gate
Inland Barrier J Menge Ave. Levee at Elev. 30 w/ Roadway	3 County Levees at Elev. 30' with no Bay St. Louis Surge gate w/ roadway
Nonstructural at Inland Barrier Footprint for Elevation 30	Coast-wide Nonstructural comparison for inland barriers
Inland Barrier C Levee at Elev. 40	3 County Levees at Elev. 40' plus surge gates
Inland Barrier H Menge Ave. Levee at Elev. 40	3 County Levees at Elev. 40' with no Bay St. Louis Surge gate
Nonstructural at Inland Barrier Footprint for Elevation 40	Coast-wide Nonstructural comparison for inland barriers
Nonstructural for Reach 7	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 37	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 38	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 1	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 2	Nonstructural buyouts / elevation of structures
Lower Bay Rd Ecosystem Restoration Plan - 6	227 Acres - residential infrastructure
Lakeshore Ecosystem Restoration Plan - 7	275 Acres - residential / commercial infrastructure
Bay St. Louis No Action	
Bay St. Louis Ring Levee at Elevation 20	Ring levee around Bay St. Louis 20' above datum (NAVD 88)

Bay St. Louis Nonstructural for Elevation 20	Buyouts and/or rasing structures accounting for a 20' surge
Bay St. Louis Ring Levee at Elevation 30	Ring levee around Bay St. Louis 30' above datum (NAVD 88)
Bay St. Louis Nonstructural for Elevation 30	Buyouts and/or rasing structures accounting for a 30' surge
Shoreline Park ABO Plan	buyouts of structures in high risk zones
Shoreline Park Ecosystem Restoration Plan	Restore tidal marsh - Requires buyout
Bayou LaCroix Ecosystem Restoration Plan - 10	260 Acres - residential infrastructure
Admiral Island DSS Ecosystem Restoration Plan - 11	245 Acres - (ABO area in Shoreline Park B and 2/3 of site is demo project and state owned)
State's Admiral Island Ecosystem Restoration	Exotic control and Debris Removal
Chapman Road Ecosystem Restoration Plan - 13	146 Acres - (ABO area in Shoreline Park C)
Diamondhead Ecosystem Restoration Plan - 15	434 Acres
Henderson Point / Pass Christian No Action	
Henderson Point A Nonstructural ABO Plan	Nonstructural Advanced Buyout Plan for areas not in Ring Levee
Delisle Ecosystem Restoration Plan - 16	Harrison County 121 Acres - removal of residential infrastructure
Ellis Ecosystem Restoration Plan - 17	443 Acres
Pine Point Shores East Ecosystem Restoration Plan - 18	103 Acres - removal of residential structures
Pine Point Shores West Ecosystem Restoration Plan - 19	84 Acres - removal of residential structures
Bayou Portage Ecosystem Restoration Plan - 21	44 Acres - Restore to emergent tidal marsh
Nonstructural for Reach 8	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 39	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 40	Nonstructural buyouts / elevation of structures
Gulf Port No Action	
Nonstructural for Reach 12	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 40	Nonstructural buyouts / elevation of structures
Turkey Creek Ecosystem Restoration Plan - 22	948 Acres - Restore Wet Pine Savannah
Brickyard Bayou at Courthouse Rd Eco Plan - 23	15 Acres - Restore to emergent tidal marsh
Biloxi River - Shorecrest Eco Restoration Plan - 24	15 Acres - Restore to emergent tidal marsh
Biloxi River - Eagle Point Eco Restoration Plan - 25	17 Acres -
Biloxi No Action	
Nonstructural for Reach 14	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 17	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 19	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 16	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 20	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 48	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 50	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 47	Nonstructural buyouts / elevation of structures
Keegan Bayou Ecosystem Restoration Plan - 27	55 Acres - restore to emergent tidal marsh
Ocean Springs No Action	
Nonstructural for Reach 21	Nonstructural buyouts / elevation of structures

Nonstructural for Reach 23	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 25	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 32	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 33	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 34	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 35	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 41	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 42	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 43	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 44	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 45	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 46	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 49	Nonstructural buyouts / elevation of structures
Nonstructural Elevations for Waveland	Elevation of Houses in the City of Waveland
Moss Point Municipal Structures Relocation	Relocating Municipal services to higher ground
Escatawpa Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
Pearl River Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
Bonnie Carrie Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
Violet Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
St. Martin Ecosystem Restoration Plan - 28	Jackson County 468 Acres - restore to emergent tidal marsh
Fort Point Ecosystem Restoration Plan - 29	84 Acres - restore to emergent tidal marsh

8.1 Refinement of Damage Reduction Measures

During early discussion with the public, many people stated the opinion that the barrier islands could be “armored”, or otherwise modified to produce a greater damage reduction effect than their current or even pre-Camille condition. Suggestions for their modification included adding additional height or length, closing off the gaps between them, or armoring them. While some thought that this idea was not a valid means of reducing damage on the mainland, the idea had a great deal of credence among numerous residents. In fact, there is a strong feeling among many that the erosion of the barrier islands contributed to the level of damage created by Katrina. While the application of armor would not be possible (due to their environmental value and inclusion in the National Parks system), the concepts of adding additional height or length were examined, to determine what degree, if any, of surge or wave reduction the barrier islands do contribute, and what they might also contribute if restored to their former dimensions and elevation. The various configurations of the barrier islands were modeled in a sensitivity analysis and is presented in Section 2.10 of the Engineering Appendix.

In conjunction with the development of various barrier islands damage reduction modeling scenarios, a structural “Lines of Defense” concept was drafted that started with an initial (or outermost) line along the alignment of the barrier islands, progressing inland to offshore breakwaters, beaches with elevated dune systems, seawalls or elevated roads (immediately inland from the beach), levees or embankments along the shoreline, or levees on various inland alignments (Highway 90, the railroad alignment, Interstate 10).

These same “lines” could also be designed to provide an increasing level of damage reduction (by increasing height) as one progressed inland.

The “Lines of Defense” (LOD) concept was modeled using both the ADCIRC model, to determine the degree of surge height reduction, and also the Beach-FX model, which was used to determine beach behavior (primarily the erosion resulting) during a hurricane event. In addition to numerous separate “lines” (barriers to surge), additional combinations of measures were also modeled to determine the most productive package of measures.

Although all iterations of the process of creating and modifying “lines” are placed under this single section of “Round Two”, there were dozens of rounds of iteration of the LODs that occurred.

The first Line of Defense, designated as LOD-1, included restoration to a pre-Camille condition, restoration to a pre-Katrina condition, restoration to a condition equivalent to the 1920’s, and one in which additional height and length was created on each island. In 1969, Hurricane Camille caused extensive erosion on the islands and created a large breach in Ship Island. This breach began to heal from the east as the littoral drift of sand added land mass to the west end of East Ship Island. This large scale breaching occurred again during Katrina, eroding away all the sand that had collected over the previous 35 years. After Katrina, it was widely expressed that if the islands had been in a pre-Camille condition, the storm surge would have been much less along the mainland coast. This scenario was modeled to help predict what effects the islands play in storm reduction. These results are discussed in Section 2-10 of the Engineering Appendix. There are a total of seven different options included in this report covering a wide range of possible ways to mitigate erosion of the islands.

The beaches (manmade in the 1950s) that extend along much of the coast were also considered as a feature that could be modified to provide some level of protection by construction of dunes on the beaches. Other projects are underway to improve the some of the beaches and proposed projects would construct small dunes on most of the beaches. Improving on these features by adding higher dunes and/or dune vegetation was designated as LOD-2. These would not provide protection from large storms, but would be beneficial for smaller storms and would provide recreational and environmental benefits. Each of the three counties has beaches that fit this scenario for adding dunes. For each county, 11 options were considered for adding some measure of dune creation. Most of the options have versions that included adding vegetation and sand fencing as well as dunes without these features. Eight of the options in each county have the dune placed against roadways that parallel the beaches with the assumption that these roadways would be elevated as a separate measure. Each of these options have a dune crest elevation less than the adjacent roadway(possibly raised in the future under LOD-3 options) to prevent sand from constantly being blown onto the road These options have some value as protection for the road, but more value as an ecological benefit. Two other options include a stand-alone dune out on the beach that could provide some level of surge defense along with ecological benefits. Each county also has an option with a wide sand berm fully planted with sea oats, the preferred vegetation to help stabilize dunes. This option will allow the sea oats to trap wind-blown sand and naturally build a dune with time. The dune options in all three counties total 33 different measures that could be considered.

As mentioned above, another existing condition along much of the coast is roadways that coincide with the beaches. It was envisioned that raising these roadways would have minimal environmental impact and provide the first hardened barrier to surge damage. These roadways, while not continuous along the coast, were designated as LOD-3. The new road elevations would not be as high as to act as a seawall for very large storms, but like LOD-2, they would be beneficial for smaller, more frequent storms. While different elevations were initially considered for the roadways, the technical difficulty of raising the roads over six feet was realized. This is due to the numerous intersecting roads, driveways, and parking areas that could not be constructed without extreme

grades. The existing beachfront roads in Hancock and Jackson have a typical grade elevation of 5.0 and the general grade elevation for US 90 in Harrison County is 10.0 although it varies from elevation7.0 to 16.0 depending on the exact location. With the existing road elevations, a top elevation of 11.0 was selected for study in Hancock and Jackson County and a top elevation of 16.0 was selected for study in Harrison County for a total of three options. It was also recognized that LOD-3 would require that a barrier be placed at the mouths of the bays to be effective against back-flooding. The location of the barriers are shown in Section 2-1 of the Engineering Appendix.

Some areas of the coast were not associated with beaches or existing roadways that allowed for a continuous defense line. When including environmental and/or technical reasons, these areas could only be viewed as stand-alone projects such as ring levees. These areas included five communities in Jackson County and two in Hancock County. For discussion purposes, these were also included in LOD-3. Each of the conceptual ring levees have been evaluated for construction at two elevations, 20.0 and 30.0 (except for the Forest Heights neighborhood) . The costs also included interior drainage, pumping stations, gates for roadways and overtopping protection. Some sites also have one or more alternate alignments. The alternate alignments were selected to lessen the impacts on wetlands, lessen the intensity of wave action or to decrease the construction costs versus adding non-structural solution areas. With all ring levee elevations and alternate alignments, there are 24 different options for further consideration.

Further inland, an existing railroad grade provided a levee-like barrier to storm surge from Katrina in some areas. This railway extends all the way across the State crossing both St. Louis Bay and Biloxi Bay. In Harrison County, the railway parallels the coastline just a few blocks inland. Using a parallel, high-ground alignment as the railway system, an inland barrier was envisioned that could be constructed to such an elevation as to protect from a large storm surge, even larger than Katrina. Like LOD-3, this system would require that the bays be closed off with barriers from surge to be effective. As LOD-4, this barrier was studied at elevations up to the maximum storm surge or maximum possible intensity (MPI) storm that could be predicted based on simulated hurricane events. These selected elevations are 20.0, 30.0 and 40.0. Possible options for LOD-4 also included omitting the surge barrier across St. Louis Bay. This would require that LOD-4 be terminated along the east side of the bay. An alternate alignment to satisfy this option was selected at Menge Avenue in Pass Christian where the LOD-4 levee could be extended northward to higher ground. This option would also leave the town of Bay St. Louis without any type of surge protection. If this alternate alignment is used, Bay St. Louis hurricane defenses could be included as a ring levee with an option under LOD-3. Many alignments for project termination on the western and eastern sides of the state were considered before one that was selected, mostly due to technical and environmental reasons. This system would not cross the Pearl River on the western side of the state nor the Pascagoula River in Jackson County. Including all the different elevations and alignments for LOD-4, there are a total of 22 options including the six options for the surge gates. A general discussion of the LOD's is included in Section 2.1 of the Engineering Appendix. A more detailed discussion can be found in Part 3 of the Engineering Appendix.

As high-level protection from the largest storm surge event, the limits of surge predicted from the MPI event was transposed to maps. While actually a non-structural measure, it was designated as LOD-5. It would be an area north of any potential surge damage that would be recommended for location of critical infrastructure such as hospitals, long-term care facilities, and emergency facilities.

To proceed with initial cost estimates, various components of the structural options were conceptually designed to the selected elevations described in previous paragraphs. The initial elevations selected for each component of the lines of defense are assumed to bracket a wide range of potential storms with corresponding surge elevations. Using these preliminary designs, rough order of magnitude cost estimates were completed for each of the structural options. These cost estimates can used to develop cost curves for future use to estimate rough estimates after final

design elevations are selected. With these cost curves, future studies can also select varied levels of protection based on risk assessments as well as taking into account future estimates of relative sea level rise.

8.2 Evaluation of Measures – Formulation Round Two

Evaluation of measures carried forward into Round Two focused on the discussion about modeling results and technical analyses on each measure and site or problem area. The study team then discussed their evaluations as a group to arrive at consensus as to what was being discovered about the benefits or issues with each remaining measure, and its conceptual application to the site or problem area in question. This evaluation process also involved the application of numerous technical models, to determine, for instance, the behavior of waves, under both a without-project and with-project condition, or the benefit over time to a particular ecosystem created by a particular measure.

At the same time as the lines of defense were being modeled and evaluated, it was also realized that some measures would not provide damage reduction from large storms. As an example, a dune placed on the beach could only be constructed to a height far short of what would be required to prevent surge resulting from a large storm event. It was also evident that several areas of the coast could not be included in continuous line of defense and would have to be addressed with either a ring levee system, or a non-structural solution. An example of this would be the original concept of a series of state-wide barriers along the coast following any one of several alignments (LODs). One concept that was initially discussed was a hard seawall type barrier southward (seaward) of any development across the entire coast, but later modified to follow only existing beach-front roadways. This eliminated the technical and environmental problems of crossing sparsely populated marshes and blocking extensive river systems. Locally populated areas were included, but defended with barriers not included with the continuous lines. These areas were included in the LOD system with individual ring levees.

From the planning session of five conceptual lines of defense, resulted numerous refined variations of each of the lines. The evaluation of these concepts was made in a study team meeting that included engineers, environmentalists, planners, and geologists. Information from along the coastline was utilized that included large scale aerial photography, topographic maps, navigation maps, and a large collection of pre and post-Katrina photographs.

The list of measures developed for each problem area was refined once more, and additional data presented for consideration, based on their continued technical, environmental, and cost-effectiveness feasibility, based on more detailed input from the resource agencies, public and private entities, and technical staff, with consideration of their ability to be combined into multi-purpose alternatives, capable of dealing with more than one identified problem at a given site. The screened list of measures was then combined into a group of well-balanced alternatives, that included both non-structural and if applicable, structural measures that could potentially address the entire suite of environmental problems plaguing an individual site or problem area. Formulation of these alternatives also incorporated the following criteria:

- Does a potential alternative provide for an improvement in function and/or habitat values of significant resources that might also provide for potential preservation of fish and wildlife and their habitats?
- Does a proposed action or project negatively impact low income or minority populations and/or children [i.e. Executive Orders (EOs) Environmental Justice and Protection of Children)?
- Does a proposed alternative provide a potential reduction in coastal erosion?

- Does a proposed alternative provide a potential reduction in the extent or level of saltwater intrusion (encroachment)?
- Does the proposed project fit in, with, or complement the objectives of the State of Mississippi and/or locals' plans and desires for the area?
- Does the proposal contribute to the short-term or long-term recovery of coastal Mississippi?

Using these questions, as continued evaluative tools, the PDT provided for consideration, the additional criteria:

- effectiveness;
- completeness;
- acceptability; and,
- efficiency (cost-effectiveness).

Additional evaluative questions being asked by the study team, in its development of information on potential measures, but not considered screening criteria, also included:

- Does that measure provide a reduction in risk at that specific site, or in other locations?
- Does that measure provide a reduction in damage at that specific site, or in other locations?
- Can that measure be combined as a component of a multi-purpose alternative?
- Can that measure be capable of dealing with more than one identified problem at a given site?
- Does a proposed measure or alternative provide an increase in the level of education on hurricane risks?
- Does a proposed measure or alternative provide a decrease in time before one would be warned of an impending hurricane event (i.e., more time to prepare)?
- Does a proposed measure or alternative provide an increased level of precision in information on the level of threat (i.e., better information on landfall location and magnitude of the event)?
- Does a proposed measure or alternative provide an increase in the effectiveness of hurricane/storm warning to area residents and visitors?
- Does a proposed measure or alternative provide better education as to evacuation options, required items a family or business might want to evacuate, and definitive information on routes to safety?
- Does this effort duplicate or compliment the work of others?
- Does the problem (or would lack of a solution to the problem) enhance protection of life?
- Does the problem (or would lack of a solution to the problem) enhance protection of property?
- Is a potential alternative sustainable after implementation?
- Does a potential alternative still provide a potential reduction in hurricane or storm damage (if applicable)?
- Does a potential alternative still provide a potential reduction in coastal erosion (if applicable)?
- Does a potential alternative still provide a potential reduction in the extent or level of saltwater intrusion (if applicable)?

- Does a potential alternative still provide for potential preservation of fish and wildlife and their habitats (if applicable)?
- Does a proposed action or project negatively impact low income or minority populations?
- Is the cost reasonable in the light of the risk and consequences of not implementing the project?
- Are there unresolved issues (with other groups or organizations) regarding this problem or proposed solution that may lead to longer implementation times?
- Would a proposed activity or project have potential regulatory and/or environmental issues that would preclude being implemented in the near-term?
- Does the proposed project fit in with, or complement the objectives of the State and/or locals plans and desires for this area?
- Would the implantation of the proposed project preclude other future options that may have a higher level of contribution or damage reduction?
- Does the proposed project contribute to the short, or longer-term recovery of coastal Mississippi?

8.3 Comparison of Measures – Formulation Round Two

Comparison of Round Two measures consisted of presentation of conditions and potential change in conditions, under "No-Action", future "without-project", and future "with-project" conditions for each site or problem area. Data presented for comparison in Round Two included preliminary costs, benefits (monetary, or economic, environmental outputs, societal, etc.) to be derived from measure implementation, problems related to implementation, more detailed design considerations, environmental outputs and potential impacts, potential damages prevented, geotechnical/site considerations, more detailed technical requirements, source material and source area considerations, variations in materials that could be used to solve the problem in a similar way, species benefits or impacts considerations, and many other technical, environmental, or economic issues.

Comparison of damage reduction measures centered on the performance of a given measure in regards to how effectively it reduced surge height and extent, compared to other measures of similar output. This involved numerous iterations of potential height and geographic coverage, since literally thousands of potential alignments of levee or embankment might be created. The goal in damage reduction measure formulation was to reduce damages to the maximum extent possible for a given type of structural or non-structural measure. While many different measures such as levees, gates, seawalls, relocations, or structure elevations might produce a similar monetary damage reduction benefit, numerous iterations were necessary to develop the best measure of a given type, given the large number of variations that might be required to produce the least costly and most productive measure. The most notable differences in flood damage reduction measures were found when comparing 3rd line of defense (elevated seawall and beach roadways) with nonstructural measures along the same area (see Table 26). The structural measures are very costly for the amount of damages reduced compared to the nonstructural measures, especially when taken in consideration that they must be constructed in tandem with surge barriers across the bays.

Table 26.
Expected Annual Damage Reduction

Measures	Expected Annual Damage Reduction (Annual $)[1]	Residual Damage (Annual $)[1]	Implementation Cost ($)	Annual O&M (Annual $)	Average Annual Cost (Annual $)
(No Action)	$0	$0	$0	$0	$0
Seawall/Elevated Roadway[2]	$52,030,000	$374,010,000	$5,002,500,000	$60,148,000	$306,127,051
ABFE Nonstructural at Seawall/Elevated Roadway Footprint	$200,860,000	$225,180,000	$8,483,400,000	$110,000	$417,249,166

1/ Expected annual damages reduced are rounded to the nearest thousand dollars.
2/ The elimination of the seawall and elevated roadway option also eliminates the beach and dune placement options that are dependent on the raising of the seawall and roadway.

Comparison of ecosystem restoration measures involved the comparison of costs versus outputs, expressed in functional capacity units, FHIs, and other measures of benefit output, such as achievement of a critical level of restoration in regards to the number of a certain plant required to sustain long-term restoration of a specific ecosystem, or removal of an invasive plant that would prevent full restoration of that ecosystem.

The following four models were once again utilized by the MsCIP environmental team to evaluate the performance comparison of potential ecosystem restoration measures:

- Mississippi and Alabama Gulf Coast Tidal Fringe HGM;
- Wet Pine Savannah HGM;
- FHI Coastal Maritime Forest/Beach-Dune Evaluation Model; and
- GIS-based Wetland Restoration SDSS.

Future with-project conditions were established by the study team, in analysis of the specific functions that would be modified, either positively or negatively, at each site. Those scores are presented in the Environmental Appendix, and summarized below.

Table 27.

Summary of Environmental Benefits.

Site	Restoration Acres	Plan	Average Annual Functional Unit Benefit
Turkey Creek	879	Existing Condition (plans 1-2)	0
Turkey Creek	689	Existing Condition (plans 3-4)	0
Turkey Creek	190	Existing Condition (plans 5-6)	0
Turkey Creek	879	No-action plan (plans 1-2)	0
Turkey Creek	689	No-action plan (plans 3-4)	0
Turkey Creek	190	No-action plan (plans 5-6)	0
Turkey Creek	879	plan 1	2,046

Site	Restoration Acres	Plan	Average Annual Functional Unit Benefit
Turkey Creek	879	plan 2	1,352
Turkey Creek	689	plan 3	1,565
Turkey Creek	689	plan 4	815
Turkey Creek	190	plan 5	481
Turkey Creek	190	plan 6	327
Bayou Cumbest	373	No-action plan	0
Bayou Cumbest	373	plan 1	647
Bayou Cumbest	373	plan 2	637
Bayou Cumbest	373	plan 3	622
Bayou Cumbest	373	plan 4	582
Bayou Cumbest	373	plan 5	572
Bayou Cumbest	373	plan 6	557
Dantzler	385	No-action plan	0
Dantzler	385	Plan 1	1,244
Dantzler	385	Plan 2	943
Dantzler	151	Plan 3	488
Dantzler	151	Plan 4	370
Dantzler	234	Plan 5	756
Dantzler	234	Plan 6	573
Admiral Island	118	No-action plan	0
Admiral Island	118	Plan 1	1,244
Admiral Island	118	Plan 2	943
Admiral Island	118	Plan 3	488
Admiral Island	118	Plan 4	370
Admiral Island	118	Plan 5	756
Franklin Creek	149	No-action plan (plans 1-2)	0
Franklin Creek	56	No-action plan (plans 3-4)	0
Franklin Creek	149	plan 1	516
Franklin Creek	149	plan 2	399
Franklin Creek	56	plan 3	194
Franklin Creek	56	plan 4	150

(1) AAFU's are based on a 50-year period of analysis.

(2) See Economic Appendix for cost-effective analysis.

8.4 Screening of Measures – Formulation Round Two

Screening of remaining measures again involved comparison of the relative benefits, impacts, costs, societal impacts, or other outputs of a given plan, as compared to each other and the "No-Action" Plan. Screening of measures during Round Two also included the incorporation of data presented to the public and other local decision-makers, as part of the public involvement process.

Screening in Phase Two eliminated a large number of site-specific measures, such as certain seawall or beach berm/dune alternatives, based on their failure to achieve significant damage reduction. Screening also eliminated a large number of embankment/levee options, as simply too environmentally damaging or technically infeasible for further consideration. These included levees,

embankments, and floodwalls across embayments and channels in western Hancock and eastern Jackson Counties, levees across Grand Bay Marsh, or the Pearl River delta systems, and across wetland areas along other parts of the coast, as shown in Table 28.

Table 28.

Summary of Round2 Measures Screened

Measures Screened During Round 2
Increasing Islands Footprint (Option A)
Hancock 40' Dune @ Elevated Roadway (Option A)
Hancock 50' Dune @ Elevated Roadway (Option B)
Hancock 20' Dune @ Elevated Roadway (Option C)
Hancock 30' Dune @ Elevated Roadway (Option D)
Hancock Dune Option A plus sea oats (Option E)
Hancock Dune Option B plus sea oats (Option F)
Hancock Dune Option C plus sea oats (Option G)
Hancock Dune Option D plus sea oats (Option H)
Hancock 55' Dune and beach berm (Option I)
Hancock Dune Option I plus sea oats (Option J)
Harrison 40' Dune @ Elevatied Roadway (Option A)
Harrison 50' Dune @ Elevated Roadway (Option B)
Harrison 20' Dune @ Elevated Roadway (Option C)
Harrison 30' Dune @ Elevated Roadway (Option D)
Harrison Dune Option A plus sea oats (Option E)
Harrison Dune Option B plus sea oats (Option F)
Harrison Option C plus sea oats (Option G)
Harrison Dune Option D plus sea oats (Option H)
Harrison 55' Dune and beach berm (Option I)
Harrison Dune Option I plus sea oats (Option J)
Hancock Seawall/Elevated Roadway at Elevation 11
Harrison Seawall/Elevated Roadway at Elevation 16
Jackson Seawall/Elevated Roadway at Elevation 11
Biloxi Bay Surge Gate at Elevation 20
St Louis Bay Surge Gate at Elevation 20

The screening of measures also included the dropping of large-scale modifications (i.e., adding additional height, closing off the channels between them) to the barrier islands or Mississippi Sound, as not creating a significant (or even moderate) reduction in damages and being too environmentally destructive. In addition, measures, such as offshore breakwaters and other offshore features designed for damage reduction, were also dropped from further consideration due to their inability to significantly affect surge height or extent.

The Corps' SDSS tool further allowed the team, in cooperation with the USFWS and MDMR, to further screen those potential wetland restoration areas that were forwarded from earlier phases of study. A subset of potential restoration sites were identified by use of SDSS then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS, for verification of

appropriate properties, the degree of environmental damage, and to further refine the applied No-Action and With-Project functional scores for each area and each potential alternative output.

This effort was also further coordinated at this stage with the ongoing efforts of the MsCIP non-structural damage reduction committee, and their results were used as the team identified potential restorations sites in coastal Mississippi that had been previously developed residential or commercial sites that no longer hosted significant amounts of development and were, therefore, subject to analysis as both buy-out and restoration sites. Thirty-four restoration sites were selected for further analysis based on this screening process, based on a combination of results from the SDSS tool and input from MDMR and USFWS personnel using personal local knowledge of the study area and adjacency to existing sensitive protected natural areas (i.e. State and/or Federal lands). In addition, eleven sites that also appeared as State of Mississippi Initiative Projects were additionally evaluated for inclusion as part of the next round of evaluations by the MsCIP study team.

9 FORMULATION ROUND THREE

The final refinement of measures consisted of incorporating comments from team members and stakeholders, as well as making adjustments based on the last set of evaluations, to narrow the list down to a small set of alternatives to be analyzed at the highest level of detail. This final refinement was directed at maximum effort to identify the most cost-effective options within the four key areas of study:

- Ecosystem restoration for preservation of fish, wildlife and habitat functions and values;
- Saltwater intrusion/encroachment reduction;
- Hurricane Storm Damage Reduction;
- Coastal Erosion Reduction.

Each was refined to achieve better benefits, more damage reduction, more ecosystem benefit, greater freshwater inflow or better salinity reduction, particularly during the period of greatest importance in the life cycles of select organisms.

9.1 Refinement of Damage Reduction Measures in the Lines of Defense Framework

Based on the screening of measures in Formulation Round Two, many of the options presented in the Engineering Appendix were dropped from further consideration. After the evaluation of the many measures, the screening process has reduced the ones that will be either recommended for construction, accelerated engineering and design, or further study. In some cases, the measures being carried forward are alternates of options that were initially proposed, but modified to accommodate enhanced damage reduction, environmental reasons or technical problems. As presented in the Engineering Appendix, the following discussions are listed by order in the defined "Lines of Defense" (LOD).

Modifications to the Mississippi barrier islands were identified as LOD-1. The islands were among the first storm reduction aspects that were discussed in Mississippi's Recovery Plan. Calls to restore the islands to a pre-Camille condition presented an option that encompassed work on all four islands, but was met with resistance from the National Park Service who has ownership of the vast majority of the islands. Through many meetings with the Park Service, a selection of options were formulated that could be combined into an alternative that would meet the objectives of Mississippi's

plan plus win the endorsement of the Park Service. This alternative also meets three of the four key areas defined above. The alternative selected for accelerated engineering and design consists of the restoration of Ship Island, littoral zone sand additions at the east ends of Petit Bois and East Ship Island, changes in maintenance dredging practices that meet the requirements of the Regional Sediment Management Practice, and a study to define the best restoration option for Cat Island. With the consideration that the Park Service has an immediate need to mitigate storm damage to two historical sites on the islands, an emergency project has also been included to help protect these sites until the full comprehensive project is completed. Without support of the NPS, the other options were screened out from further consideration.

Measures that would provide some degree of protection along the mainland beaches (LOD-2) initially included constructing dunes in several configurations, some with planted dune vegetation and other without, and elevating adjoining roadways (LOD-3). Having either of these measures at sufficient elevation to avoid requiring non-structural storm damage elements in areas landward was found to be technically difficult without major modifications to the immediate coastline. The results of the surge modeling has indicated that unless the top elevation of the dune or roadway is comparable to a levee with certification, the property owners behind the structures would still be required to elevate or relocate as if these structures were not in place. Due to the technical problems and associated non-structural requirements, most of these options were screened from further consideration. The remaining option associated with the beaches and adjoining roadways is the addition a low dune with dune vegetation onto the existing beaches due to environmental benefits.

Many parts of the Mississippi coast do not have the topography or population density that would support the concept of a continuous barrier such as a levee parallel to the coast. To help provide some storm defense for these areas, ring levees could be used. The alignment of these ring levees was initially selected to provide the maximum protection for the population centers. As these alignments were evaluated, alternate alignments were selected in some cases to minimize impact on wetlands, provide attenuation from direct wave attack, or decrease the quantity of fill required fro levee construction. Examples of this can be found in the alternate alignments at Gulf Park Estates, Belle Fontaine, and Pascagoula in Jackson County. The crest elevations for these ring levees could vary depending on the amount of risk that that community wanted to assume. The recommended crest elevation is typically designed for a surge and waves with a 0.2 percent annual chance of being exceeded.

As a set of options that could provide an inland defense from larger storms (LOD-4), a conceptual design has been completed that would be comprised of inland levees with surge barriers across the mouths of the two large bays in Mississippi. In combination, this barrier could extend from the first watershed divide east of the Pearl River in Hancock County westward to the last watershed divide west of the Pascagoula River following parallel to an existing railway. This barrier could be designed to provide a defense from a very large storm, but would have some aspects that may not have public or political support. Depending on the selected crest elevation, the levee may be hardly noticeable in some areas with naturally high topography such as portions of Biloxi, but may be a very high feature in areas with low topography such as Pass Christian. Another feature is the surge gates that would be required to prevent back-flooding into the bays. Evaluation of the requirements to have the gates as a component revealed that the closure of St. Louis Bay could be omitted provided that the levee did not cross into Hancock County, but the closure of Biloxi Bay is required to provide any beneficial defense for Gulfport or Biloxi. The surge gate evaluation provided an alternate levee alignment in Harrison County that could omit this defense in western Harrison County and Hancock County. The alternate alignment would parallel the railway through Harrison County westward to the Menge Avenue crossing where the levee would turn north to high ground. Due to its east-west extent in Harrison County, this portion of the levee system could also be used to support the construction of a major roadway on top of the levee by widening the crest.

Due to the accelerated nature of this study, the study team was unable to develop a sufficient level of detail for any of the structural measures to recommend for construction. Further, based on input received at the various public and stakeholder meetings, the structural measures did not receive a majority of support. Therefore, the study team feels that should decision makers like to see any of the structural measures further developed, a full feasibility study would be required. There is, however, sufficient information to make basic comparisons with nonstructural flood damage reduction measures.

9.2 High Hazard Area Risk Reduction Plan

While the nonstructural measures were also emotionally charged at public meetings, there was consensus that buyouts as a result of the 2005 storms be limited as to not displace large portions of communities. This resulted in a two-pronged approach to homeowner's assistance. The first stage involves the buyout of those properties that have been frequently flooded, or are at very high risk of future damage due to storm surge. The second is to develop a strategy where buyouts in large contiguous areas along the coast can occur shortly after the next devastating storm event. The significant portion of the population feels that they may be too far along with the rebuilding process to start all over in another location at this time. Further information on the High Hazard Area Risk Reduction Plan can be found in the Nonstructural Appendix.

9.3 Elevating Structures and Relocating Municipal Services

In addition to the High Hazard Area Risk Reduction Plan, the team developed alternatives for pilot projects involving new methodologies in elevating structures in the hardest hit areas of Waveland, Mississippi, and relocating municipal services to higher ground in Moss Point, Mississippi, as shown in Figure 16. . Further information on these pilot projects can be found in the Nonstructural Appendix.

Figure 16: Moss Point Public Facilities Relocation Pilot Project



9.3.1 Maximum Possible Intensity Line

The one option that will provide a very low degree of risk from storm surge is in moving all future critical or emergency infrastructure construction northward of the extent of the surge based on the "Maximum Possible Intensity" (MPI) storm event modeling. While this is only a recommendation without a program requirement, it has no direct cost.

9.4 Refinement of Ecosystem Restoration Measures

The environmental PDT was faced with assessing the three counties in coastal Mississippi, which consists of hundreds of thousands of acres of uplands, wetlands, urban, coastal forest, etc. This assessment had to be conducted in a consolidated amount of time in order to meet the MsCIP condensed schedule; therefore, the team quickly began compiling various data, such as topographic maps, navigational charts, water quality reports, soil maps, etc, that would be useful in assessing potential restoration efforts. The environmental PDT also had ERDC develop the GIS-based SDSS analysis tool that could effectively assist the team in quickly narrowing down restoration sites.

The plan formulation process began with defining the overall comprehensive natural system and its current state post-hurricane season of 2005. The MsCIP environmental PDT compared the post-hurricane conditions to the pre-hurricane conditions. In some cases, environmental contrasts were very great while in other instances not much change had occurred. The environmental team worked with a variety of Federal, state, and local entities to adequately address the magnitude of problems plaguing coastal Mississippi. Minor problems to complex integrated problems were identified and discussed amongst the team members – structural, environmental, and non-structural.

Development of a comprehensive list of problem areas consisted of single or multiple problems associated with a given site that were first identified as having been caused or exacerbated by the 2005 hurricane events. These sites were identified with damage to fish and wildlife resources, and/or saltwater intrusion. The following measures were carried forward.

9.4.1 Freshwater Diversion

A freshwater diversion project may serve to enhance the wildlife resources of the area. While there is some disagreement to the benefits of freshwater diversion projects (Turner 2006), further study will assist in determining if such diversions are ecologically feasible in eastern Jackson County, Grand Bay Savannahs and Marshes, and in western Hancock County, Hancock County Marshes. Freshwater diversions enable redistribution of freshwater and much needed sediments to these systems that are experiencing losses and erosion. Hydrodynamic circulation, salinity, and water quality model calibrations have been conducted for Mississippi Sound. Existing or baseline salinity and water quality distributions were established for March – September 1997 and 1998. Alternative freshwater diversion scenarios were developed and simulated with the calibrated models to examine changes to the baseline salinity and water quality distributions. Freshwater diversion did impact the environment in Jackson and Hancock Counties. Oysters are sensitive to specific ranges of salinity; therefore, freshwater diversions have the potential to either enhance or threaten the resource.

Several projects are presently being considered to divert freshwater from the Mississippi River or other sources as a mechanism to promote reversing a historic increase in salinity in the Mississippi Sound/Biloxi marshes area in order to support fresher marshes and oyster reef health and productivity; thus, enhancing both their economic value and the ecological services they provide.

Oysters not only support a commercial fishery but interact directly with local hydrodynamic conditions, affecting currents, flow conditions, and sedimentation patterns (Lenihan 1999). They filter large amounts of phytoplankton and detritus exerting a powerful influence on water quality, phytoplankton productivity, and nutrient cycling of estuaries (Dame 1996). Oyster reefs provide habitat for a wide range of other invertebrates present either on the oyster shell itself or in the interstices between shells. Oyster reefs also support numerous resident, transient, and juvenile fish and decapod species and may provide a refuge from predation and poor water quality conditions.

Oysters are sensitive to specific ranges of salinity; therefore, freshwater diversions have the potential to either enhance or threaten the resource. For instance, where the average salinity exceeds 15 ppt oysters often experience increased predation rates by oyster drills whereas young oysters are more susceptible to certain diseases at salinities greater than 9 ppt (Cake 1983; Chatry et al. 1983). Similarly, salinities averaging below 7.5 ppt can inhibit oyster growth and sexual maturation while salinities that persist for extended periods of time below 2 ppt can result in direct mortality (Sellers and Stanley 1984). The relationship between oyster productivity and river flow is a complex one and there does not appear to be a close link between oyster harvests and freshwater inflow (Turner 2006).

Alternately, the water diverted from riverine sources not only has lower salinity, but it usually carries more sediment and nutrients. Diversions may result in areas of excess nutrients and thus cause algal blooms, lower light attenuation and other signs of eutrophication. Therefore, any proposed diversion project needs to be carefully evaluated in order to insure the maximum probability that proper habitat and water quality conditions are met. Because of the potentially large number of projects that might require evaluation, it is essential that a screening tool be developed to cost-effectively identify those proposals which warrant the level of detailed study required to make informed decisions. It is essential that proposals that have no likelihood of success are eliminated early in the evaluation process in order to maximize the effectiveness, eliminated negative impacts from poorly designed projects, and reduce costs of evaluating the remaining candidates.

In an effort to initiate the proper evaluation of freshwater diversions, a water quality model, which is based on the CE-QUAL-ICM water quality model code, is coupled to output from a three-dimensional hydrodynamic model of the region, which is based on the CH3D hydrodynamic model (Dorth et al 2007). The version of CH3D with sigma coordinate in the vertical dimension is being used. The model grid extends seaward beyond the Chandeleur Island and includes Mobile Bay, Lake Borge, Lake Pontchartrain, the Inner Harbor Navigation Channel of New Orleans and the Mississippi river Gulf Outlet Channel. Predicted water quality constituents, including nutrients, phytoplankton, dissolved oxygen, temperature, salinity, and underwater light intensity, were evaluated for several scenarios and compared to modeled existing baseline conditions to assess relative changes.

The water quality model was applied for three alternative scenarios: (1) diversion of freshwater flow from the Mississippi River at Bonnet Carre' spillway, (2) diversion of freshwater flow from the Mississippi River at Violet Marsh, and (3) diversion of all of the Escatawpa River flow into Grand Bay. The Bonnet Carre' diversion varied by month while the Violet Marsh diversion was a constant flow of 7,500 cubic feet per second. The Escatawpa diversion is the flow that occurred in the Escatawpa River during 1998, and those values were varied daily in the model. The water quality model was applied for the period April through September 1998 using the same inputs as the final calibration run except for different hydrodynamics and different boundary conditions for the diverted flow and associated concentrations of the flow. The hydrologic model was run with the same conditions as used for the base conditions used in the water quality model calibrations for 1998 except that the additional freshwater flows were introduced.

In an effort to apply this water quality data to ecological issues, MsCIP and ERDC convened a panel of representatives from TNC, MDMR, and USM at the Gulf Coast Research Laboratory. The aim of the panel is to suggest simplistic ecological models that can be incorporated with projections from the combined hydrodynamic and water quality models to identify simulations which might result in an improvement in oyster habitat quality. The panel has identified several key attributes that need to be incorporated into the evaluation of freshwater diversion options. The first is that salinities average as closely as possible to the optimal range for oyster health and productivity. This is clearly of critical importance since the primary purpose for contemplating freshwater diversions is to improve habitat conditions for oysters. Second, a diversion should not result in extended periods of low salinity resulting in mortality or poor growth and reproduction. This consideration is particularly critical during times of high river flow or other extreme conditions. Third, a diversion should not unduly influence habitat conditions for other critical resources. Diversions that result in favorable conditions for oyster health may not be conducive to other equally important resources. For instance, most seagrasses do poorly at salinities less than 20 ppt. A diversion that results in excellent conditions over the prime commercial beds but drives salinities below 20 ppt in the seagrass elsewhere would not be acceptable. Other important habitat requirements that should also be considered for seagrass health include light availability and nutrient concentrations. These environmental concerns associated with water diversions, in addition to potential impacts on important fisheries species of those areas, require conservative actions and more study of potential impacts (positive and negative) of such practices for the long-term sustainability of nearshore and estuarine resources.

As an example, the results from a simulated diversion of 7,500 cubic feet per second of Mississippi River water near Violet, Louisiana are presented in Figure 17. The results suggest that 180 days after initiation of the diversion salinities were lowered in western Mississippi Sound. Dortch et al. (2007) sufficiently warrant additional examination. However, at present, absolute salinity values predicted by the model poorly match calibration data. Further refinement of the models should correct this limitation and must be made to allow the usefulness of the model results for estimating potential beneficial or deleterious effects on oysters and other coastal resources.

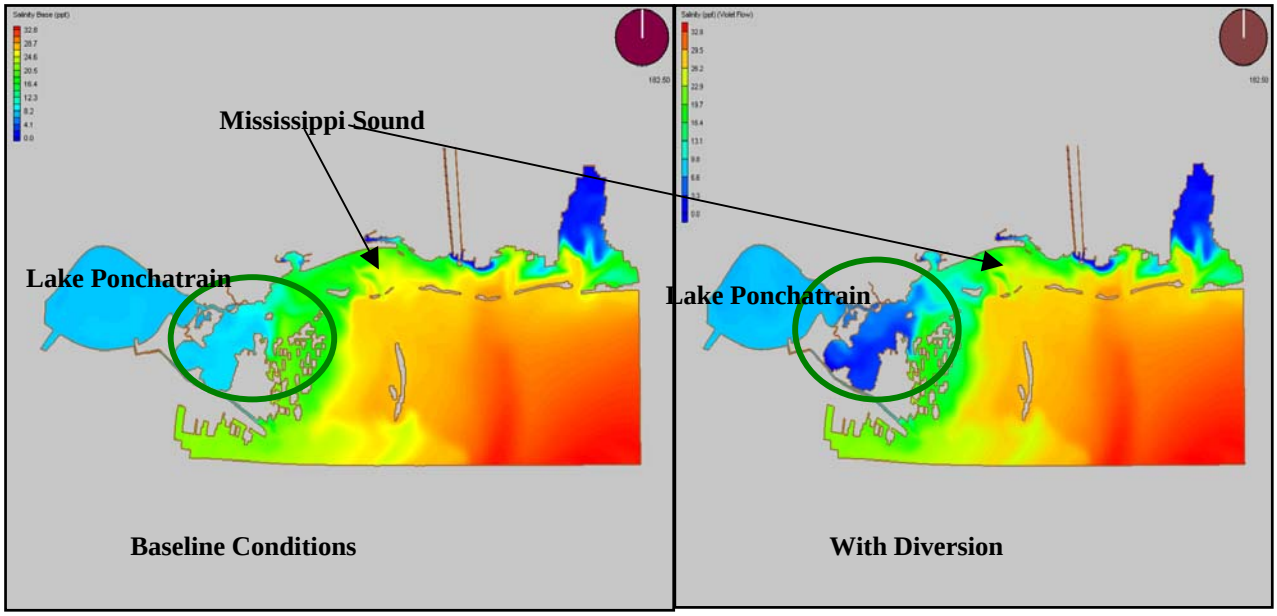


Figure 17. Projected Salinity Values 180 days after initiation of a diversion of 7,500 cfs of Mississippi River water at Violet, LA Simulated Diversion of Mississippi River into Lake Borgne Near Violet, Louisiana

Results also showed that diversion through the Bonnet Carre and through the Escatawpa/Grand Bay system have the potential to significantly influence coastal salinities. The more freshwater (i.e. 0 to about 20 ppt) areas are designated with blue and green colors while more saline (i.e. 20 to 33 ppt) conditions are designated with yellow, orange and red colors.

Ongoing and future studies can be used to refine the hydrodynamic and water quality model and tighten the calibrations. This will allow for better integrating the water quality results to ecological concepts. Also, this preliminary effort just developed information for some possible discharge scenarios in order to do a sensitivity analysis as to whether diversion could potentially affect the areas of concern. These efforts showed the potential for freshening the systems. Future studies and model runs will need to be performed to test precise operational discharge plans and seasonal influences.

Historically, the estuarine marsh within the Grand Bay NERR represented the former deltaic environments of the Pascagoula and Escatawpa Rivers in eastern Jackson County. The outlets of these rivers have shifted westward over time, severely limiting the inflow of freshwater, nutrients, and sediments into the Bayou Cumbust area of the reserve.

Currently, it is speculated that much of the freshwater entering the Grand Bay NERR estuary is from surface runoff through Bayou Heron and Bayou Heron, within the Bangs Lake Hydraulic Unit, measuring approximately 21,374 acres. Human disturbances to the area have also altered historic sheet flow and surface water flows into the area, as well as the natural migration of the Pascagoula and Escatawpa Rivers. A freshwater diversion project in the area, if feasible, may serve to enhance the wildlife resources of the area. The need for freshwater diversion at the Grand Bay savannahs and marshes would help restore the predominant wet pine savannah habitat. Shoreline erosion along the Grand Bay area (i.e. loss of the Grand Batture Islands) has also contributed to the increased salinity in the area.

The proposed project will seek to develop a refined hydrodynamic model for the area, inputting biological, water quality, and physical data into the model to evaluate a variety of freshwater

diversion scenarios. This work represents a critical first step in the final assessment of potential water diversion projects for this area. Community information will be solicited and a public workshop will be held to share the results.

Diversion of Mississippi River freshwater and/or sediments in the vicinity of Violet, Louisiana has been strongly considered because of a number of positive factors. These include proximity of the river to target coastal wetlands restoration areas, strong public support, and high confidence in potential environmental benefits. The Violet Diversion Project is under consideration by the MsCIP (Corps, Mobile District) and Corps, New Orleans District as a freshwater diversion project that could potentially have a positive impact to the Hancock County Marshes. Preliminary results from modeling a simulated diversion of 7,500 cubic feet per second of Mississippi River water near Violet, Louisiana, suggest that after 180 days of initiation of the diversion, salinities were lowered in Western Mississippi Sound sufficiently to warrant additional examination (Dortch et al 2007). Further refinement of the models should address current limitations and must be made to estimate potential beneficial or deleterious effects on oysters, seagrasses, marsh systems, and other coastal resources. Although the idea is viable, at this point, additional information is needed to determine current problems within Hancock County Marshes and potential impacts to existing coastal resources as well as navigational impacts.

9.4.2 Environmental Restoration of Historical Wetland Sites

The Corps, Mobile District began investigations for identifying potential environmental restoration sites for the purposes of storm and flood damage reduction, flood reduction, preservation of fish and wildlife habitat, and removal of habitable structures within high hazard areas. When residential and/or commercial structures and/or land are purchased for the purpose of restoring floodplain areas (i.e. non-structural component), the structures are demolished and the land is no longer available for residential and/or commercial development. Historically, when land is purchased across the U.S., it is left with all or some of the infrastructure at the site rather than restoring it to its historic setting. With the MsCIP environmental plan, land that is purchased (i.e. non-structural component – refer to Non-structural Appendix) would then be restored into historical functional wetlands. The Corps, Mobile District, in cooperation with ERDC, developed a tool to help identify potential restoration sites throughout the study area.

Development of a GIS based SDSS tool allowed the Corps, Mobile District, working in cooperation with the USFWS and MDMR, to identify and prioritize potential wetland restoration areas throughout coastal Mississippi (Lin 2007). A detailed discussion of this GIS based SDSS tool is included in the Environmental Appendix. A subset of potential restoration sites were identified by the SDSS tool and then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS. This interagency team allowed us to both confirm the accuracy of the SDSS results and to collect additional on-site information pertinent to restoration efforts. There are some major benefits in using a GIS-based SDSS approach to wetland restoration. First, it allows for the relatively rapid assessment of the large number of restoration sites across the wide study area. Second, potential sites can be evaluated and restored in a watershed or landscape context, which allows us to comprehensively evaluate the overall natural system. This approach can maximize the benefits of wetland restoration, as opposed to simply restoring wetlands where convenient or where property is available. Essentially use of this SDSS tool allowed the MsCIP environmental team to assess the entire coastline as a holistic natural system; thus, the team was more effectively able to analyze needs in coastal Mississippi.

The SDSS effort resulted in the following products:

1) A ModelBuilder based SDSS tool, which can be subsequently edited and applied to other areas along coastal Mississippi in the future as funding becomes available;

2) Maps, such as aerial photography, topographic, soil layers, etc., depicting areas in the study region that have a high probability of being successfully restored into wetland functions that buffer and/or store stormwater, and provide suitable habitat for fish and wildlife;

3) Photograph documentation and data sheets containing information on ground-truthed potential restoration sites.

This project has been further coordinated with the ongoing efforts of the MsCIP non-structural flood-proofing committee, and their results were used as the team identified potential restorations sites in coastal Mississippi. The selection of 34 restoration sites, discussed in detail in Section *4.1.5.2 Environmental Restoration of Historical Wetland Sites* of the Environmental Appendix, was based on a combination of results from the SDSS tool and input from MDMR personnel based on local knowledge of the study area and adjacency to existing sensitive protected natural areas (i.e. State and/or Federal lands).

The SDSS tool evaluated potential wetland restoration sites that had been initially selected based on having a non-natural land cover (i.e. urban, deforested, and agricultural land cover, based on MDMR 2001 land cover GIS layer) and were located in the 100-year floodplain (Lin 2007). Numerous potential environmental restorations sites were initially identified. This initial group of sites was narrowed down based on the results of the SDSS. Sites with the following characteristics were screened out:

- < 5 acres in size
- Restorability class of Low or Medium Low
- Habitat class of Low or Medium Low
- Storm Surge/Flood Protection class of Low

Initial screening yielded hundreds of sites that were then reviewed by the Corps, Mobile District, MDMR, and USFWS personnel. A more detailed discussion of the initial sites yielded is located in the Environmental Appendix. Following detailed assessment, the Environmental PDT screened these sites and selected the following 34 final restoration sites. These final environmental restoration sites include a combination of those identified based on the SDSS results, as well as some additional sites. These were made using only the non-natural land-use and 100-year flood calculations as the original site selectors (i.e. no damage layers were used), and sites were greater than or equal to 5 acres (Table 29).

Table 29.

Environmental Restoration Sites in Coastal Mississippi

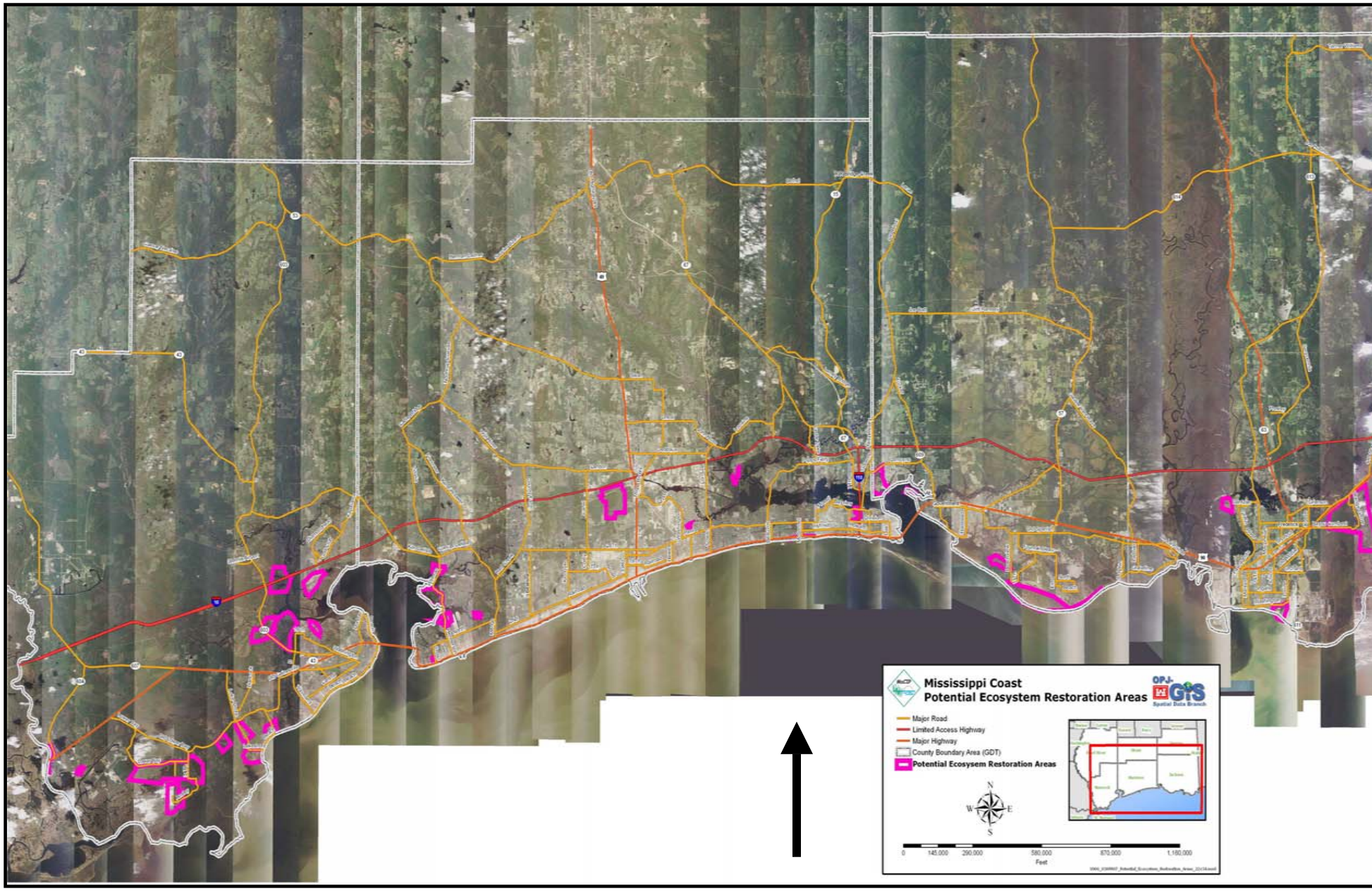
Site	Restoration Acres	Environmental Setting
(1) Pearlington, Hancock	76 acres (State owns 2,200 acres in the Pearlington area)	Emergent aquatic vegetation Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(2) Pearlington South, Hancock	11 acres	Emergent aquatic vegetation Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(3) Port /West, Hancock	49 acres	Emergent aquatic vegetation
(4) Ansley, Hancock	2,023 acres (State owns 6,000 acres west of Lakeshore Road)	Emergent aquatic vegetation Wet pine savannah
(7) Lakeshore, Hancock	275 acres	Emergent aquatic vegetation

Site	Restoration Acres	Environmental Setting
(8) Bayou Caddy/Lakeshore, Hancock	362 acres	Emergent aquatic vegetation
(9) Clermont Harbor, Hancock	209 acres	Emergent aquatic vegetation
(10) Bayou La Croix, Hancock	259 acres	Emergent aquatic vegetation
(11) Shoreline Park, Hancock	889 acres	Emergent aquatic vegetation
(12) Chapman Road, Hancock	146 acres	Emergent aquatic vegetation
(13) Jourdan River – Interstate 10 Development, Hancock	638 acres	Emergent aquatic vegetation
(14) Diamondhead, Hancock	433 acres	Emergent aquatic vegetation
(15) Delisle, Harrison	120 acres (State owns 1,000 acres)	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs
(16) Ellis Property, Harrison	443 acres	Emergent aquatic vegetation Pine savannah - wet pine flatwoods.
(17) Pine Point East, Harrison	103 acres (State owns 40-50 tax forfeited lots)	Emergent aquatic vegetation Wet pine savannah habitat
(18) Pine Point West, Harrison	83 acres (State owns 40-50 tax forfeited lots)	Emergent aquatic vegetation Wet pine savannah habitat
(19) Pass Christian Beach Front, Harrison	21 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs
(20) Pass Christian Site – Bayou Portage, Harrison	43 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs
(21) Brickyard Bayou, Harrison	14 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs
(22) Biloxi River – Shorecrest, Harrison	15 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs Riverine/levee forests
(23) Biloxi River – Eagle Point, Harrison	17 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs Riverine/levee forests
(24) Biloxi Front Beach - South of Highway 90, Harrison	40 acres	Dune System
(25) Keegan Bayou, Harrison	54 acres	Emergent aquatic vegetation Wet Pine Savannah habitat
(26) St. Martin, Jackson	467 acres	Emergent aquatic vegetation
(27) Fort Point, Jackson	83 acres	Emergent aquatic vegetation
(28) Pine Island, Jackson	237 acres	Emergent aquatic vegetation
(29) Belle Fontaine, Jackson	1,516 acres	Dune System
(30) Griffin Point, Jackson	182 acres	Emergent aquatic vegetation
(31) Bayou Chico, Jackson	258 acres	Emergent aquatic vegetation
(32) Grand Bay/Bayou Cumbest, Jackson	2,666 acres	Emergent aquatic vegetation
(33) Wachovia, Hancock	1,200 acres total – 800 marsh, 200 forested, 200 savannah	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(34) Ansley, Hancock	900 acres – 800 marsh, 100 forested	Emergent aquatic vegetation, Wet pine savannah

Site	Restoration Acres	Environmental Setting
(35) LaFrancis Camp Trenaisse, Hancock	45 acres total – all open water	Open Water
(36) DuPont, Harrison	650 acres – 170 marsh, 480 forested	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(37) Danztler, Jackson (Alternate)	900 acres – 500 marsh, 385 forested	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(38) Pascagoula River Marsh, Jackson	11,150 acres	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests

This project has been further coordinated with the ongoing efforts of the MsCIP non-structural flood-proofing committee, and their results were used as the team identified potential restorations sites in coastal Mississippi. The following selection of 38 restoration sites was based on a combination of results from the SDSS tool and input from MDMR personnel based on local knowledge of the study area and adjacency to existing sensitive protected natural areas (i.e. State and/or Federal lands). See Figure 18 for the specific identified environmental restoration sites.

Figure 18 Potential Ecosystem Restoration Site



9.4.3 Submerged Aquatic Vegetation

The continued survival and growth of seagrasses (i.e. SAVs) may be threatened by the cumulative effects of man's activities, in addition to, natural processes in the coastal marine environment. Natural causes of SAV (i.e. *D. wrightii, C. manatorum, T. testudinum*, and *R. maritime*) decline, such as disease, storm events, salinity fluctuation, and hypoxic events, coupled with declining water quality caused by anthropogenic eutrophication currently threaten the health of many SAV systems (Montague and Ley 1993, Durako and Kuss 1994, Olesen and Sand-Jensen 1994, Zieman et al 1994). These habitats provide vital refuges, feeding, resting, staging, and spawning grounds for a variety of species found in Mississippi Sound and also in the Gulf of Mexico. Past studies throughout the years have attributed anywhere from 50% to 90% of all marine species to utilize this vital habitat at some point in their life state.

In 1969, an estimated 20,000 acres of SAVs were documented and as of 1998, only 2000 acres were documented (Moncrieff 1998), see Table 30. Dramatic decreases have been noted on every Mississippi barrier island. Areas of SAV habitat loss coincide with areas where rapid coastal erosion and massive long-term movement of sand has been well-documented (Otvos 1981 and Oivanki 1994). Loss of vegetated areas corresponds with potential loss in water clarity over time due either to: (1) anthropogenic influences, (2) cyclic shifts in precipitation patterns, which would affect both salinity and turbidity, or (3) a combination of these factors (Moncrieff 1998). Primary reasons for the disappearance of SAVs are most likely an overall decline in water quality, extended periods of depressed salinities, and physical disturbances, such as tropical storms and hurricanes (Moncrieff 1998). Physical loss of habitat and decreased light availability coupled with declining water quality are the most visible features that directly affect SAVs (Moncrieff 1998). Moncrieff (1998) identified approximately 14,900 acres as being suitable SAV habitat [i.e. Potential Seagrass Habitat (PSGH)].

Table 30.

SAV Historical, 1992 and Potential Habitat

Location	1969 (acres)	1992 (acres)	PSGH
Buccaneer State Park	206	55	316
Cat Island	598	169	5,128
Ship Island	1,536	253	1,603
Dog Keys Pass	2,079	0	1,149
Horn Island	5,567	530	4,350
Petit Bois Island	1,690	364	1,810
Point-aux-Chenes Bay	1,306	627	534
Totals	12,982	1,998	14,890

Reference: Moncrieff 1998

Areas of SAV habitat loss coincide with areas where rapid coastal erosion and massive long-term movement of sand has been well-documented (Otvos 1981 and Oivanki 1994). Loss of vegetated areas corresponds with potential loss in water clarity over time due either to: (1) anthropogenic influences, (2) cyclic shifts in precipitation patterns, which would affect both salinity and turbidity, or (3) a combination of these factors (Moncrieff 1998). Primary reasons for the disappearance of SAVs are most likely an overall decline in water quality, extended periods of depressed salinities, and physical disturbances, such as tropical storms and hurricanes (Moncrieff 1998). Physical loss of habitat and decreased light availability coupled with declining water quality are the most visible features that directly affect SAVs (Moncrieff 1998). Moncrieff (1998) identified approximately 14,900 acres as being suitable SAV habitat (i.e. PSGH).

Mapping techniques have very much advanced since Moncrieff's last mapping of Mississippi Sound in the late 1990s. In discussing a potential SAV restoration project with the scientific community, the one consistent need was to re-inventory the existing SAVs in Mississippi Sound. Mississippi Sound and barrier island sedimentary processes as related to seagrass biomes are important, but not currently available. The nature, extent and volumes of sediment types within both Mississippi Sound and the barrier islands are constantly in flux, necessitating a comprehensive and ongoing assessment of sedimentary dynamics. Further studies would determine existing conditions and remaining problems that challenge establishment of SAVs within Mississippi Sound. Opportunities exist to create partnerships with other Federal and state resource agencies, and NGOs to begin identifying potential SAV restoration and establishment projects. Restoration efforts should target historical locations as a starting point to begin determining current conditions and challenges, including water quality issues, available nursery stock of plants, etc., prior to implementation of actual projects.

9.4.4 Deer Island Ecosystem Restoration

Deer Island, located within the boundaries of Harrison County, Mississippi near the mouth of Biloxi Bay and the City of Biloxi, has a history of tropical storm damage. Damages from these storms has varied based on varying degrees of storm surge, wave action and wind depending on the speed, intensity, direction of travel, and proximity of the given storm. Figure 19 displays a recent aerial photograph of Deer Island, which damage was acerbated during Hurricane Katrina .

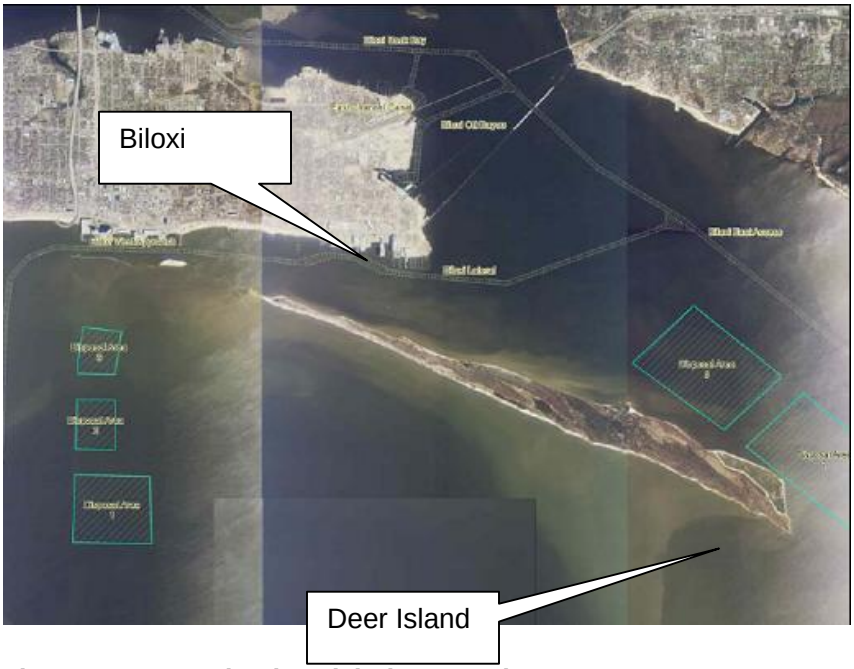


Figure 19 Deer Island Aerial Photograph

The island is considered a mainland remnant and is not part of the coastal barrier system of islands along the Mississippi Coast. The island contains a diversity of habitat areas including beach/dune areas, marsh area, and maritime forest areas. It's proximity to the City of Biloxi provides a certain amount of protection to the city from waves generated by approaching hurricanes. This protection comes at a cost to the island as that energy affects the seaward shoreline and the interior marshes. It has been estimated that the island has lost approximately 300 acres or about 34 percent of its area since 1850, due to eroding shoreline.

In 2003, because of loss of wetland marsh areas, an aquatic restoration project was proposed near the eastern tip of Deer Island. The project was authorized under the continuing authority of Section 204 of the Water Resources Development Act of 1992, as amended. Dredged material from maintenance of Biloxi Harbor was used to create approximately 45 acres of tidal marsh on the north shore of the east end of the island. Wetland vegetation was planted by over 100 volunteers in April 2005. The created marsh area withstood Hurricane Katrina with minor scouring within the site but with a minor breach of the containment dike of the marsh area. Plants within the marsh area are thriving. Figure 20 displays the existing Section 204 project.



Figure 20. Existing Section 204 Project

Currently, the island has a large breach on its western end and a small breach has formed in the central area of the island in what is know as the Grand Bayou area. As the island degrades, the Federally authorized shallow draft Biloxi West Approach and Biloxi Lateral navigation channels that run between the City of Biloxi and Deer Island will experience increased shoaling and will require more frequent, and costly, maintenance dredging activities. Dredging frequency in this area is typically as much as half the frequency of similar nearby channels. Deer Island also provides erosion protection to the mainland of the City of Biloxi. As the island continues to degrade, the impacts of increased wave action on the mainland shoreline will increase the amount of storm damages that can be suffered by commercial development congregated in this area. Figure 21 displays the general location of the west end breach and the Grand Bayou area.

In summary, there is a need to restore the shoreline of Deer Island, fill the breach areas, repair/improve existing marsh and maritime forest areas, and add additional marsh area. These

efforts will provide protection to the mainland areas behind the island and improve critical coastal wetlands.



Figure 21. Areas of Concern

There are a number of possible solutions that can be implemented to provide improvements on Deer Island. Restoration of the seaward shoreline is needed with filled areas graded and planted to establish/restore marshes and maritime forest areas. Restoration of the created marsh at the eastern end of Deer Island is needed to preserve, maintain, and enhance the aquatic habitat established by that project. Listed below, in order of precedence, are the proposed actions and their approximate cost:

Because of the shoreline losses and concern about the breaches and the resulting loss of area, following Hurricane Katrina, Federal authorization and funds were provided to restore the lost seaward shoreline and fill the breaches. That project, scheduled to begin construction in early 2008, will provide for ecosystem restoration as well as preservation of critical coastal wetlands by restoring portions of the island and its shoreline lost during storm events. However, funding for this effort is not adequate to completely restore the entire seaward shoreline. The estimated cost to completely restore the seaward shoreline of Deer Island is about $4,750,000.

Repair/replace the damaged portion of the containment dike: The small failure area of the containment dike during Hurricane Katrina contributed to the loss of material within the site. Repair or replacement of this portion of the containment dike is necessary to restore the marsh area to its

pre-Katrina level and would prevent further loss of marsh area. The estimated cost to repair/replace this portion of the containment dike is about $200,000.

Add/replace material in the containment area: New material is needed to restore the marsh area to its pre-Katrina level. This additional material will replace that which has been lost and will also be used to raise marsh areas that had through consolidation had become too low to sustain marsh habitat. The estimated cost to add this material is estimated to be about $600,000.

Analyze new stone training dikes on the north and south ends of the island: Initially, short training dikes were constructed on the eastern side of the Section 204 project. These dikes were to protect the containment dikes from erosive forces within the Mississippi Sound. Review of the failure of the containment dike suggests that the shortness of the training dikes may have contributed to the failure. A modeling analysis of the training dikes needs to be conducted to insure that the dikes are long enough to prevent future failures. The estimated cost to conduct this analysis is about $50,000.

Lengthen stone containment dikes on north and south ends: Lengthening the stone containment dikes may be necessary to reduce/eliminate the reoccurrence of failure of the containment dike. The modeling noted above will help in this determination. The estimated cost to lengthen the stone containment dikes is about $1,000,000.

Create additional marsh area adjacent to existing created marsh: The existing created marsh area and that which will be restored with the shoreline restoration project help to replace marsh areas that have been lost over time on Deer Island. The creation of additional marsh area will help to offset losses that have occurred and will enhance aquatic habitat on the island. The existing created marsh successfully demonstrates the durability of the design of the marsh area as well as the selection of the site for the creation of the marsh. The project proved its ability to withstand a fairly strong hurricane event during Hurricane Katrina. An additional marsh area can be created adjacent to the west side of the existing created marsh. The created marsh area will be about 20 acres in size and is estimated to cost about $2,400,000.

The total estimated cost for the proposed work items totals $9,000,000. Figure 22 displays the location of the proposed work items 2 through 6.



Figure 22. Location of Proposed Work Items

9.5 Evaluation of Measures – Formulation Round Three

Evaluation of measures carried forward into Round Three focused on the results of the final refinement of modeling results and technical analyses on each final measure or alternative. The study team then discussed their final evaluations as a group, to arrive at consensus as to what alternatives would be compared in the System of Accounts analysis. This final evaluation process involved the determination of final surge and wave heights for a given event frequency, surge behavior under these same events, costs required for those structural and non-structural designs or lists of features applying to a certain design level, final determination of damage reduction benefits derived for a certain design, potential societal and other OSE benefits and outcomes fort each plan, or the benefit over time to a particular ecosystem created by a particular measure. Table 31 shows the results of the final evaluation of measures to be carried over into the System of Accounts analysis.

Measure	Tidal Habitat Restored (Acres)	Tidal Habitat Lost (Acres)	Non-Tidal Habitat Restored (Acres)	Non-Tidal Habitat Lost (Acres)	Damages Reduced / Avoided ($)	Residual Damages ($)	Cost to Implement Plan ($)	Local Cost Burdens (1-10)	Regional Economic Benefits (1-10)	Cultural and Historical Heritage (1-10)	Public Service Disruptions (1-10)	Personal Impacts (1-10)	Long-Term Sustainability (1-10)	Consequences of Plan Failing (1-10)	Residual Risk (1-10)
Barrier Island No Action	0	4058	0	2705	$-	$426,040,000	$ -	10	1	1	1	1	1	2	1
Barrier Island Option A	644	0	2036	0	$ -	$426,040,000	$ 942,200,000	4	5	5	3	3	6	5	5
Barrier Island Option B	1029	0	686	0	$ -	$426,040,000	$ 1,013,800,000	3	5	4	2	3	4	3	4
Barrier Island Option C1 & C2	326	0	217	0	$ -	$426,040,000	$ 232,900,000	7	2	6	2	3	5	4	5
Barrier Island Option D	0	0	820	0	$ -	$426,040,000	$ 14,200,000	9	1	5	2	3	1	2	3
Barrier Island Option E	0	0	907	0	$ -	$426,040,000	$ 39,200,000	8	1	6	2	3	1	3	3
Barrier Island Option F	4400	4058	0	2705	$ -	$426,040,000	$ 264,500,000	3	2	2	2	3	1	2	3
Barrier Island Option G	130	1227	477	2453	$ -	$426,040,000	$ 114,100,000	5	1	7	2	3	3	4	3
Barrier Island Comp Plan	456	0	694	0	$ -	$426,040,000	$ 347,902,000	5	2	8	3	3	6	6	6
LOD2 No Action	0	0	0	0	$ -	$426,040,000	$ -	10	1	3	1	1	2	2	2
LOD2 Option I	0	0	351	0	$ -	$426,040,000	$ 63,880,000	3	2	4	2	2	4	5	2
LOD2 Option J	0	0	351	0	$ -	$426,040,000	$ 65,480,000	4	2	5	3	3	5	4	2
LOD2 Option K	0	0	304	0	$ -	$426,040,000	$ 15,430,000	7	1	6	3	3	7	4	2
Turkey Creek No Action	0	0	0	0	$ -	$ 16,890,000	$ -	10	1	3	1	1	10	10	1
Turkey Creek Ecosystem Plan 1	0	0	879	0	$ -	$ 16,890,000	$ 7,200,000	4	1	6	1	1	5	7	5
Turkey Creek Ecosystem Plan 3	0	0	689	0	$ -	$ 16,890,000	$ 5,900,000	6	1	5	1	1	6	6	4
Turkey Creek Ecosystem Plan 5	0	0	190	0	$ -	$ 16,890,000	$ 2,300,000	8	1	4	1	1	7	5	3
Bayou Cumbest No Action	0	0	0	0	$ -	$ 6,674,000	$ -	10	1	3	1	1	10	10	1
Bayou Cumbest Acquisition	0	0	0	0	$ 459,000	$ 6,674,000	$ 15,500,000	7	1	1	2	2	7	10	5
Bayou Cumbest Ecosystem Plan 1	373	0	0	0	$ 459,000	$ 6,674,000	$ 74,610,000	4	1	1	2	2	6	7	6
Bayou Cumbest Ecosystem Plan 2	373	0	0	0	$ 459,000	$ 6,674,000	$ 58,720,000	5	1	1	2	2	5	7	6
Bayou Cumbest Ecosystem Plan 3	373	0	0	0	$ 459,000	$ 6,674,000	$ 50,830,000	6	1	1	2	2	4	7	6
Bayou Cumbest Ecosystem Plan 6	373	0	0	0	$ 459,000	$ 6,674,000	$ 50,780,000	6	1	1	2	2	4	7	6
Admiral Island No Action	0	0	0	0	$ -	$ 150,860,000	$ -	10	1	2	1	1	10	10	1
Admiral Island Ecosystem Plan 1	118	0	0	0	$ -	$ 150,860,000	$ 42,900,000	4	1	3	1	1	6	7	6
Admiral Island Ecosystem Plan 2	118	0	0	0	$ -	$ 150,860,000	$ 38,400,000	5	1	3	1	1	5	7	6
Admiral Island Ecosystem Plan 3	118	0	0	0	$ -	$ 150,860,000	$ 36,100,000	6	1	3	1	1	4	7	6
Admiral Island Ecosystem Plan 6	118	0	0	0	$ -	$ 150,860,000	$ 36,000,000	6	1	3	1	1	4	7	6
Dantzler No Action	0	0	0	0	$ -	$ 7,130,000	$ -	10	1	3	1	1	10	10	1
Dantzler Ecosystem Plan 1	0	0	385	0	$ -	$ 7,130,000	$ 1,880,000	6	1	6	1	1	5	7	5
Dantzler Ecosystem Plan 3	0	0	151	0	$ -	$ 7,130,000	$ 870,000	7	1	5	1	1	6	6	4
Dantzler Ecosystem Plan 5	0	0	234	0	$ -	$ 7,130,000	$ 1,040,000	8	1	4	1	1	7	5	3
Franklin Creek No Action	0	0	0	0	$ -	$ 7,130,000	$ -	10	1	3	1	1	10	10	1
Franklin Creek Ecosystem Plan 1	0	0	149	0	$ -	$ 7,130,000	$ 1,630,000	6	1	6	1	1	5	7	5
Franklin Creek Ecosystem Plan 3	0	0	56	0	$ -	$ 7,130,000	$ 550,000	7	1	5	1	1	6	6	4
Forrest Heights No Action	0	0	0	0	$ -	$ 816,791	$ -	10	1	3	2	2	10	10	1
Forrest Heights Plan 1	0	0	0	9	$ 331,036	$ 485,755	$ 6,000,000	5	1	8	5	5	6	8	5
Forrest Heights Plan 2	0	0	0	20	$ 331,508	$ 485,283	$ 9,000,000	5	1	9	6	6	5	9	6
Nonstructural No Action	0	0	0	0	$ -	$426,040,000	$ -	10	1	3	2	2	10	10	1
Long-term Homeowners Assistance and Relocations Plan	0	0	0	0	$ 209,665,350	$ 216,374,650	$ 7,999,019,430	2	6	3	6	8	5	9	9
Very High Risk Homeowners Assistance and Relocations Plan	0	0	0	0	$ 22,380,000	$ 403,660,000	$ 482,000,000	6	3	5	5	5	8	9	7

Table 31 Evaluation Results of Final Plans

9.6 Comparison of Measures – Formulation Round Three

Comparison of Round Three measures consisted of presentation of conditions and potential change in conditions, under "No-Action", future "without-project", and future "with-project" conditions for each site or problem area, in both a descriptive presentation, and also in a "System of Accounts" comparison format. Data presented for comparison in Round Three included revised costs, benefits (monetary, or economic, environmental outputs, societal, etc.) to be derived from measure implementation, potential impacts related to implementation, detailed design considerations, environmental outputs, damages prevented, geotechnical/site considerations, more detailed technical requirements, source material and source area considerations, and other technical, environmental, or economic issues. The "System of Accounts" analysis presents information in four separate "accounts" or categories for comparison, that include "National Economic Development" (NED), which in this case only compares and contrasts the cost-effectiveness of each group of alternatives, "Regional Economic Development "(RED), which discusses the potential regional impacts of each group of alternatives, Environmental Quality (EQ), which discusses potential positive and negative environmental impacts of each group of alternatives and their environmental quality implications, and Other Social Effects (OSE) evaluations, which discusses and contrasts the potential social, and other effects of each group of alternatives.

The alternatives were also compared and contrasted according to their achievement of the additional criteria of a) effectiveness; b) completeness; c) acceptability, and d) efficiency (cost-effectiveness) according to applicable Corps guidelines.

In addition to these four traditional accounts, information on potential risks, uncertainties, and consequences, is also presented in System of Accounts format, for comparison at the same level of scrutiny of the information presented in other accounts.

After the weighting of the metrics, a multi-criteria decision analysis was made to obtain a multi-attribute utility, or stakeholder risk score for each of the final plans. This number rates each alternative as a percentage of a theoretical "perfect plan" (in the eyes of the stakeholder groups). In other words, the higher the percentage, the more acceptable the alternative should be to that stakeholder group.

The stakeholder risk scores presented in the system of accounts help to identify plans that meet stakeholder expectations. The results of the metric weighting analysis identified four distinct stakeholder groups, each clearly showing which accounts are more important to them. Therefore, the "perfect plan" would show high scores from each of the cluster groups, as well as rate well in the other accounts. Table 32 summarizes how the stakeholder risk scores vary for each alternative by each cluster group.

Table 32.

System of Accounts table for Nonstructural Alternatives

	Preference Pattern			
Location	**A**	**B**	**C**	**D**
Barrier Islands	Barrier Island Comp Plan	Barrier Island Comp Plan	Barrier Island Option A	Barrier Island Option A
LOD2	LOD2 Option K	LOD2 Option K	LOD2 Option K	LOD2 Option K
Turkey Creek	Turkey Creek No Action	Turkey Creek No Action	Turkey Creek No Action	Turkey Creek Ecosystem Plan 1
Bayou Cumbest	Bayou Cumbest Acquisition	Bayou Cumbest Acquisition	Bayou Cumbest Acquisition	Bayou Cumbest Ecosystem Plan 1
Admiral Island	Admiral Island No Action	Admiral Island No Action	Admiral Island No Action	Admiral Island Ecosystem Plan 1
Dantzler	Dantzler No Action	Dantzler No Action	Dantzler No Action	Dantzler Ecosystem Plan 1
Franklin Creek	Franklin Creek No Action	Franklin Creek No Action	Franklin Creek No Action	Franklin Creek Ecosystem Plan 1
Forrest Heights	Forrest Heights Plan 2	Forrest Heights Plan 2	Forrest Heights No Action	Forrest Heights No Action
Non-Structural	Phase I High Hazard Area Risk Reduction Plan	Long-term High Hazard Area Risk Reduction Plan	Phase I High Hazard Area Risk Reduction Plan	Long-term High Hazard Area Risk Reduction Plan

The full set of system of accounts evaluation tables are presented in the Main Report. A detailed discussion of the development of stakeholder risk scores, including an example systems of account evaluation table is presented in the Risk Appendix.

10 SELECTION OF RECOMMENDED MEASURES, PLANS AND ACTIVITIES

Members of the public, agencies, and local decision-makers, weighed in on the final list of alternative plans. Those plans identified by the “best-buy” analysis as possessing Federal interest in implementation, and passing all screening criteria, fell into one of these categories:

a) Inclusion as a project recommended for Construction Authorization;
b) Inclusion as a project requiring additional preconstruction engineering design (PED) for specific features (i.e. a long-term solution that needs more technical analyses based on the complexity of the system);
c) Inclusion as project(s) under a Programmatic Plan Authorization;
d) Inclusion as a project requiring additional Feasibility Studies Authorization (i.e. requiring extensive evaluation); and
e) Inclusion as a project requiring Advanced Design Studies for Innovative Concepts Authorization.

10.1 Projects Recommended for Construction Authorization

Eight (8) potential restoration sites (Barrier Islands, Deer Island, Turkey Creek, Bayou Cumbest, Franklin Creek, Admiral Island, Dantzler, and Bayou Cumbest SAV), and two flood damage reduction areas (Forrest Heights and HARP), were chosen as initial projects to be carried forward in the environmental component of the MsCIP Comprehensive Plan and Integrated Programmatic EIS. The potential restoration sites are located throughout the study area, in each coastal county. Two of the sites consist of restoring emergent tidal marsh habitat, three other sites restore wet pine savannah habitat, and one restores SAVs in Bayou Cumbest, one will restore the barrier islands, and one will complete restoration efforts on Deer Island. These sites allow the Corps, Mobile District to demonstrate the planning process involved in developing environmental restoration measures at each site and county, development of alternatives, and selection of a cost-effective restoration plan for each potential environmental restoration site. If authorized for further study, all other potential ecosystem restoration sites previously identified in this report would go through a similar planning and evaluation process under a Programmatic Authority.

In addition, two pilot projects are tentatively recommended. The Moss Point Municipal Structure Relocation Project is a pilot project involving relocating municipal services to higher ground within Moss Point. The information gained from this effort could help other communities in relocating their facilities to reduce the risk from future storm surge. The Waveland Flood Proofing Project is a pilot project involving new methods for elevating structures in the hardest hit areas of Waveland. The information gained from this effort could help other communities in elevating structures using FEMA's new 550 guidelines, thereby reducing their risk from future storm surge. These projects are discussed in more detail below, and are fully developed in the Non-structural Appendix.

10.1.1 Turkey Creek Ecosystem Restoration

This project site is located in north Gulfport, Mississippi, adjacent to U.S. Highway 49, a major north-west thoroughfare, and within the impaired Turkey Creek watershed. The area is becoming increasingly urbanized and development pressures are resulting in increased wetland degradation and loss by direct filling with the incumbent decrease in flood storage capability. The Turkey Creek site is approximately 880 acres of predominately undeveloped land. The site is divided by an east-west running railroad berm and contains a number of dirt road/paths and several miles of drainage ditches. These drainage ditches were constructed in the past in an effort to drain the site and control the drainage across the site into specified areas in hopes of making the site more attractive for development. Approximately 689 acres are south of the existing railway and 190 acres are located north. The railway berm effectively separates the two portions of the site and therefore these areas functions separately. The site is primarily comprised of degraded pine savannah wetland habitat. The elevated railway berm, miles of drainage ditches, and undeveloped fragments the wetland habitat and substantially alters the hydrology of the wetlands located to the north. Hurricane Katrina damages and/or destroyed much of the remaining habitat (wind and salt damage to vegetation as well as salinity increases in the soils from the surge) such that the area has been determined to be incapable of unassisted recovery.

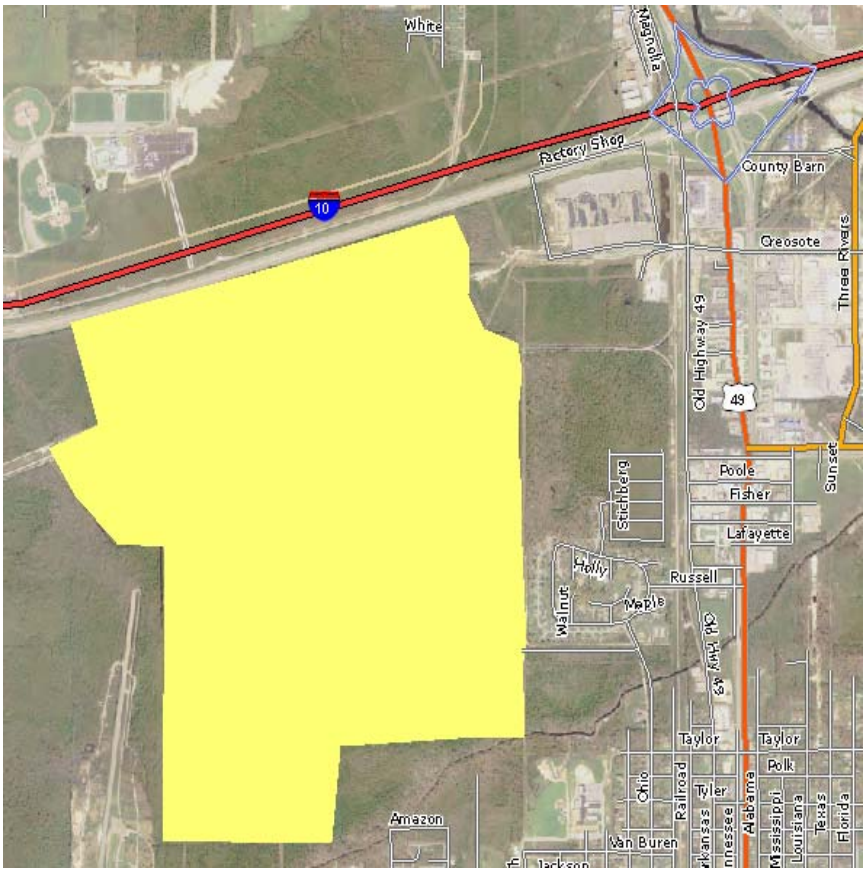


Figure 23. Location of Turkey Creek Restoration area.

Several plans were evaluated in order to determine the most cost-effective plan for restoration. The Turkey Creek site had an HGM assessment performed in 2000, using the *Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains* (Rheinhardt et al 2002). Results from this earlier assessment were used to establish baseline (current) conditions at the site.

The east-west railroad berm effectively divides the site into two distinctive areas for restoration options. These options included evaluating on the basis of addressing the degraded nature of the entire site (879 acres), the northern portion of the site (190 acres), and the southern portion of the site (689 acres). Any restoration option considered would require the acquisition of the specific portion of the site as well as any removal and/or demolition of structures.

Seven plans were developed (including no action) that considered filling in man-made ditches, maintaining native vegetation (by either burning or mowing), and excavating and removing the existing roadbeds and any additional fill placed by man. The economically ineffective plans were identified and eliminated in a cost-effective analysis which can be found in the Economic Appendix. An economically ineffective plan is a plan that costs more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the seven plans analyzed, three plans were eliminated because they produced less benefit at greater cost than a subsequent plan as shown in Figure 24. All three of the plans eliminated included the use of mowing as a management measure for restoring and/maintaining the wet pine savannah habitat.

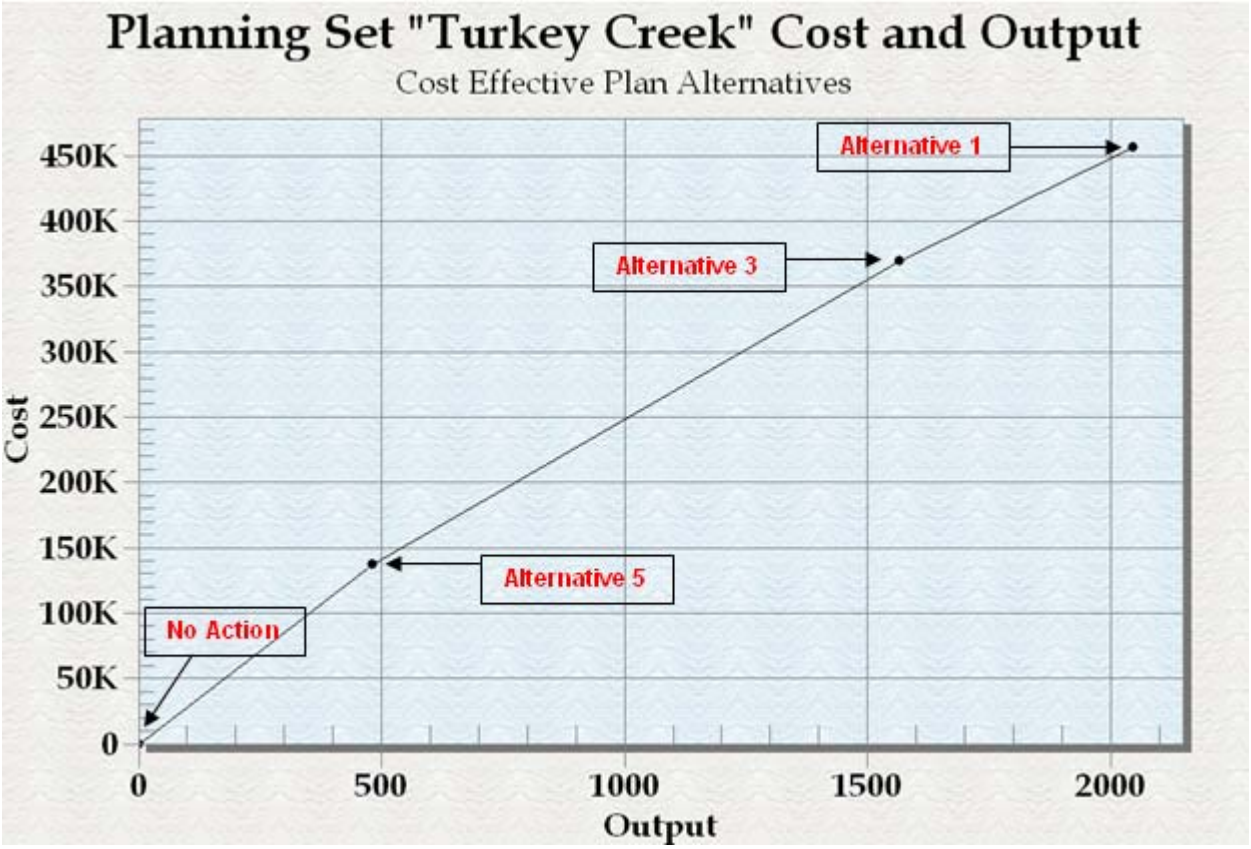


Figure 24. Display of Cost Effective Alternatives for the Turkey Creek Area

Of the three remaining plans, Plan 3 (shown as Alternative 3 above) proved to be the most cost-effective. There is not very much difference in the benefits gained in Plan 1 when compared to extra cost. There is, however, a much bigger difference in benefits for a small amount of cost when comparing Plan 3 with Plan 5, or the No Action Plan.

As shown in the System of Accounts (Table 1.18-3), the major differences between the 4 remaining plans are with the sustainability of the plan, as well as the cost to maintain the site. Again, Plan 3 has a distinct advantage over the larger Plan 1 because of the sheer volume with regards to maintenance, and in sustainability because of getting water to flow through the railroad barrier.

An essential component necessary when selecting the recommended plan at Turkey Creek was the need for burning. Burning allows the wet pine savannah environment to continue naturally as a functioning system. Although mowing does effectively keep understory plants from over colonizing the area, it does not simulate the natural conditions (i.e. seed germination, heating the pine bark, etc.) Therefore, Plan 2 is not as effective as Plans 1 and 3 due to its mowing component. The benefits are also different between Plans 1 and 3, primarily due the acreages. Plan 1 includes both the north and south parcels while Plan 3 included only the south parcel. Also, the man-made barrier within the project site will make it more difficult to maintain the necessary hydrology (water flow) for Plan 1. The MsCIP team took all of these factors into consideration and believes that Plan 3 would do the best job of achieving the desired environmental restoration outputs (i.e. a functioning wet pine savannah) while also being a cost-effective plan.

Plan 3 consists of requires the acquisition of 689 acres of predominately undeveloped land, filling the previously constructed draining ditches, excavating and removing existing roadbeds and any

additional fill, and maintaining vegetation growth by burning the project area in the initial year of construction as well as maintaining it by burning every three years over the life of the project as needed. The acquisition of properties and the demolition of structures will cost $762,000. The restoration work on the site will cost approximately $ 5,108,000, and the average annual cost of operating and maintaining the project is estimated to be $47,000.

10.1.2 Bayou Cumbest Ecosystem Restoration

The Bayou Cumbest site is located in the extreme southeastern portion of Jackson County adjacent to Bayou Cumbest and the Mississippi Sound. The area contains approximately 373 acres to be restored to emergent tidal marsh. The area currently consists of a degraded tidal marsh, as well as filled and developed areas (see Figure 25). Due to the severity of Hurricane Katrina, most of the residential development was severely damaged or destroyed. The area contains low elevations and since most residential structures have been destroyed, the opportunity exists reduce the risk of future hurricane and storm damage and to restore the once existent tidal marsh. Pursing this initial restoration project would relocate residents outside of the low-lying areas and would help demonstrate the environmental recovery of this area of the valuable marsh resource. In addition, this would also provide additional future storm surge protection to the overall coastal area by increasing the natural protection that marsh provides.

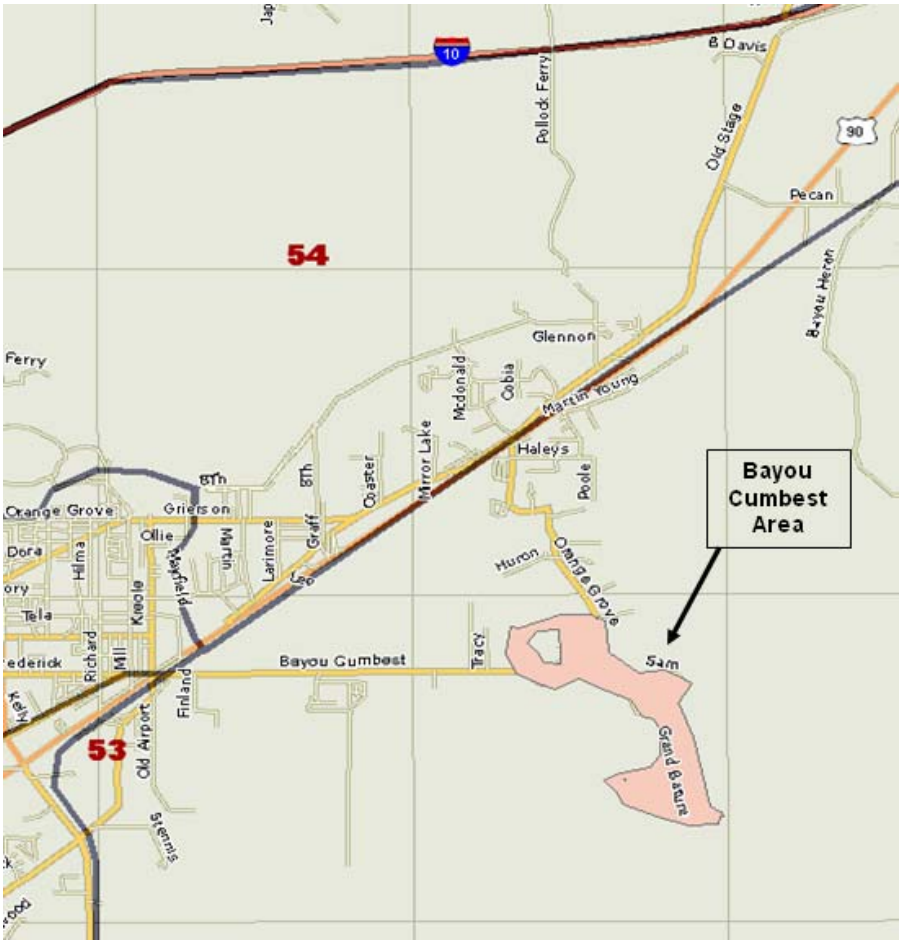


Figure 25 Bayou Cumbest Area

The acquisition of 178 parcels and the removal of 62 structures would be required for all alternatives considered for this area. The acquisition of many, if not, all of the parcels with structures for this area are being considered as part of a Jackson County request to the Mississippi Emergency Management Agency for funding via FEMA Hazard Mitigation Grams Program (HMGP). As part of all of the plans (except the no action plan) considered for this site, the Corps in cooperation with the State and Jackson County would undertake the acquisition of those properties not acquired via the HMGP which would effectively reduce the future risk of damage from hurricane and storm surges. No Ecosystem Restoration would be performed as part of the HMGP, and the 373 acre area would be allowed to remain in a degraded nature, as with the No Action alternative. Alternatives to this option include the implementation of various management measures including excavating old fill material, removing exotic species, filling in existing artificial ditches, and planting native vegetation at various densities ranging from a ½ meter to 2 meter spacing.

These management measures were combined to create seven plans (including no action) that were analyzed to determine the cost-effectiveness of each. The economically ineffective plans were identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the seven plans analyzed, Plans 4 and 5 were eliminated because they produced less benefit at greater cost than a subsequent plan. These plans lack the aspect associated with filling the artificial ditches and with native vegetation at 0.5 and 1.0 meter spacings. Similarly, Plan 6 was eliminated because it would not be a “best-buy” plan in that it produces much less benefit for only slightly less cost than Plan 3 as shown in Figure 26 below.

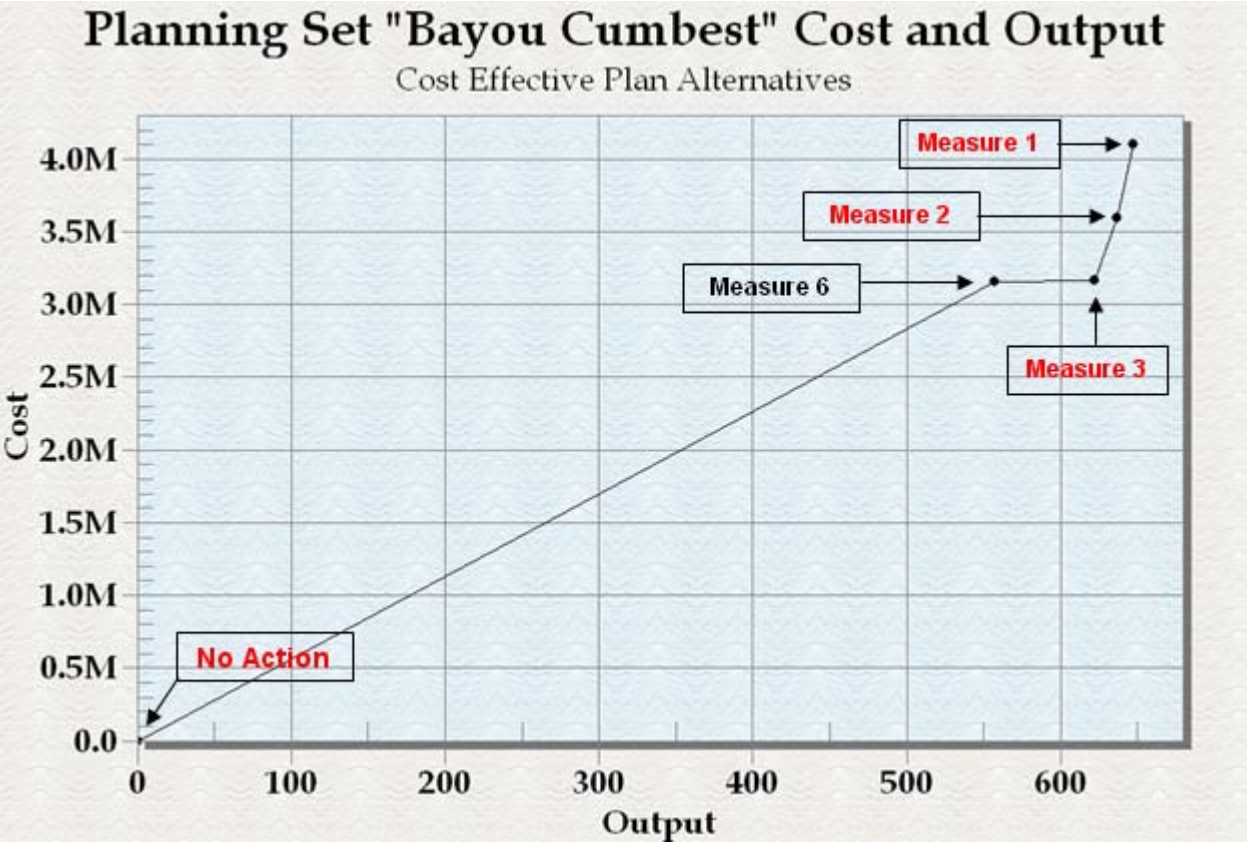


Figure 26 Cost Effective Measures (Plans) for Bayou Cumbest Area.

Plan 1 only produces slightly more benefits than Plan 2 and at a significant increase in cost. In addition, the MsCIP team has had found that the 1 meter spacing has a higher success rate than the 2 meter based on professional experience by the Corps, universities, NGOs, State, and other Federal agencies with restoration of similar emergent marsh habitats. Past experience in coastal Mississippi has proven that spacings, elevation, and hydrology are the three key essential components to obtain a successful emergent marsh site. The three spacing techniques (0.5, 1.0, and 2.0 meters) have been used recently at a local coastal Mississippi project on Deer Island in Harrison County. Although the 0.5 meter spacing may have a slightly higher success rate, the overall goal of the restoration project can be achieved by spacing the tidal emergent plants out to 1.0 meters per plant at a significant reduction in cost. The 2.0 meter spacing of Plan 3 was determined to leave the site too vulnerable to storms and/or hurricanes; thus, this spacing technique proofed to be rather risky.

The recommended plan (Plan 2) will restore 373 acres. The recommended plan consists of restoring the natural ecosystem by excavating old fill material, removing exotic plant species from non-excavated areas, filling existing artificial ditches, and planting native vegetation, such as *Spartina alterniflora* (Smooth Cordgrass) at the seaward edge of marsh; *Juncus roemerianus* (Black Needle Rush). The construction cost is estimated to be $58,700,000 with an annual average operation and maintenance cost of $372,000.

10.1.3 Admiral Island Ecosystem Restoration

The 118 acre restoration area is located in Hancock County adjacent to Bayou La Croix and near Bay of St. Louis (Figure 27). The property is owned and maintained by the State of Mississippi and consists of degraded wetland habitat as a result of debris and sediment deposited during the storm surge event of Hurricane Katrina.



Figure 27. Admiral Island Ecosystem Restoration Area

The tidal marshes in this area were ditched during the 1960s causing changes in the natural hydrology and subsequent changes in the species composition. Hurricane Katrina left extensive debris fields and sedimentation throughout the area and destroyed many native trees and vegetation. Due to the loss of native species, this area is experiencing a severe infestation of the invasive Chinese tallow tree, which is invading the marshes and the adjacent flatwoods. These exotic species outcompete the native vegetation, which provides food sources to the many fish and wildlife important species, including T&E species. Without any native competing species, these exotic species eventually become the only species in the area and result in a much degraded function of the wetlands.

Since the entire site is owned by the State and is not divided by any natural or manmade hydrologic divide, the entire site is evaluated with combinations of measures including no action, excavating old fill material, removing exotic species, and filling in the existing artificial ditches on the site.

The management measures were combined to create seven plans that were analyzed to determine the cost-effectiveness of each. Economically ineffective plans are identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the seven plans analyzed, Plans 4 and 5 were eliminated because they produced less benefit at greater cost than a subsequent plan (see Figure 28). The plans that were eliminated included leaving artificial ditches in place with native vegetation planted at 0.5 and 1.0 meter spacing.

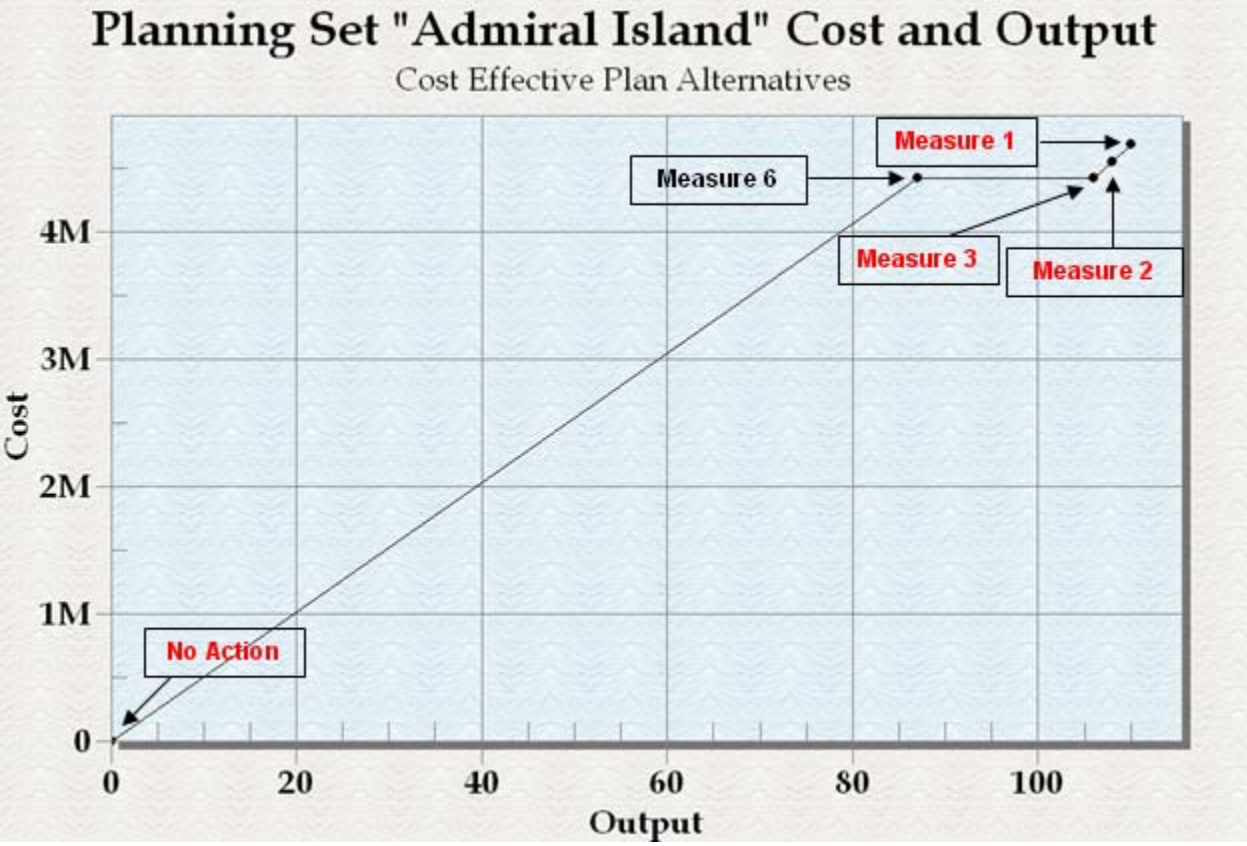


Figure 28 Display of Cost Effective Measures (Plans) for the Admiral Island Area.

Plan 1 only produces slightly more benefits than Plan 2 and at an increase in cost. In addition, the MsCIP team has had found that the 1 meter spacing has a higher success rate than the 2 meter spacing. The 2.0 meter spacing of Plan 3 was determined to leave the site too vulnerable to storms and/or hurricanes; thus, this spacing technique proofed to be rather risky.

The recommended plan (Plan 2) will restore 118 acres. The recommended plan consists of restoring the natural ecosystem by excavating old fill material, removing exotic plant species from non-excavated areas, filling existing artificial ditches, and planting native vegetation, such as *Spartina alterniflora* (Smooth Cordgrass) at the seaward edge of marsh; *Juncus roemerianus* (Black Needle Rush). The construction cost is estimated to be $38,400,000 with an annual average operation and maintenance cost of $114,000.

10.1.4 Dantzler Ecosystem Restoration

This 385-acre State-owned site is located in central Jackson County near the Pascagoula River (Figure 29).



Figure 29. Dantzler Ecosystem Restoration Area.

The site was planted in plantation pine during the 1960s and drainage ditches and stormwater lines were constructed in the early 1970s in anticipation of residential development of the site. The restorable area is split by a road, 151 of the acres are north of the road and the remaining 234 acres are south of the road. The long-term exclusion of fire and the invasion of non-native species, such as Cogon grass and Chinese tallow tree, have also severely degraded the site. These exotic species out compete the native vegetation, which provides food sources to the many fish and wildlife important species, including T&E species. Without any native competing species, these exotic species eventually become the only species in the area and result in a continuing degradation of the functional value of the wetlands. The importance of the wet pine savannah has been previously been discussed in the Turkey Creek ecosystem restoration project above.

Winds from Hurricane Katrina destroyed most if not all of the plantation pine leaving massive amounts of tree litter on the ground. In addition, debris and sedimentation resulting from the storm surge added even more litter. The exotics that were present in the site prior to the storm thrive in this type environment and it is likely that without restoration of the site they will become the dominant species inhabiting the site. Six alternative plans were developed to address the ecosystem restoration of the area.

The site is divided into two portions which could be addressed separately or in combination. Plans were evaluated on the basis of addressing the degraded nature of the entire site (385 acres), the northern portion of the site (151 acres), and the southern portion of the site (234 acres). Since the State is the owner of the site no lands would need to be acquired to accomplish this plan. The plans were also developed using a combination of measures including no action, maintaining native vegetation by burning or mowing, removing exotic vegetation, filling in artificial ditches.

These seven plans were analyzed to determine the cost-effectiveness of each. Economically ineffective plans were identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the seven plans analyzed, Plans 2, 4, and 6 were eliminated because they produced less benefit at greater cost than a subsequent plan. All three of the plans eliminated included the use of mowing as a management measure for restoring and/maintaining the wet pine savannah habitat. Of the three remaining plans, Plan 1 proved to be more cost-effective (see Figure 30) and consists of restoration of 385 acres of restoration maintained by burning. Details of the plan evaluation may be found in the Environmental Appendix to this report.

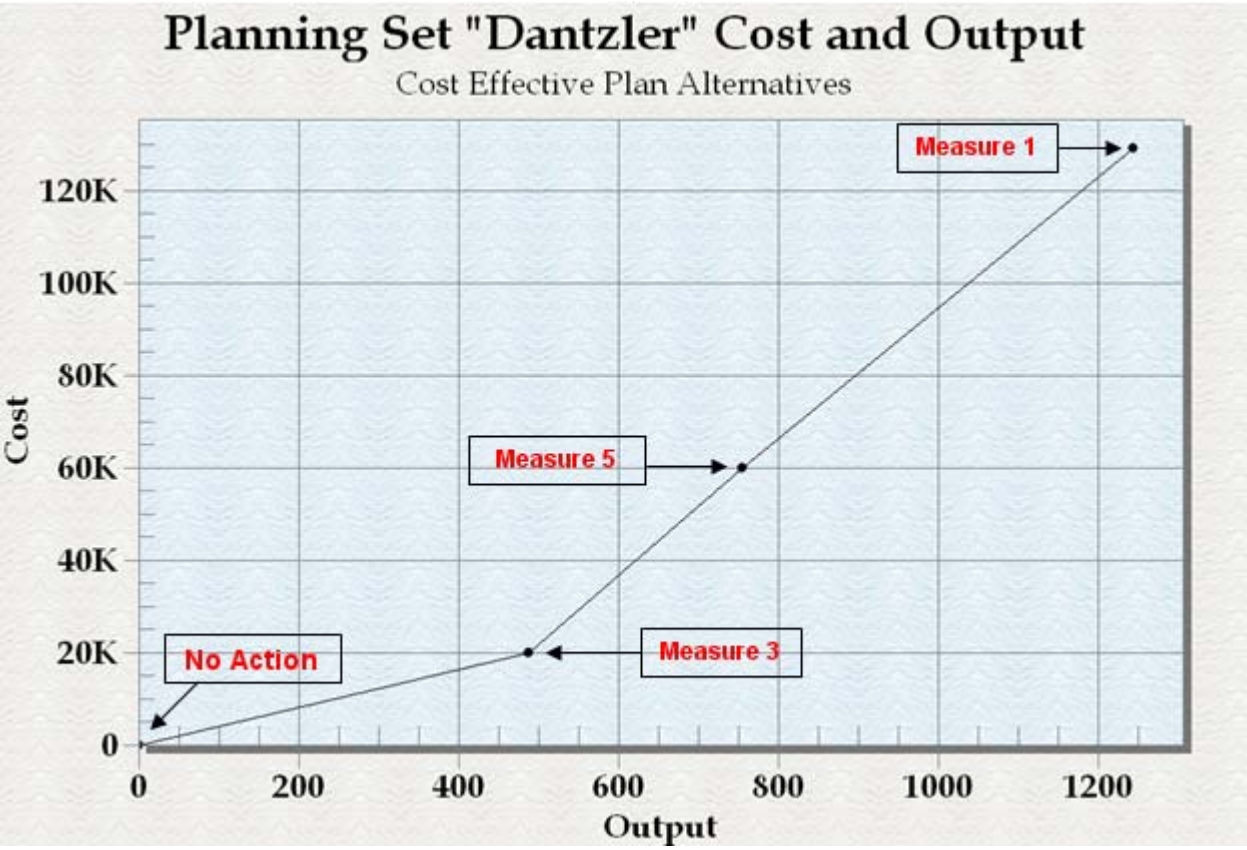


Figure 30. Display of Cost Effective Alternatives for the Dantzler Area.

An essential component necessary when selecting the recommended plan at for this restoration site was the need for burning. Burning allows the wet pine savannah environment to continue naturally as a functioning system. Although mowing does effectively keep understory plants from over

colonizing the area, it does not simulate the natural conditions (i.e. seed germination, heating the pine bark, etc.) Therefore Plan 1, with its burning measure, ranked higher than that of the mowing.

Plan 1 requires filling ditches, excavating and removing existing roadbeds and any additional fill, and maintaining vegetation growth by burning the project area in the initial year of construction as well as maintaining it by burning every three years over the life of the project as needed. As with the Turkey Creek ecosystem restoration, periodic burning of the site is a critical element to the success of the restoration. The cost of this plan is estimated to be $1,880,000 with an annual average operation and maintenance cost of $26,000.

10.1.5 Franklin Creek Ecosystem Restoration

The Franklin Creek ecosystem restoration area is located near the communities of Orange Grove and Pecan, Mississippi in eastern Jackson County, near the Mississippi - Alabama state line (see Figure 31). This area has already been funded for acquisition and demolition of 30 structures as part of the MsCIP Interim Report. The restoration area consists of 149 acres located north and south of U.S. Highway 90, a major thoroughfare through the community. This area routinely floods with only a slight rainfall; thus, this would also provide additional flood storage capacity by restoring the natural habitat. Pine savannah wetlands are commonly referred to as sponges that provide floodwater retention, groundwater recharge, and water purification. This wetland habitat is under increased developmental pressures due to the extreme and urgent housing need faced by Mississippians as they are trying to rebuild. This habitat is becoming fragmented and with the increased development, fire maintenance is increasingly harder to perform.

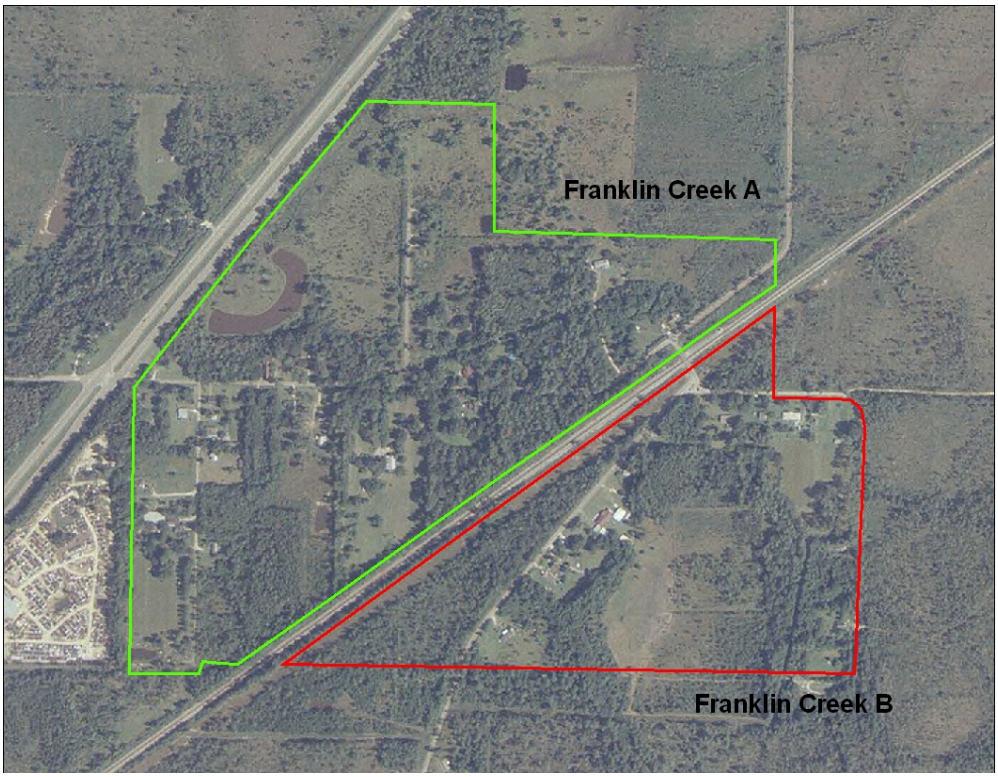


Figure 31. Franklin Creek Restoration Site.

Site evaluation options are limited to restoring the ecosystem of the entire 149 acre area or just restoring the portion of the site south of U.S. Highway 90 / L&N Railroad. Restoring the portion of the site north of the highway is not an option due to the frequent flooding of the area.

Five plans were created from a combination of measures including no action, maintaining native vegetation, excavating and removing roadbeds and fill material, filling in artificial ditches, and adding culverts to improve hydrology. The addition of culverts under the railroad berm is a necessary management measure in the restoration of the entire site as this would allow the flow of water from the frequently flooded northern area into the southern area for restoration of the natural hydrology. These plans were analyzed to determine the cost-effectiveness of each. Economically ineffective plans are identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the five plans analyzed, Plans 2 and 4 were eliminated because they produced less benefit at greater cost than a subsequent plan. These plans all involved maintenance of vegetation via mowing. Of the two remaining plans, Plan 1 proved to be by far the most cost effective and this recommended plan consists of restoration of 149 acres of restoration aided by managed water flow and maintained by burning.

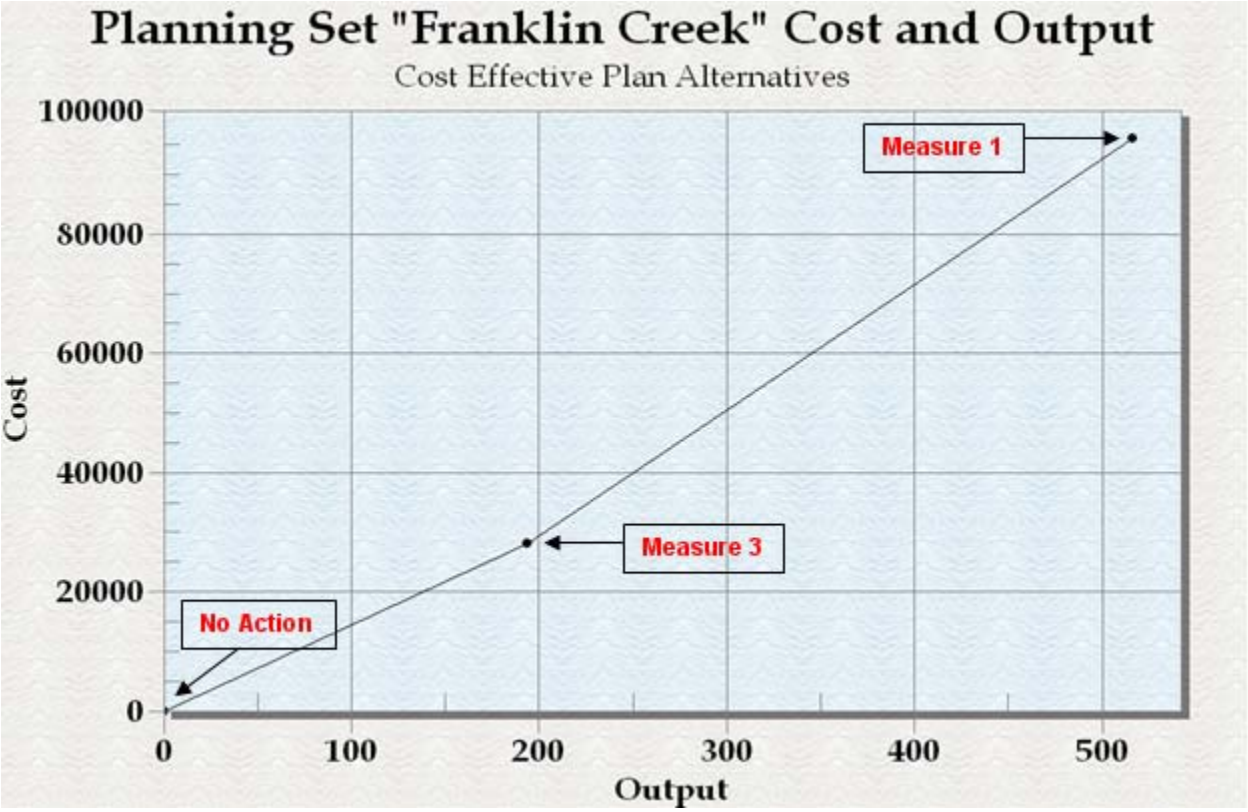


Figure 32. Display of Cost Effective Measures (Plans) for the Franklin Creek Area.

The recommended plan (Plan 1) requires filling ditches, excavating and removing existing roadbeds and any additional fill, installing culverts under the highway, and maintaining vegetation growth by burning and mowing the project area in the initial year of construction as well as maintaining it by burning every three years over the life of the project as needed. The cost of this plan is estimated to be $1,630,000 with an average annual operation and maintenance cost of $11,000 over the life of the project.

10.1.6 Moss Point Municipal Services Relocation

This report supports the recommendation for authorization to immediately implement the Moss Point Municipal Services Relocation component of the Comprehensive plan. The City of Moss Point is located north of the City of Pascagoula in Jackson County. All of the City's municipal services were disrupted by Hurricane Katrina, and their structures were either severely damaged or deemed uninhabitable. The MsCIP has formulated alternatives that would aid the city in providing basic community services in a more timely fashion after future storm events, and further demonstrate the effectiveness of relocations projects as a hurricane and storm damage reduction measure along the Mississippi coast. The best means of achieving these goals consists of relocating the city's municipal buildings to a lower risk site with regards to flooding within the incorporated limits. These buildings include the city hall, police station, fire station and community services building. Future use of the existing site of these buildings would be as open space that would provide a buffer between City and the Escatawpa River further reducing the damages from hurricane surge and flooding events.

The relocation of these facilities would greatly reduce future damages to the local infrastructure and provide a higher confidence in uninterrupted public service in future events. Regional economic benefits include an increase in sales volume of $20,250,000, a $4,286,426 increase in local income, and a net increase of 129 jobs. The construction cost of this project is $8,429,000. There are no operations and maintenance costs.

10.1.7 Waveland Floodproofing

This report supports the recommendation for authorization to immediately implement the flood proofing at Waveland, MS. The city of Waveland is located in Hancock County and was directly in the path of Hurricane Katrina. Because of the low lying nature of the city, the only flood damage reduction measures available to a portion of Waveland are either acquisition or floodproofing of individual structures. FEMA has released a manual for "Recommended Residential Construction for the Gulf Coast" which is meant to aid residents in rebuilding on strong and safe foundations. The design manual (FEMA 550) provides recommended foundation design and guidance for rebuilding homes destroyed by hurricanes in the Gulf Coast. The Waveland floodproofing alternatives are designed to evaluate the FEMA 550 guidelines with regards to current Corps' floodproofing practices. In addition to showing the application of existing elevation techniques and construction practices to reduce flood damages, this alternative would evaluate the use of possible innovative contracting techniques. These techniques would be designed to improve the Corps – contractor – homeowner relationship, focusing on using more timely and customer focused approaches. The 25 structures selected for floodproofing represent an adjacent group of structures that were not destroyed by Hurricane Katrina.

In order to evaluate the different foundation and building types, 25 structures would be selected in the Waveland area that could be safely elevated out of the 1% chance storm event, and which could not be protected by any other structural measures evaluated as part of this study. Damages to these structures would be significantly reduced and the area would serve as an example of smart growth. Regional economic benefits include an increase in sales volume of $20,250,000, a $4,286,426 increase in local income, and a net increase of 129 jobs. The construction cost is $3,130,000. There are no operations and maintenance costs.

10.1.8 SAV Restoration Pilot Project

Additional study is required to assess the complex environmental make-up impacting SAVs in Mississippi Sound due to the fact that mere planting would possibly not survive. Many questions must be answered (i.e. water quality, circulation, etc.) prior to SAV restoration implementation throughout the Mississippi sound. SAV restoration efforts across the nation have proven to be rather challenging and many examples can be identified close to Mississippi over in Florida. Therefore, the MsCIP team is recommending a pilot project in the Bayou Cumbest area. Opportunities exist to partner with Federal, state, and local resource agencies as well as NGOs. Extensive coordination with the NPS, responsible for managing and operating the Gulf Islands National Seashore, would be required for areas of potential restoration within their park boundaries. Involvement of local colleges and universities with ongoing research programs would also help to identify and pinpoint specific problems for development of potential solutions.

The first goal of this proposed community-based restoration pilot project in the Grand Bay National Estuarine Research Reserve (NERR) will result in restoration of up to 5 acres of *Ruppia maritima* resulting in the recovery of an equal amount of SAV habitat to that lost during the 2005 hurricane season. The second goal is to evaluate 3 restoration techniques to demonstrate their feasibility for larger restoration projects. The third and final goal to be achieved through volunteer involvement and educational outreach will increase awareness of the importance of SAV habitat in Mississippi Sound and provide coastal managers and restoration practitioners with the knowledge of techniques to maximize their return on dollars spent.

Three transplanting methods for restoring *R*. *maritima* will be evaluated as follows:1) direct planting from the donor site, 2) harvesting plant sprigs with one or more meristems (growth regions) from the donor site with subsequent growth in a greenhouse setting prior to planting, and 3) spreading seeds or mature flowering shoots over the restoration site. All plants and seeds would be acquired from a common donor site within the same system. After transplanting, quarterly monitoring for two years would be conducted to determine plant establishment, photosynthesis, growth, and expansion.

The education and outreach components of the project will consist of volunteer involvement and dissemination of results through a professional workshop conducted at the end of the project. Volunteers will be recruited from Grand Bay NERR's established volunteer base, which includes local schools, universities, agencies, and civic groups. This effort will help determine the most successful and cost- and labor-effective transplanting method for restoring SAV. Results will be disseminated through Grand Bay NERR's Coastal Training Program to inform coastal decision-makers and resource managers of successful restoration techniques.

This community restoration project will address the larger issue of SAV losses nationally and rates of natural recovery following disturbance versus recovery via restoration following disturbance. An estimated $500,000 would be required for the Bayou Cumbest SAV ecosystem restoration pilot and includes all effort associated with the planting and monitoring and producing a final restoration report.

10.1.9 Barrier Island Ecosystem Restoration

The barrier islands have historically constituted a barrier to saltwater, maintaining a careful balance of saltwater and freshwater flows, which sustain the valuable marine resources of Mississippi Sound. The barrier islands also provide a barrier to onshore movement of waves, and to a lesser extent storm surge, by attenuation.

Alternatives being evaluated include very limited restoration of Ship Island, only in the vicinity of the endangered cultural sites of Fort Massachusetts and French Warehouse, on (the post-Katrina

condition) “West” and “East” Ship Islands, respectively up to ‘massive’ restoration of the historic island dimensions. Although the protection of the cultural resource sites appears to be a justified option, this alternative would neither represent a complete solution, nor a completely effective means of addressing the larger problem faced on that island and the others. On the other hand, a more massive plan for barrier island restoration, or more direct application of sand, was rejected by many on the team, as unmanageable and potentially damaging, due to the unknown effects that might be introduced by placing sand into an area that could not be maintain by littoral drift over the long-term. More massive measures did not appear to provide a significantly greater volume of functional increase, for a much larger outlay of funds.

As part of the evaluation increasing the volumes of sand to the system is determined to be increasingly effective in achieving additional functional value, particularly when sand was provided directly into the littoral drift that created and nourishes the islands, so that “Mother Nature” can finish the job of distributing the sand in a natural way, to those areas of the island most suited to the current drift climate.

Several alternatives have been evaluated regarding the restoration of the Mississippi barrier islands. The most promising alternative for barrier island renourishment and protection of Mississippi Sound is the comprehensive plan. This plan would produce the greatest functional benefit per dollar expended, is a complete solution, represents an efficient use of Federal and local funds, is effective in its treatment of the problem (particularly in comparison to less effective structural wave reduction measures), and is acceptable to stakeholders in terms of existing laws, policies and priorities. In addition, the public is highly supportive of its measures to address the degradation of the barrier islands, as an element of a natural barrier to storms, and in the restoration of marine resources associated with Mississippi Sound.

This alternative includes the direct placement of sandy sediments to fill the breach in Ship Island and thereby reconnect West and East Ship Islands to their historic condition and to place sandy sediments within the littoral zones of Ship, Horn and Petit Bois Islands to ensure that the sediment budget of the islands is sufficient to maintain the islands in the future. This littoral zone placement would also benefit from the modification of dredging and disposal practices of the federally maintained Gulfport and Pascagoula Harbor navigation projects. These coupled efforts would begin the long-term process of barrier island repair and sustainability. Another consideration that still must be addressed is the best alternative for dealing with the erosion of Cat Island. This island is geomorphically different from the other 3 barrier islands and our understanding of the processes controlling Cat Island is not well developed. Additional effort would be required to add this island into an overall comprehensive barrier island restoration plan. The estimated construction cost of the barrier island comprehensive plan is $345,000,000 including the Cat Island study.

10.1.10 Forrest Heights Flood Damage Reduction

In Harrison County Mississippi the Forrest Heights community is located within the city of Gulfport at the lower end of the Turkey Creek floodplain and in a part of the larger historic Turkey creek community. Harrison County was over topped and heavily damaged by the hurricanes of 2005. Particularly, the storm surge and winds generated by Hurricane Katrina on August 29, 2005, caused structural damage to the existing levee that provides inland flood protection to this low lying residential community.

Storm surge inundation reached a depth of 2-8 ft over the entire community during Hurricane Katrina. In addition, prior to Hurricane Katrina, Forrest Heights was frequently inundated by flood waters due to inland flooding along the lower reach of Turkey Creek that overtopped the existing levee. An economically justified improvement to the existing earthen levee for inland flooding protection was evaluated in July 2005, prior to landfall of Hurricane Katrina. These evaluations

included 100-year, 250-year and 500-year protection and elevations up to 19.5 feet above sea level. This plan was put on hold following Katrina in order to evaluate suitable defense of Forrest Heights from hurricane storm surge flooding. The levee was evaluated at elevations 17 ft and 21 ft above sea level.

All evaluated alternatives were also gauged against the intent of Executive Order 12898, "Federal actions to address environmental justice in minority and low-income populations". Since the establishment of the Turkey Creek Community by freed slaves and their descendants, federally funded construction programs including the Gulfport Regional Airport, US Highway 49 and Interstate Highway - 10 have impacted the Turkey Creek Watershed. In addition, numerous other constructions including hotels, shopping centers and housing developments have been federally permitted to fill wetlands and construct within the Turkey Creek watershed.

Through modeling results, a levee height of approximately 21 feet above sea level was determined to be consistent with the levee certification guidelines with the basis measure being a storm surge elevation that has a 0.2% probability (500-year event) of occurrence in any given year. The levee is estimated to be 6,500 linear feet and require 93,000 cubic yards of fill. An existing park of 12 to 14 feet in elevation would serve as a water detention area for temporary containment of rainfall during storm events. The cost of this plan is estimated to be $ 9,000,000, with an average annual operating and maintenance cost of $ 77,000 over the 100-year life of the project.

10.1.11 High Hazard Area Risk Reduction Plan

The most effective alternative for reducing the risk from future hurricane surge events is to relocate structures and population from the high risk zones. Formulation of alternatives ranged from those which would provide for a minimum level of risk reduction (approximate base flood elevation) up to those that would provide for risk reduction from increasing levels of inundation. In addition an alternative concentrating on acquisition in the high to moderately high hazard areas was evaluated.

Hurricane Katrina destroyed an estimated 32,446 structures, which were "significantly" (i.e., 51% to 100%) damaged, and caused substantial damage to another 15,000 to 25,000 structures located within the inundation footprint of the three coastal counties in Mississippi. The vast majority of all destroyed homes within the inundation footprint have not yet been rebuilt, more than two years after the event. The rebuilding rate within the inundated area is much slower than might typically be expected following a hurricane. This is due in part to a significant increase in construction costs since Katrina, higher flood insurance rates and uncertainty resulting from the fact that FEMA has only in late 2008 released the revised Flood Insurance Rate Map (FIRM) and requirements outlining the elevation future first-floor construction must adhere to in order to qualify for flood insurance through the FIP. Limited rebuilding is occurring within the surge-plain, at a variety of elevations. Those that are rebuilding at former elevations are largely self-insured (or un-insured), while those rebuilding at higher elevations are doing so with an assumptions as to what the Base Flood Elevation (BFE) may be for their area. Regardless, most of those that would need flood insurance have not rebuilt at the time of this report, due to unavailability of that BFE data.

10.1.11.1 Phase I High Hazard Area Risk Reduction Plan (HARP)

Phase I involves the buyout of those properties that have been frequently flooded, or are at very high probability of future damage due to storm surge. The first phase of the HARP would include acquisition of approximately 2,000 properties which can be implemented over the next five years. Further information on the High Hazard Area Risk Reduction Plan can be found in the Nonstructural and Real Estate Appendices. The advantages of such a program are numerous including:

- Reduces future property loss and potential loss of life;

- Eliminates costly structural alternatives and associated long term operation and maintenance costs;
- Provides a buffer and aids in reducing storm surge to adjoining properties; and
- Provides a potential opportunity to initiate alternative uses of the acquired land for fish and wildlife, ecosystem restoration and public recreation.

Benefits of the program include reduction of future damages and risks to lives within those areas, and incidental recreation and social effects benefits. Select areas within certain acquired areas would be available for ecosystem restoration, and could also produce additional restoration benefits. Regional economic benefits include an increase in sales volume of $1,171,260,000, a $246,056,800 increase in local income, and a net increase of 7,213 jobs. The estimated costs for implementation of Phase I range between $187,500,000 and $397,000,000 depending on the ultimate number of parcels acquired and range of benefits provided under P.L. 91-646.

Prompt initiation of acquisition is more cost effective to the Government than commencing acquisition at a later date. Sensitivity analysis indicates that for every 1,000 previously-occupied parcels acquired prior to rebuilding, approximately $100 - $150 million could be saved by prompt acquisition, as compared to acquiring these same parcels after they are rebuilt. Acquisition prior to rebuilding avoids displacement impacts which increase significantly after residents have rebuilt. Near-term acquisition would reduce requirements for other Government-assisted temporary housing programs for those owners that might be still displaced, and would be continuing to receive financial assistance from the Federal Government.

10.1.11.2 Long-term High Hazard Area Risk Reduction Plan Evaluation

Evaluation of long term HARP is warranted to address the relocation of structures from the high to moderately high risk areas of the Mississippi coast. This program which could cover risk reduction opportunities over the next 20 to 40 years could target those properties which have been rebuilt but are still susceptible to significant future damage. A long-term HARP could involve the acquisition of large contiguous properties immediately following any large future hurricane events and be a joint effort between the USACE, FEMA, and the State of Mississippi.

The benefits of an ongoing acquisition and relocation program for coastal Mississippi could be tremendous taken into account the implications of sea level rise, continued development along the coast, and the frequency and magnitude of storms known to affect this area of the northern Gulf of Mexico. The additional study effort aimed at developing the framework and guidelines, detailed benefits, and costs would involve local and State interests as well as the Federal Emergency Management Agency.

Estimated study cost for development of a long-term HARP program is $5,000,000.

10.2 Studies Recommended for Finalization Under Programmatic Plan Authorization

Using the GIS based SDSS model, the MsCIP environmental team was able to effectively analyze needs in coastal Mississippi. A subset of potential restoration sites was identified by the SDSS tool and then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS. Using this interagency team allowed us to both confirm the accuracy of the SDSS results and to collect additional on-site information pertinent to restoration efforts. The MsCIP environmental team recommends immediate construction of the above 2 initial environmental restoration projects – Turkey Creek, Harrison County and Bayou Cumbest, Jackson County. In addition, the team

recommends potential environmental restoration projects specified in *Table 1.16.2.2-1* that would be studied further and restored under a MsCIP Environmental Restoration Programmatic Authority. The Environmental PDT anticipates studies, such as Project Information Reports (PIR), would range from $100,000 to $350,000 depending upon the specific project complexness. This cost has been incorporated into the cost-estimates. A rough order of magnitude cost-estimate has been prepared so that an upward construction budget is determined. The Environmental PDT will utilize the SDSS tool to prioritize environmental restoration site construction.

Development of partnerships with Federal resource agencies, state agencies, and NGOs is crucial to the success of this program. These partnerships would provide opportunities to access local knowledge of the existing environment. Specialists in specific restoration techniques would be available as well as opportunities to build on existing programs.

Once the restoration sites have been prioritized, a sequencing plan would need to be developed identifying the events necessary to accomplish restoration. This would ensure prioritized sites received immediate attention and further details developed for the required analysis. This plan would serve as an outline of the programmatic authority structure.

Once the PIR received approvals, a contracting mechanism would need to be put forward. The District PDT would need to incorporate Contracting Division in order to establish the most efficient type and beneficial use of contracting options and/or existing construction contracts. Oversight and quality assurance would ensure restoration was accomplished as envisioned.

Development of individual project monitoring plans should be incorporated into each restoration project. Adaptive management of ecosystem restoration projects, which would include the implementation of adaptive measures if required, would enhance the likelihood of the project achieving its goals and interim targets.

10.3 Additional Recommendations

While not compared in a system of accounts analysis, there are other areas that warrant either additional feasibility study or implementation by others. These include education on hurricane risk, hurricane and storm warning, evacuation plans, other structural measures, flood insurance, zoning changes, and saltwater intrusion plans. These are described in detail in the Main Report.

11 REGIONAL CONSIDERATIONS AND ACROSS-REGION INFLUENCES OF MSCIP AND LACPR ALTERNATIVES

11.1 MSCIP-LACPR COORDINATION ON REGIONAL ISSUES

11.1.1 Interaction/Coordination Between the Study Teams

The hurricanes of 2005 affected the entire region of the northern Gulf of Mexico from the panhandle of Florida to the Texas coast causing direct destruction to the immediate coast and its population centers. It also had unprecedented impacts to the much broader region from the subsequent migration of the affected population, wholesale disruption of the region's economy, disruption of the region's educational infrastructure, and untold impacts on the human resources of the region. In

essence, these impacts were not only local, but regional, and system wide as well. In its response to this disaster, the Congress of the United States authorized the U.S. Army Corps of Engineers (USACE) to initiate two important and comprehensive planning efforts to address the impacts caused by these storms and to plan actions that would make the region more resilient and less susceptible to future risk from such disasters. In formulating these actions, the USACE has taken a systematic and regional approach and has required that both the Louisiana Coastal Protection and Restoration (LaCPR) and Mississippi Coastal Improvements Program (MsCIP) efforts be fully coordinated with each other. In addition, both efforts used the same plan formulation strategy, as well as shared the use of the many technical tools required to perform the evaluations.

To this end, both teams are considering structural, nonstructural, and coastal restoration measures during the plan formulation. To ensure consistent communication and coordination, both teams have attended critical meetings regarding study goals and objectives, plan formulation, and Independent Technical and External Peer Review efforts. All modeling used in both efforts has been well coordinated, and both teams made use of, and jointly coordinated, the efforts of those USACE laboratories, Centers of Expertise, and ITR and EPR teams involved in these studies. In addition, the development of the Risk Informed Decision Framework (RIDF) has been a joint effort of the two studies.

All potential impacts, both adverse and beneficial impacts, are being considered without regard to geographic boundaries. Any measures which induce adverse impacts must be eliminated from further consideration or their impacts satisfactorily mitigated on a regional basis. Several measures may have beneficial impacts outside specific study boundaries. For example, the diversion of freshwater from the Mississippi River to Lake Borgne via the Violet marsh area could not only reduce saltwater intrusion in the Mississippi Sound south of Hancock County, but it could also provide much needed sediments to the Biloxi marshes of Louisiana. Also, the systematic restoration of the coastal sediment budget and sand transport system along the Mississippi barrier islands could provide benefits to eastern Louisiana.

11.1.2 Identification of Key Regional Issues

There are several key issues that are common to both Mississippi and Louisiana. These include problems with shoreline erosion, wetlands loss, salinity intrusion, and storm surge and waves. Besides the obvious economic and societal impacts associated with hurricanes, both states have a significant problem with eroding barrier islands. These islands reduce wave energy and help significantly in reducing erosion to the mainland. The loss of wetlands along the coast is also a critical issue. Wetlands, including marshes and near shore marine and estuarine habitat, are the nursery grounds for the entire marine food chain in the Gulf of Mexico. And, like the barrier islands, they also help to reduce wave energy. Linked to both the degradation and loss of the wetlands and barrier islands is the increase of salinity in the estuarine areas of the Mississippi, Breton, and Chandeleur Sounds. These increasingly scarce areas of the United States require a delicate mix of fresh and salt water to provide habitat for oysters, shrimp, sturgeon, and other fisheries which also provide an important economic source for both states. Both LaCPR and MsCIP teams are working together to solve these issues at the local, regional, and national levels. Multiple focus groups, public meetings, and regional workshops have been held to make sure that the solutions presented in this report are comprehensive in nature, and also maintain the delicate balance between people and their environment.

11.1.3 Coordination with FEMA

In addition to the significant coordination between the MsCIP and LACPR teams, the teams have also coordinated fully with the Federal Emergency Management Agency (FEMA) to ensure a unified

approach in the development of appropriate hurricane and storm damage reduction alternatives. FEMA has different regional offices to manage different areas of the United States. FEMA Region IV serves the state of Mississippi, and FEMA Region VI serves the State of Louisiana. After Katrina, Regions IV and VI began the complex process of updating their Flood Insurance Rate Maps (FIRMS) to include storm surge. FEMA Region VI utilized the Corps, New Orleans District to provide the model for updating their FIRMS, while Region IV contracted with an Architect-Engineer firm for this effort. Both the MsCIP and LACPR teams employed a consistent methodology for storm surge modeling, and coordinated their efforts closely with both FEMA regions. FEMA Region IV's contractor adopted some slight differences in terms of the specifics of their modeling approach; however, the agencies reconciled the differences in water levels generated for Regions IV and VI, and used an averaging technique to achieve a unified approach and result.

11.2 REGIONAL STORM SURGE AND WAVE MODELING

11.2.1 Interaction of Storm Surge and Waves with Coastal Protection Measures

Large-scale levee systems; other man-made barriers; restoration of barrier islands that involve substantial increases in an island's cross section, crest elevation or length; or wetland restoration on a massive scale, all have the potential to influence storm surge levels and wave conditions produced by extreme hurricanes on a regional scale. Levees and barriers are intended to protect against storm surge, but they also can cause a build-up of storm surge by obstructing or completely blocking the movement of water that is driven by hurricane-force winds. The pocket formed by the natural barriers of the Mississippi coast, the Mississippi River delta, and, when the wetlands of the delta become inundated, the levee systems along the Mississippi River facilitates a build-up of storm surge as winds push water into the pocket. Barrier islands alter the movement of water toward the coast, providing some blocking action and by forcing the water to move through gaps between islands, an effect that is lessened once the storm surge overtops an island. The enhanced roughness of wetlands can slow the advance of storm surge somewhat, which can cause a small local increase in storm surge seaward of the wetland and slightly reduce the surge landward of the wetland or slow its arrival time slightly. Each of these processes might tend to retard the storm surge propagation in one area; but in the process of slowing the storm surge advance, the movement of water might be slightly redirected toward another location causing a local storm surge increase elsewhere. Natural and man-made protection and buffering features like wetlands and barrier islands do not decrease the mass of water driven into the region by the hurricane winds (mass is conserved); however, they do change the momentum and redistribute the storm surge.

Natural and man-made coastal protection measures can also significantly alter wave conditions during hurricanes, reducing the potential for wave-induced damage along the coastline during elevated storm surge levels. Levees and barriers can completely block wave energy; and barrier islands act to block ocean waves from reaching the mainland coastline or reduce wave energy. Even though the reduction is less, barrier islands greatly reduce ocean wave energy even when the surge has overtopped the barrier island. Wetlands reduce wave energy, although it is difficult to accurately quantify the reduction given the current lack of detailed knowledge about the physics of this process.

In both the MsCIP and LaCPR studies, the regional influences of several proposed project alternatives on storm surge levels were examined with regional storm surge and wave modeling. The regional surge/wave model was specifically designed with this requirement in mind by having model domains and grid meshes that encompassed both Louisiana and Mississippi, and by developing the models consistently (for example, adoption of similar grid resolution throughout the

model domain). The process for developing the regional model is briefly described below. Additional details can be found in appropriate appendices to the LaCPR and MsCIP reports (cite references to those appendices).

11.2.2 Initial Model Development by the IPET

As part of Interagency Performance Evaluation Task Force (IPET) work to examine the response of the southeast Louisianan hurricane protection system to Hurricane Katrina, regional storm surge and wave models were set up and applied for the coasts of Mississippi and Louisiana. The suite of models included ADCIRC, the regional storm surge model, WAM, the offshore wave model (a basin-scale wave model covering the entire Gulf-of-Mexico), and overlapping STWAVE shallow-water wave models for the complete nearshore zone spanning both states. The ADCIRC and STWAVE models were coupled to treat the very important interactions between waves and storm surge. Coupling was done to maximize accuracy of the regional models.

The IPET was a community effort, drawing on experts from several federal agencies (including the USACE, FEMA, NOAA, and the USGS), state agencies, the private sector, and academia. The work involved considerable sharing of data, model technology, and expertise among all the agencies, groups, and individuals involved. Work of the IPET was reviewed by two panels: one assembled by the American Society of Civil Engineers and the other by the National Research Council. Both panels included experts from the public and private sectors, and each was comprised of individuals representing a wide range of technical disciplines. Both review panels gave extremely high marks to the regional storm surge and wave modeling approaches used by the IPET.

11.2.3 Regional Consistency Between the LaCPR and MsCIP Projects

A collaborative effort was undertaken to meet the storm surge and wave modeling needs of both the USACE MsCIP and LaCPR studies and the FEMA work to update flood insurance rate maps for the region. The MsCIP and LaCPR studies required storm surge and wave modeling for the entire coastline of both states. The IPET modeling had focused only on southeastern Louisiana and western Mississippi. Therefore, the regional storm surge and wave models that were initially developed by the IPET were expanded and refined with higher model resolution to create regional models that spanned the entire Louisiana and Mississippi coastal zone. The linked ADCIRC and STWAVE models are completely consistent from the perspectives of regional model resolution, level of model detail, and input data quality. Higher resolution enables: (1) a more detailed representation of the landscape features that influence surge and wave propagation and coastal flooding, and (2) a more accurate representation of certain wave and surge physical processes. Model accuracy is directly related to model resolution. Figure 11.2.3-1 shows the portion of the regional ADCIRC storm surge model domain for the Mississippi/Louisiana coastal region, and Figure 11.2.3-2 shows the overlapping regional STWAVE model domains.

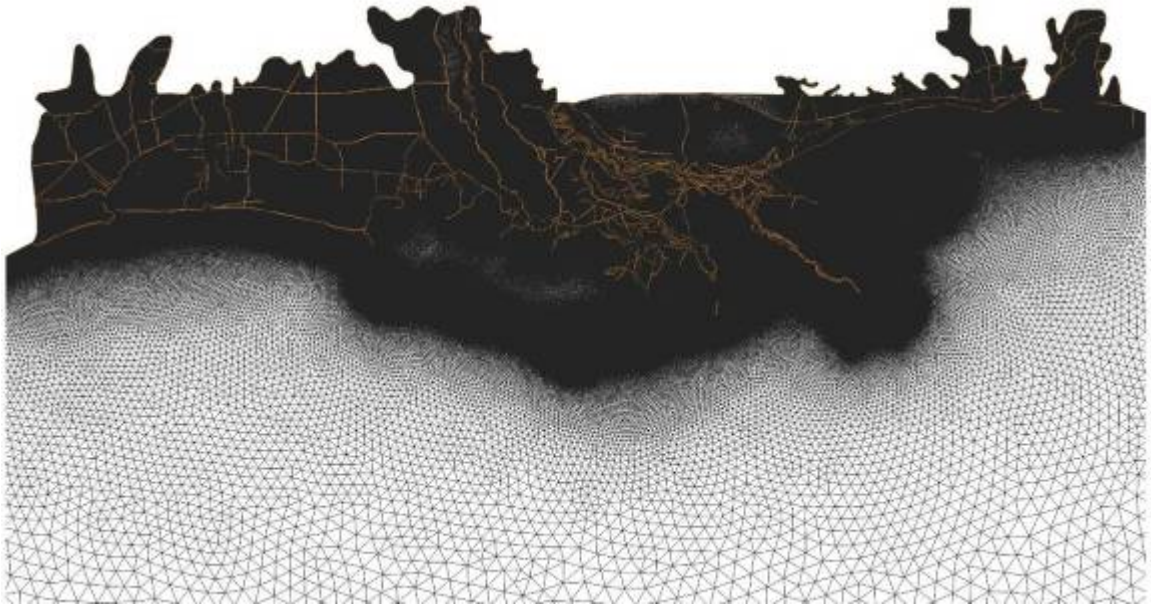


Figure 11.2.3-1. Representation of the Mississippi/Louisiana coastal region in the regional ADCIRC storm surge model

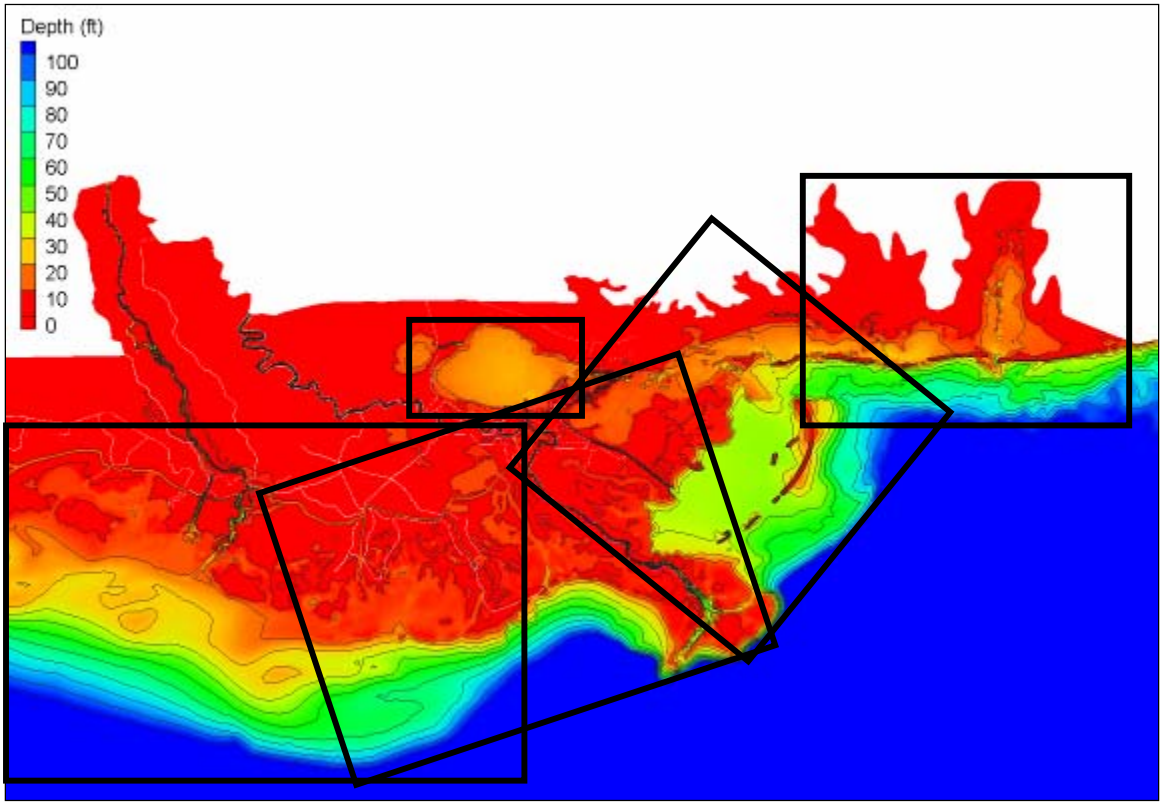


Figure 11.2.3-2. Overlapping STWAVE shallow water wave model domains spanning the Louisiana and Mississippi coasts (only the eastern portion of the westernmost Louisiana STWAVE model domain is shown here)

11.2.4 Hurricane Hazard Definition

In addition to having a regional-scale and regionally-consistent storm surge/wave model, a regionally consistent definition of the hurricane hazard was also important. A multi-disciplinary team, the Risk Assessment Group (RAG), was assembled by the Corps to characterize the probabilities of different hurricanes that can impact the northern Gulf of Mexico region. Their work fully utilized the best of today's knowledge, data and technology. Many of those involved in the work of the IPET contributed to the RAG, along with others from around the country (including members from NOAA and FEMA), in the same community spirit as the IPET. Consequently, results generated by the RAG have strong technical credibility and inter-agency acceptance. A significant achievement of the RAG, which supported both the MsCIP and LaCPR work and FEMA's remapping efforts, was the adoption of a unified general coastal flooding methodology that is being applied by USACE and FEMA. The unified approach involves coupled regional storm surge and nearshore wave models, the same approach originally taken by the IPET. The RAG developed a number of new insights into the behavior of hurricanes. One notable and extremely important finding was the tendency for all major intense hurricanes to decrease in intensity prior to landfall. The RAG developed a regionally-consistent Joint Probability Method-Optimal Sampling approach (JPM-OS) for defining hurricane probabilities and for calculating probabilities associated with hurricanes having a certain set of characteristics (track, intensity, size, forward speed). Figure 11.2.5.2-1 shows an estimate of the frequency of occurrence for major hurricanes in the north central Gulf of Mexico that was produced by the RAG. The figure shows the relatively higher probability of severe hurricane occurrence for southeastern Louisiana and Mississippi, relative to the probability of occurrence elsewhere in the Gulf of Mexico.

11.2.5 Corps-FEMA Coordination in Louisiana and Mississippi - Consistency of Hurricane Frequency Estimates

11.2.5.1 Development of Louisiana Data

Both FEMA Region VI and USACE employed the ADCIRC-WAM-STWAVE regional storm surge and wave model described above and the JPM-OS approach recommended by the RAG. The same set of model results was used in both the LaCPR work and in the FEMA Region VI remapping effort to characterize the hurricane hazard.

11.2.5.2 Development of Mississippi Data

Storm surge and wave modeling done for the MsCIP study was performed by USACE using the same regional modeling methodology as the LaCPR study (the approach outlined above). The MsCIP modeling work was coordinated with FEMA Region IV. However, results for the MsCIP project were required well before final numbers would become available from the FEMA contractor (URS Corporation) working on Region IV remapping. URS used a similar coupled surge and wave modeling

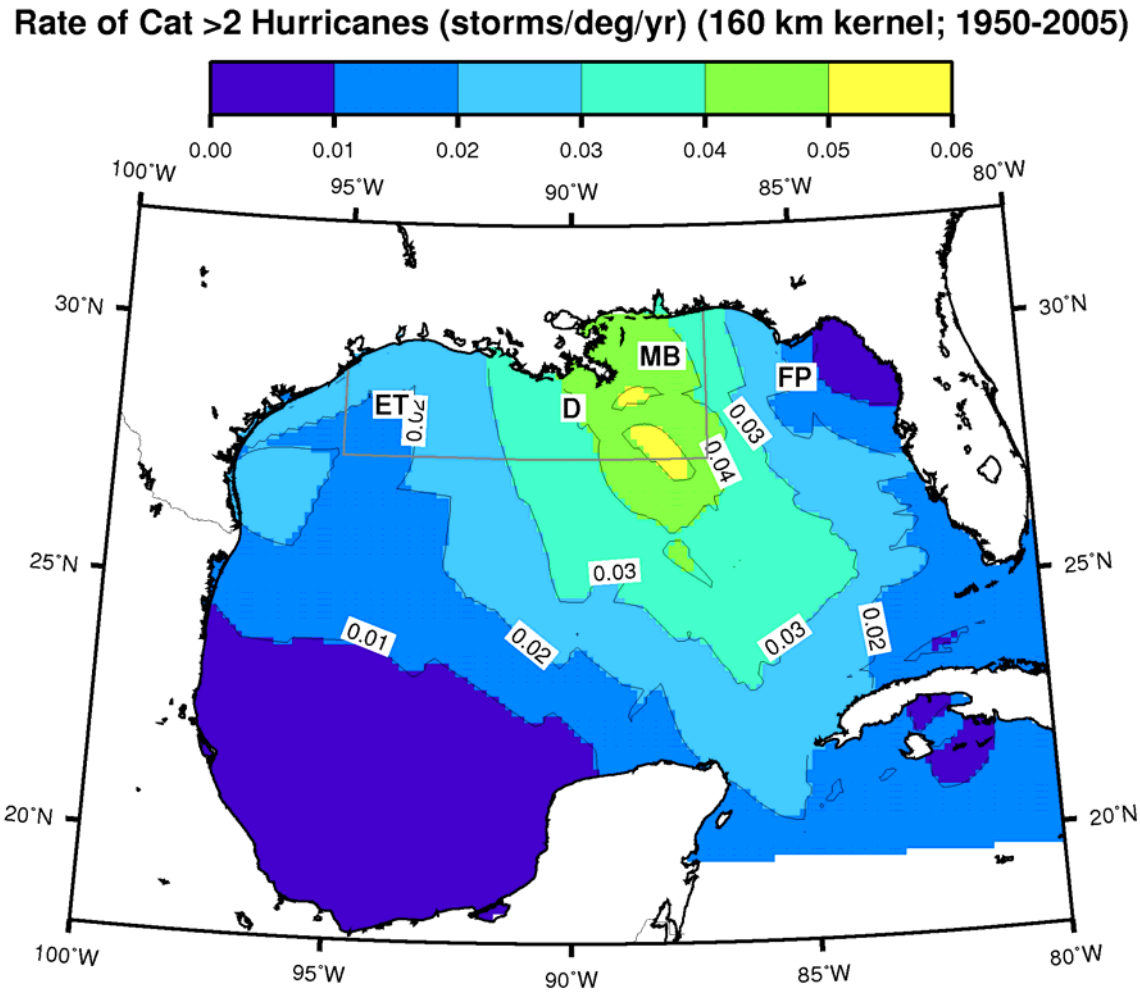


Figure 11.2.5.2-1. Analysis of hurricane frequency from Toro (Risk Engineering) from an analysis using an optimized spatial kernel (from the White Paper on Estimating Hurricane Inundation Probabilities by Resio et. al. 2006)

methodology but used the nearshore wave model SWAN, whereas USACE used the STWAVE model. However, the biggest difference in the approach used by the FEMA contractor was not in the modeling methodology, but rather in the specification of storm parameters and in the statistical computations. The FEMA Region IV/URS effort used different storm parameters and a different landfall (more inland) than USACE, which resulted in less pre- and post-landfall filling (i.e. less weakening) of the storms. In essence this resulted in stronger storms, producing higher water levels than those calculated by USACE. The agencies met and reconciled the differences in water levels for the Mississippi Gulf Coast through an averaging technique to achieve a unified Federal government set of results. Thus, there is a single Federal number for water levels corresponding to certain return periods. However, it should be noted that much of the MsCIP work proceeded with the preliminary values computed by the Corps to meet the Congressional schedule. The vast majority of storm surge-frequency curves computed by USACE and the FEMA contractor were within +/- 1 ft across the Mississippi coast. This is within the level of accuracy expected from these types of storm surge simulation models.

11.2.6 Comparison: Mississippi and Louisiana Data

When the Mississippi storm modeling results were compared to the Louisiana results near the Louisiana-Mississippi border, the Mississippi FEMA approach resulted in higher elevations around the state line than those resulting from the approach used by the LaCPR and FEMA Region VI studies. To resolve the issue, the USACE Engineer Research and Development Center (ERDC) provided a "blending algorithm" to achieve a smooth transition. As a result, the predicted still water elevations in the vicinity of the MS-LA border, corresponding to certain frequencies of occurrence, are considered scientifically accurate.

11.2.7 Present State of the Regional Storm Surge and Wave Model

A completely coupled and consistent regional storm surge and wave modeling capability is available to examine the regional influences associated with planned and proposed project alternatives being developed in the LaCPR and MsCIP studies, but only from the perspectives of project influences on storm surge levels and wave conditions. The model is based on the coupled ADCIRC-STWAVE models that were described above. The regional surge and wave model has been extensively validated using measured data acquired during Hurricanes Katrina and Rita, during the IPET and MsCIP and LaCPR projects.

This regional modeling capability was applied to examine regional-scale changes to storm surge levels associated with several of the proposed project alternatives, for example the influence of proposed barriers across Lake Pontchartrain on storm surge levels along coastal Mississippi, the influence of widespread Louisiana wetland restoration on storm surge levels in Mississippi, and the influence of Mississippi barrier island restoration on storm surges in Louisiana. Results from these applications are presented later in this chapter.

11.3 REGIONAL SALINITY/WATER QUALITY MODELING

In addition to regional influences on storm surge and waves, construction of large-scale levee systems or other man-made barriers, restoration of barrier islands that might involve increasing an island's footprint or length, or wetland restoration on a large scale, all have the potential to influence water exchanges and current patterns during normal tidal action and typical wind conditions. Such persistent changes to the hydrodynamic regime can alter salinity and water quality regimes leading to changes to habitat. These types of influences have not yet been examined in detail in either the LaCPR or MsCIP studies.

Wetland restoration measures proposed for construction in the MsCIP study are relatively small-scale features within small estuaries, and the barrier island changes proposed for construction in the MsCIP study do not involve significant changes to the barrier island footprints. Therefore regional-scale influences on salinity and water quality due to these alternatives are not expected to be significant. Wetland restoration and barrier island restoration at a much larger and widespread scale are being considered in the LaCPR study. These restoration measures can induce significant regional changes in terms of salinity, water quality and habitat and, therefore, will be examined in more detail in the future.

11.3.1 Consideration of Freshwater Diversions

Several alternatives are presently being considered in both the MsCIP and LaCPR studies to divert freshwater from the Mississippi River or other sources as a mechanism for promoting a reversal of a historic increase in salinity in the Mississippi Sound/Biloxi Marsh area. The intent of the diversion is to build wetlands, support fresher marshes and improve oyster reef health and productivity thus

enhancing both their economic value and the ecological services they provide. However, the water diverted from riverine sources not only has lower salinity, but usually carries more sediment and nutrients than marine water. Diversions may result in areas of excess nutrients and thus cause algal blooms and eutrophication, greater light attenuation, and changed substrate characteristics, so their system-wide impacts need to be carefully evaluated. Spatially-explicit evaluations of habitat change over large areas are required for such system-wide impacts.

Stated goals for the freshwater diversions in the lower Mississippi River/Mississippi Sound area include the following:

1) The enhancement of oyster resources in the Bay St. Louis area;

2) Desire to maintain oyster and shellfish resources in the Lake Borgne area;

3) The return of the ecosystem to historical salinity conditions;

4) The utilization of Mississippi River sediments to build and support wetland development;

5) The return of wetlands to a “fresher” condition, with particular emphasis in restoring areas of historical cypress forests.

These goals may in fact compete with one another, and may not be able to be met simultaneously. In addition, other competing resources in the system include the presence and location of shrimp fisheries, the survival and restoration of seagrass beds and the presence and survival of gulf sturgeon, a federally-listed, threatened subspecies. Therefore, any proposed diversion alternative needs to be carefully evaluated in order to fully understand the positive and negative aspects of various diversion scenarios and to assess their ability to meet any or some of the goals listed above.

11.3.2 Initial Model Development

To initiate evaluation of freshwater diversions, a regional water quality model (WQM) has been developed. The WQM, which is based on the CE-QUAL-ICM water quality model code, has been coupled to output from a three-dimensional hydrodynamic model of the region, which is based on the CH3D hydrodynamic model. The horizontal model grid (see Figure 11.3.3-1) extends seaward beyond the Chandeleur Island and includes Mobile Bay, Lake Borgne, Lake Pontchartrain, the Inner Harbor Navigation Channel of New Orleans and the Mississippi River Gulf Outlet Channel; and it includes all the major tributaries that introduce fresh water into the system, from the Tickfaw and Amite Rivers west of Lake Pontchartrain to the Mobile River in the east end of the grid. The model simulates changes in water quality constituents, including nutrients, phytoplankton, dissolved oxygen, temperature, salinity, and underwater light intensity.

11.3.3 Present State of the Regional Salinity/Water Quality Model

The regional salinity and water quality model has been extensively validated for the Mississippi Sound region, as part of previous work done by the ERDC and Mobile District. The model has not yet been as extensively validated for the Lake Pontchartrain and Biloxi Marsh areas; however, in light of past experience with the model in numerous studies, it is expected that the current state of the model is yielding reasonable results in this region for the purposes of the screening-level studies that have been conducted to date to examine the possible benefits of freshwater diversions.

To more accurately answer detailed questions about changes to salinity and water quality, and to answer them with greater confidence (a level which can withstand a high

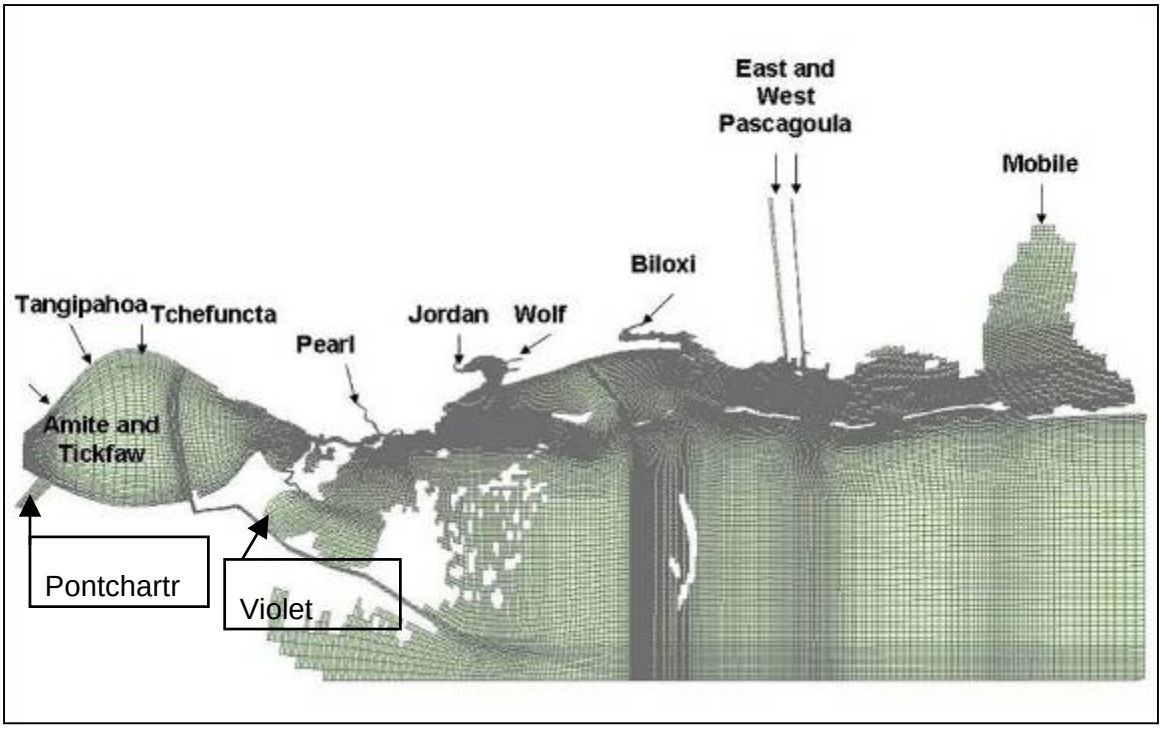


Figure 11.3.3-1. The model domain for the 3-D current hydrodynamic/water quality model, WQM

level of technical scrutiny), additional resolution and model refinement and validation, is needed. To answer more detailed questions about how changes in sedimentation, salinity and water quality translate to changes in landscape and habitat, additional model development, testing, and validation will be required. Requirements are discussed later in this chapter where the path ahead is discussed. Also note that the WQM model domain does not cover the entire coast of Louisiana. To properly examine questions regarding regional salinity, water quality and habitat questions throughout coastal Louisiana, the regional water quality model would have to be extended into those areas with a consistent level of resolution and detail, and be developed further in concert with work that is underway by Louisiana State University on habitat and ecological responses. For example, there might be regional influences in Texas associated with alternatives that are developed for western Louisiana. The need for expansion of the model will depend on the specific project alternatives that surface as preferred alternatives within the LaCPR study.

To date, the WQM has been applied to examine freshwater diversions at three locations: (1) diversion from the Mississippi River at Violet Marsh, (2) diversion of all of the Escatawpa River flow into Grand Bay, and (3) diversion from the Mississippi River at Bonnet Carre' spillway. Locations of these three diversions are shown in Figure 11.3.3-1 (annotated with boxes). Results were evaluated for several scenarios and compared to modeled existing baseline conditions to assess relative changes in the various water quality parameters. Results from these applications are discussed later in the chapter.

11.3.4 PRELINARY ASSESSMENT OF ACROSS-REGION INFLUENCES

11.3.4.1 Lake Pontchartrain Surge Reduction plan.

In general, there were four ADCIRC grids (levee alignments) used to investigate the feasibility of blocking or reducing the storm surges from entering Lake Pontchartrain via the tidal passes from Lake Borgne to Lake Pontchartrain and via overtopping of the land bridge that separates Lake Pontchartrain from Lake Borgne. The ADCIRC grids were designated as Grids A, B, C and D. See Figures 11.3.4.1-1 through 11.3.4.1-4.

Grid A was developed essentially as a theoretical plan that was designed to study the maximum reduction in surge responses in Lake Pontchartrain by eliminating any inflow into Lake Pontchartrain regardless of the intensity and surge heights in Lake Borgne. The features of this plan called for non-overtopping gated closure structures in the Chef and Rigolets Passes and connecting levees that were set sufficiently high so as to prevent overtopping from any of the storms used in the JPM-OS application. Grid A therefore isolated Lake Pontchartrain from having additional water volumes inflowing into the lake and restricted surge responses in the lake to the maximum extent possible.

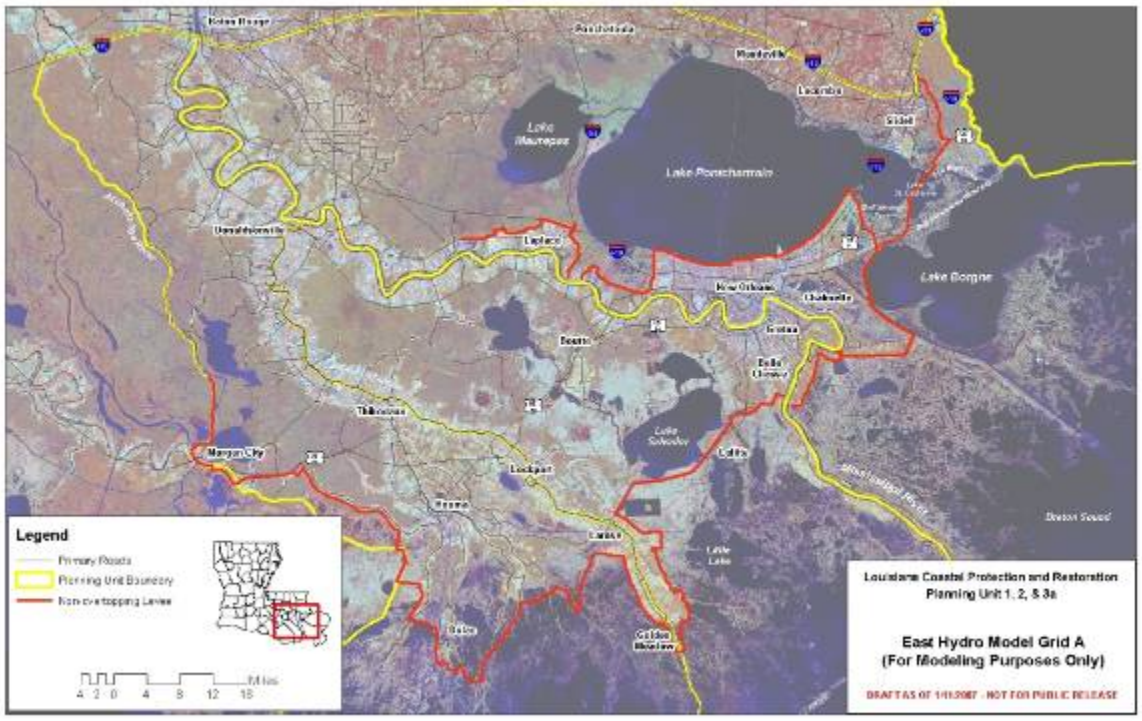


Figure 11.3.4.1-1. LACPR Model Grid A

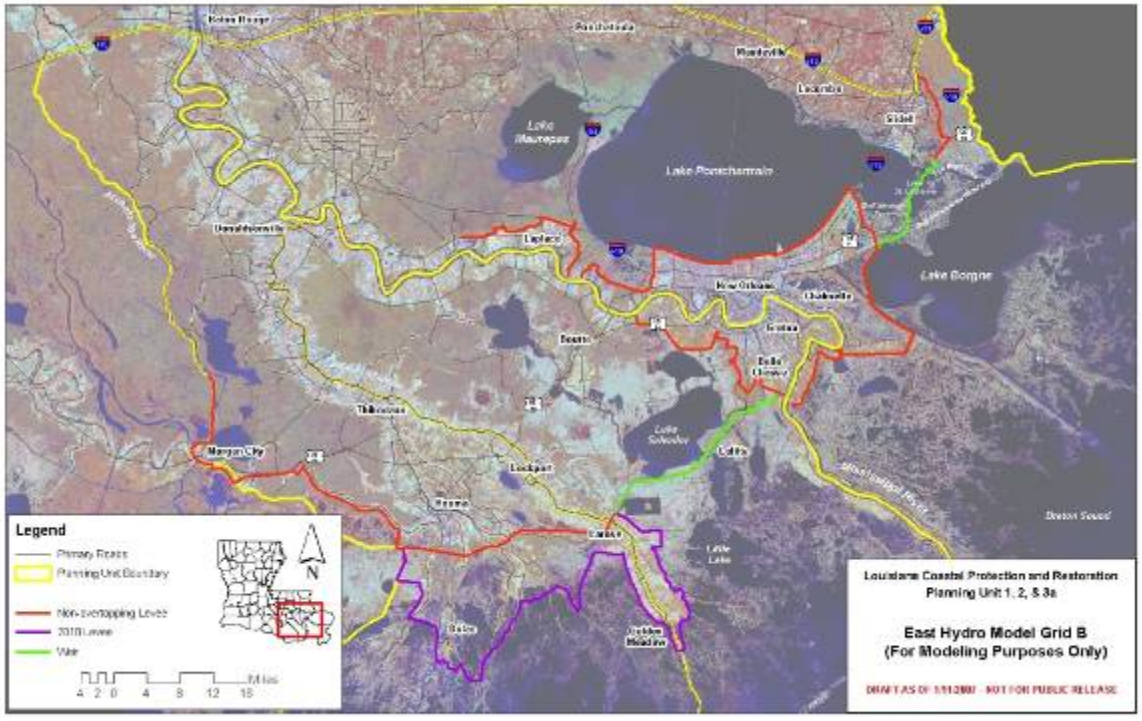


Figure 11.3.4.1-2. LACPR Model Grid B

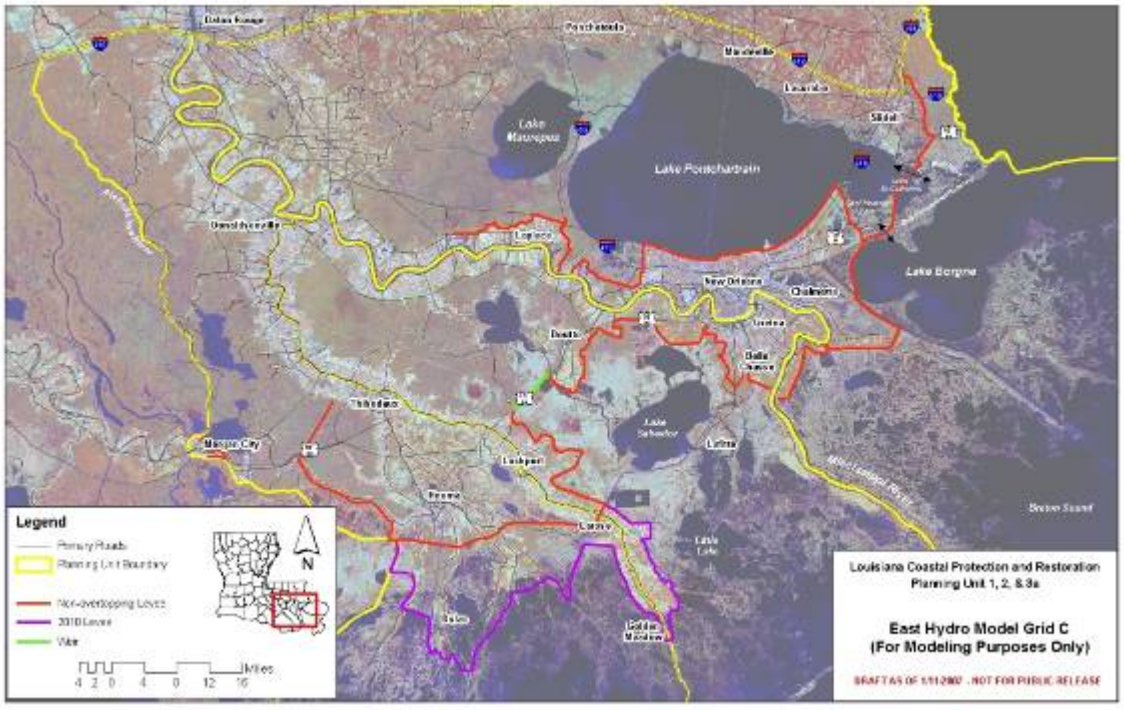


Figure 11.3.4.1-3. LACPR Model Grid C

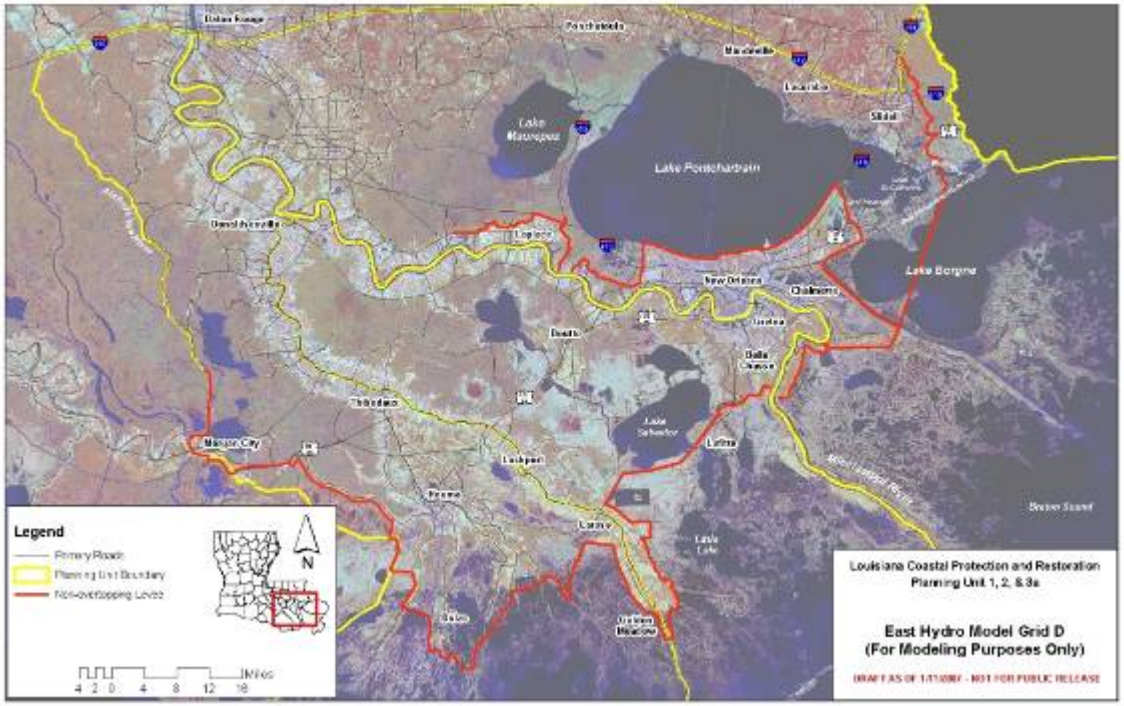


Figure 11.3.4.1-4. LACPR Model Grid D

Note that Grid A was not considered feasible and was eliminated due to the extreme height of the levees required to prevent overflow and the large increases in water levels in Lake Borgne and the Mississippi Sound.

Grid C contained the same non-overtopping levees but the gated control structures proposed for the Chef and Rigolets passes were removed from the grid so that the passes were left open during the hurricane simulation. The plan calling for removal of the control structures was suggested as an environmental plan by the US Fish and Wildlife Service. It was found that the surge responses in and around Lake Pontchartrain for this grid were essentially the same as with the Base 2010 Grid which represents the authorized 100-year hurricane protection system. Therefore the Grid C plan was eliminated as not being effective.

Grid D involved a barrier at a different location compared to the other barrier plans. Results for Grid D were similar to those for Grid A in that there were significant lowering of water levels in Lake Pontchartrain but outside stages were increased due to the Grid D levee alignment having closer proximity to the Mississippi Gulf Coast. Therefore the Grid D plan was eliminated from further consideration. Elimination of the alternatives reflected in Grids A and D were based in part on cross-region influences of these alternatives.

The Grid B, the Lake Pontchartrain surge reduction plan, essentially follows the Grid A alignment and has similar closures at the tidal passes. The connecting levees in grid B were, however, set to a lower elevation so that the levee would function as a weir and the more intense or severe storm surges would overtop this system and enter the Lake Pontchartrain Basin. The Grid B plan also showed substantial reduction in surges in Lake Pontchartrain, however, it caused increases in water levels on the Lake Borgne side of the proposed alignment and the Mississippi Sound. Figures

11.3.4.1-5 through 11.3.4.1-7 show the increase in water levels on the outside of the Grid B Pontchartrain surge barrier structure for the 100, 400 and 1000 year frequency events. It should be noted that due to the limited time for conducting the LACPR work an optimization of the weir height for a proposed surge reduction plan was not done. However, the results suggest that adjustments to the weir height could lead to perhaps a more cost effective plan that maximizes risk reduction and minimizes costs over the entire Louisiana/Mississippi project area. Should a surge reduction plan move to the next phase of planning, then a comprehensive assessment of weir elevations will be performed to evaluate any impacts.

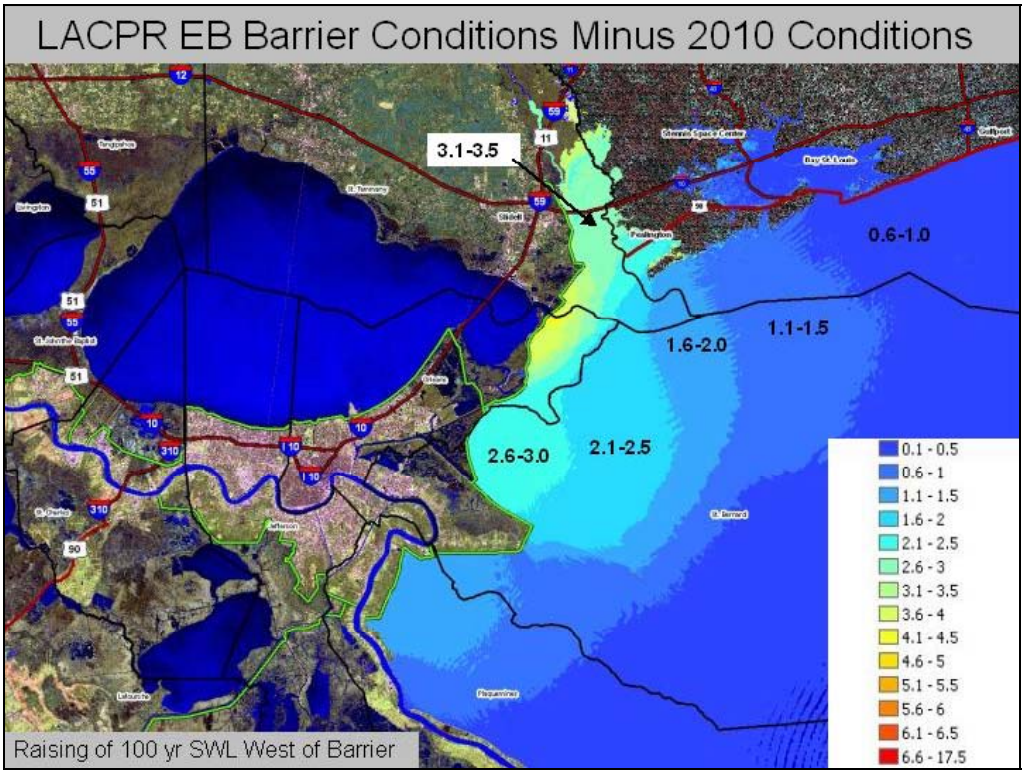


Figure 11.3.4.1-5. Regional-scale changes to 100-yr storm surge levels associated with the Grid B being considered in the LaCPR study

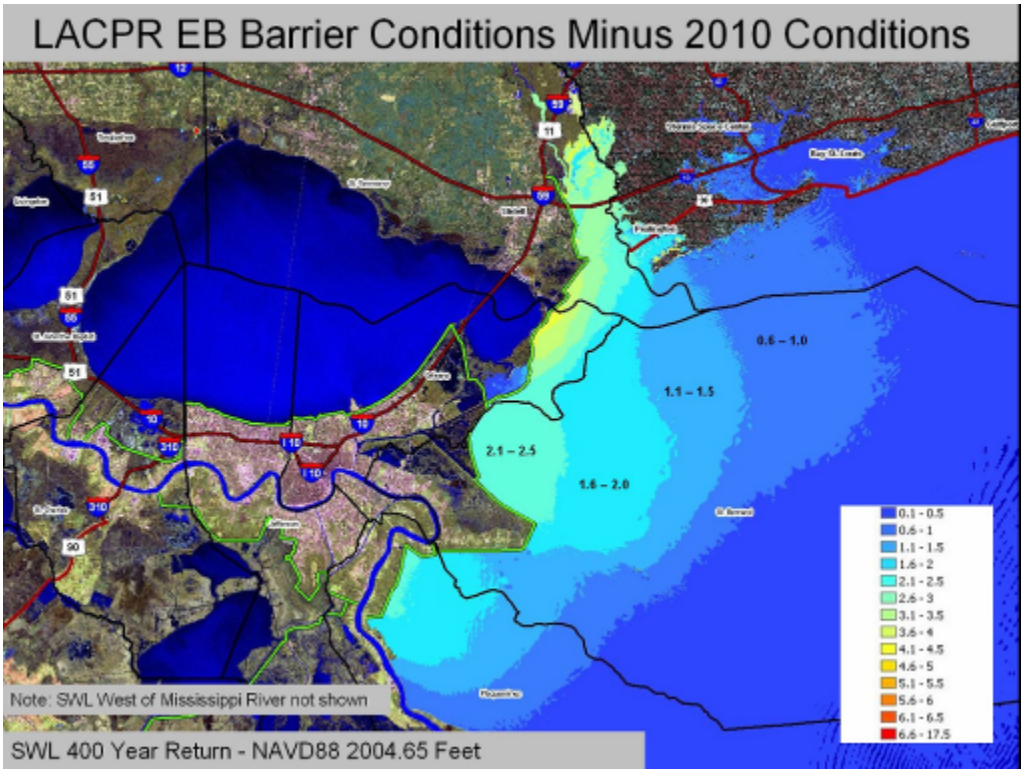


Figure 11.3.4.1-6. Regional-scale changes to 400-yr storm surge levels associated with the Grid B being considered in the LaCPR study.

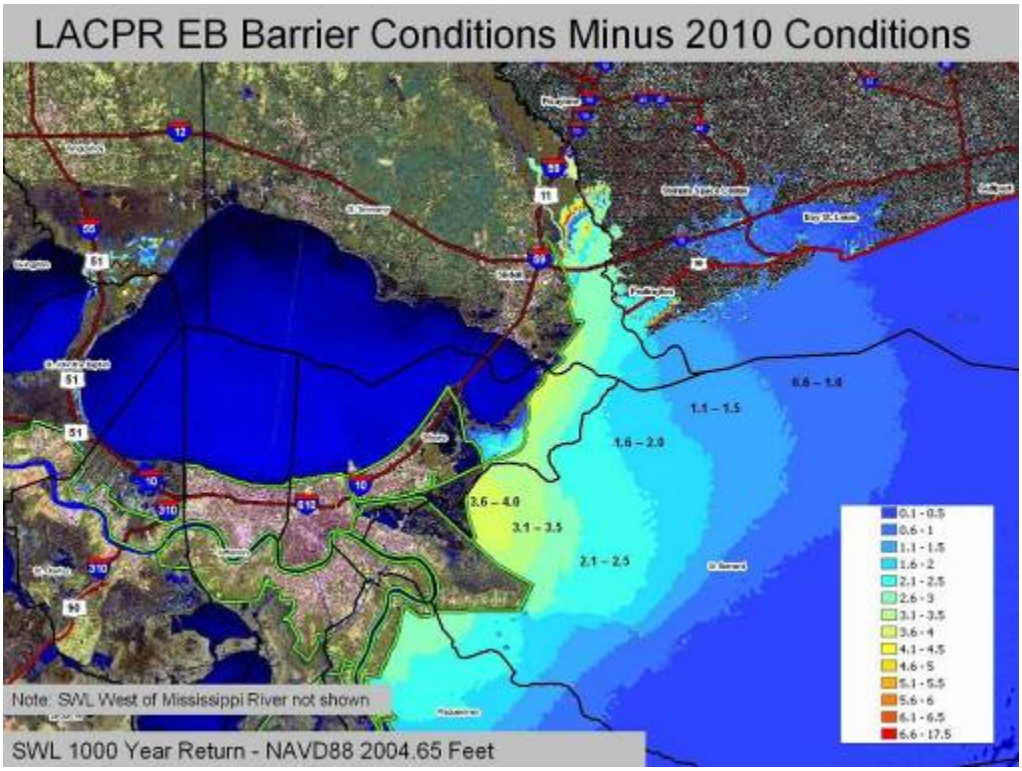


Figure 11.3.4.1-7. Regional-scale changes to 1000-yr storm surge levels associated with the Grid B being considered in the LaCPR study

11.4 Mississippi Barrier Island Restoration

The options being considered for MsCIP include potential projects involving the placement of sand in two of the planning zones, the Offshore Zone which includes the barrier islands of Mississippi, and the Coastal Zone which includes the mainland beaches of Mississippi. The barrier islands are mostly owned by the National Park Service (NPS) and are included in the Gulf Islands National Seashore. The mainland beaches are all man-made and stretch along about 40 miles of Mississippi's coast.

Immediately following Hurricane Katrina, the State of Mississippi proposed restoring the barrier islands back to a pre-Hurricane Camille condition with the concept that this would reduce storm surge on the mainland. Analysis of the land loss among the four islands indicated that from 1917 to 2006 (post-Katrina) over 1600 acres of the islands had been lost. To return the islands back to a 1917 footprint, approximately 66,000,000 cubic yards of sand of a quality similar in color, grain size, and roundness to the sand that currently comprises the barrier islands would be required. The NPS had concerns over the State's proposal because it directly contradicted their policy of letting nature take its course unless it was to restore by mitigating for the activities of man or to protect historical sites within Park boundaries.

Studies by the USGS and ERDC showed a continuing trend in erosion of the islands and that West and East Ship Island would probably be totally lost in the future. Loss of the islands would also be expected to drastically change the ecology of the estuary formed between the islands and the mainland. With all these considerations, the NPS and USACE formulated a plan (referred to as the NPS Plan) for the barrier islands that would help mitigate some of the loss at the islands due to frequent intense storms, relative sea level rise, and anthropogenic activities that may have resulted in a reduction in sand supply and prolong the existence of the islands. This plan includes direct placement of sand to fill a breach in Ship Island, commonly called Camille Cut, that has existed since Hurricane Camille, add sand to the littoral zone in two areas, and proposed changes in the disposal practices of littoral zone sediment removed from local navigation channels.

The proposed restoration of barrier islands has regional implications with respect to sediment sources that are required to achieve the restoration and may have impacts on storm surge in Louisiana. Landscape features such as barrier islands have the potential to reduce storm surge elevations. Land elevations greater than the storm surge elevation provide a physical barrier to the surge. Landscape features (e.g., ridges and barrier islands) even when below the surge elevation have the potential to create friction and slow the forward speed of the storm surge. The barrier islands serve as the first line of defense for the Mississippi coast.

The restoration of these islands is a large-scale project and regional influences on storm surge, waves and salinity/water quality should be considered. Any significant lengthening of a barrier island, or reductions to the width and cross-section of gaps between barrier islands has potential for altering tidal exchange and the regional salinity and water quality regimes.

11.4.1 Assessment Approach

The impact of barrier island restoration on storm surge at the mainland coast of both Mississippi and Louisiana was assessed with a sensitivity study of various barrier island configurations. Influences on salinity and water quality have not been examined. The sensitivity study is a primarily a qualitative assessment that provides valuable information on trends and relative performance but

one should be cautious about making quantitative assessments of surge reduction. The barrier island sensitivity study was conducted on a grid consistent with that applied for the IPET study. It should be noted that the analysis does not consider the morphologic changes to the barrier islands caused by erosion that occur during a storms passage. In these sensitivity tests, the barrier island cross-section was assumed to be invariant, which might be a reasonable assumption for the very high restored barrier island elevation that was considered in the sensitivity tests, but it would not be a good assumption for a low more natural Mississippi barrier island elevation. The analysis also does not consider changes in the structure of the hurricane itself due to landfall infilling phenomenon that may be influenced by landscape features such as barrier islands.

A suite of storms were identified for evaluating storm surge response to changes in barrier island configuration. The suite included two historical storms, Camille and Katrina, because those hurricanes did in fact make landfall on the Mississippi coast in 1969 and 2005, respectively. The storm simulated that would most effect the Louisiana coast was Hurricane Katrina. The barrier island configurations modeled for the historical Katrina were: 1) the existing Post-Katrina degraded condition (elevations ranging from approximately 2 to 6 ft (NAVD88 2004.65)); and 2) a Restored-High barrier island configuration with an extended (pre-Camille) footprint and an elevation of 20 ft NAVD88 2004.65. The Restored-High configuration represents a massive barrier island configuration that would be difficult to achieve; it was modeled for sensitivity purposes. The proposed restoration referred to as the NPS plan above is substantially less than the restoration modeled for sensitivity purposes and thus impacts on regional surges are expected to be much less than those reported below.

11.4.2 Preliminary Results

For the purposes of discussion and comparison, Figure 11.4.2-1 plots the difference in the Post-Katrina and Restored-High peak surge levels for simulations of Hurricane Katrina. There is a reduction in peak storm surge levels of 1.0 to 3.5 ft landward of the barrier islands and an increase in water level of less than 1 ft seaward of the barrier islands. The most significant change in peak storm surge is in the Pascagoula basin where levels are reduced 1 to 3 ft. Note that the impact of the restoration decreases moving east to west and there are smaller changes in the Louisiana area, on the order of tenths of feet. Surge reductions at the Mississippi mainland were approximately 20% in the Pascagoula area, 5 to 10% in the central part of the state, and less than 5% in Waveland. The increase in water level in Louisiana is less than 0.5 ft. The level of restoration recommended in the MsCIP study is much less than the Restored-High configuration and thus the impact on Louisiana is also expected to be less than the results presented in Figure 11.4.2-1. These preliminary results indicate that the restoration of the Mississippi barrier islands, as it is being proposed, is not likely to adversely impact storm surge levels in Louisiana. Once a barrier island restoration level is set, the specifics of the restored barrier island configuration for all islands can be used to modify the regional storm surge and wave model and simulated to more accurately estimate regional impacts. Impacts on waves and salinity should also be evaluated.

11.4.3 Regional Sediment Management Issues

The total quantity of sand required for NPS barrier island plan and mainland beach restoration is considerably less than what would be required for the total restoration of the islands, but still substantial. To fill the breach, the sand would have strict requirements on color, grain size, and roundness. In discussions with the USGS, a potential source of sand was identified at St. Bernard Shoals which is a submerged chain of barrier islands approximately 45 miles south of the Mississippi barrier islands. Both quality and quantity are assumed to be available, but further investigations are required to verify the source. Activity from oil and gas production in the local area must also be considered. Approximately 8,000,000 cubic yards of the high quality sand are needed to fill the

breach. An additional 10,000,000 cubic yards of sand is being proposed for placement into the littoral zone east of East Ship Island. This sand would not require the same quality as the direct beach placement, but would still have some physical characteristics that must be considered.

If additional studies are performed on these two measures, another potential source of sand would be investigated that would be much closer to the project site and would allow the beneficial reuse of dredged material. This further study would look at historical disposal areas for the Gulfport navigation channel that crosses through the littoral zone. The sediments that are removed from the channel during routine maintenance dredging have been placed in approved disposal areas that have been used for an extended period of time. While the material placed in these areas was not segregated by grain size, there may be substantial quantities of beach quality material that has potential for use at Ship Island, either for filling Camille Cut, adding to the littoral zone, or both. Reuse of the sediments from the disposal areas would follow Regional Sediment Management practices that promote keeping sediments in the littoral system and/or beneficial use of material that is removed during both new and maintenance dredging.

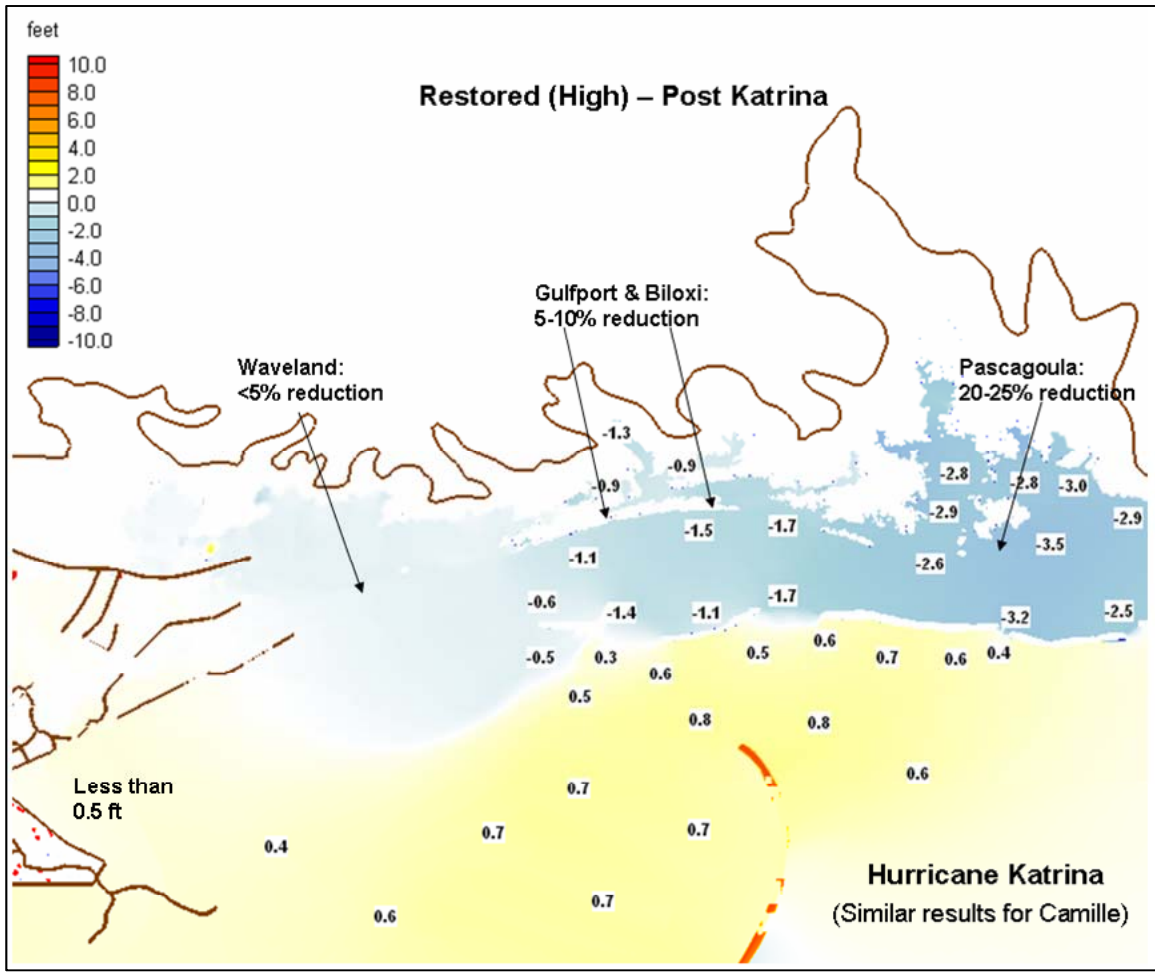


Figure 11.4.2-1. Difference in peak storm surge level (Restored-High – Post Katrina) for Hurricane Katrina

In this same local area, recent sediment transport studies have shown that westward sediment migration has been affected by the southward extension of the Mississippi River delta. This extension has cut off the littoral current and terminated the westward migration of sediments in the pass in the vicinity between Cat and West Ship Island. The fate of these sediments has not been determined, but there may be a large deposit of sand that could be used at Camille Cut or replaced in the littoral system.

Another segment of the Comprehensive Barrier Island Restoration Plan would be to add sand into the littoral zone east of Petit Bois Island. The source of this sand is proposed to be from the inland river system that flows into Mobile Bay provided that the sand is found to be compatible with sediment that exists within the littoral system. Prior to its use, these physical characteristics will be determined by sampling and testing of the inland sand for color, gradation, and particle shape (angularity). To maintain channel depths, sand is dredged from these rivers and placed in numerous upland disposal areas along the river. The lower Tombigbee River has several million cubic yards of sand stored along its banks that could potentially be used for the littoral zone placement based on the compatibility requirements mentioned above. Prior testing, including toxicity studies, has already been conducted on many of the sites. Due to the location of the disposal areas, this sand is being considered for use for the Petit Bois Island littoral zone placement. This source will provide the beneficial use of sand suitable for the littoral placement and at the same time provide additional dredged material storage capacity along the river system.

The placement of sand to fill Camille Cut and the two large littoral zone placements are planned as one-time events to restore some of the islands' land surface that may have been lost to erosion due to man's past activities or from mass erosion during storm events. This decision was based on an agreement with the NPS that allows them to mitigate ay damage from man's activities or to perform necessary means to preserve historic sites. This agreement has a positive aspect to MsCIP with the replacement of sand that has been lost from the littoral system. This sand addition will extend the life of the islands and the closure of Camille Cut will help maintain the boundaries of the estuary. It is understandably difficult to quantify either of these sand loss causes because the barrier islands themselves are dynamic systems that are undergoing constant change. The presence of two deepwater navigation channels that pass through the littoral zone have created artificial boundaries to the westward migration of the islands. The continued maintenance of these channels will require that sand and other sediments be removed, but under the guidelines of the Regional Sediment Management Practices, the sand removed from the channels will be returned to the littoral system.

The continuing study would evaluate future placement of maintenance material dredged from the Pascagoula Harbor Navigation Channel. It has been recommended that sand from the channel be placed down-drift in a newly designated disposal area located in the littoral zone near Sand Island. Much of the sand dredged in the past was placed down-drift, but was formed into a small island commonly called Sand Island. Sand Island has become a prime environmental resource vegetated with dune grasses that provide habitat to many types of shore birds. With no further sand additions, the sand within this island will probably return to the littoral system as wind, waves and currents erode the land mass.

Material removed from the Gulfport Channel has historically been placed in disposal areas south of the littoral zone. In keeping with the guidelines of the Regional Sediment Management Practices, new recommendations have been made to dispose of the material removed from the littoral zone segment of the channel. The channel at the western tip of West Ship Island is a trap for the migrating sand. It has been recommended to place the dredged sand in the littoral zone east of East Ship Island. This practice will allow the sand to nourish Ship Island and slow erosion of the land mass. How to best achieve this will be considered in the continuing study of the islands. Initial ideas include stockpiling the sand in selected areas so the material would be available in the future to relocate it into the littoral zone.

The mainland beaches that are in the Coastal Zone were created in the 1950s to provide protection to the seawalls along beachfront roads. Through time, the beaches have evolved into recreational use and environmental habitat. Some of the beaches have been periodically renourished by the local sponsors, primarily the counties. Options that have been studied under MsCIP have included the construction of dunes of various sizes and configurations. The sand for any dune construction will be purchased from any of numerous commercial sources along coastal Mississippi. This sand is typically of good quality and has been used in some of the past nourishments. There is also limited sand reserves available in approved borrow areas just offshore of the mainland beaches. This offshore sand is currently being used for a renourishment project in Harrison County.

Many of these same types of issues will be considered for alternatives that involve barrier island restoration in Louisiana. All of the sediment requirements discussed above must be considered in concert with any sand-source requirements that develop from the LaCPR study. Sediment management will be carried our in accordance with Regional Sediment Management practices.

11.5 LaCPR Wetland Restoration Plan

The LaCPR study is considering various restoration alternatives that will provide multiple benefits, particularly ecological benefits. Figure 11.5.1-1 shows an outline of the marsh restoration features being considered for eastern Louisiana. These features have the potential to reduce storm surge and wave action, and the regional implications of these projects will be considered. Landscape features such as wetlands also have the potential to create frictional resistance and affect storm surge even when vegetation is inundated by the storm surge.

11.5.1 Assessment Approach

The impact of wetland restoration on storm surge at the mainland coast of both Louisiana and Mississippi was assessed with a sensitivity study. The sensitivity study was primarily a qualitative assessment that provides valuable information on trends and relative performance but one should be cautious about making quantitative assessments of surge reduction. It should be noted that the analysis does not consider the morphologic and vegetation cover changes to the wetlands caused by erosion and/or damage to vegetation that occurs during a storm's passage. The analysis also does not consider changes in the structure of the hurricane itself due to landfall infilling phenomenon that may be influenced by landscape features such as wetlands.

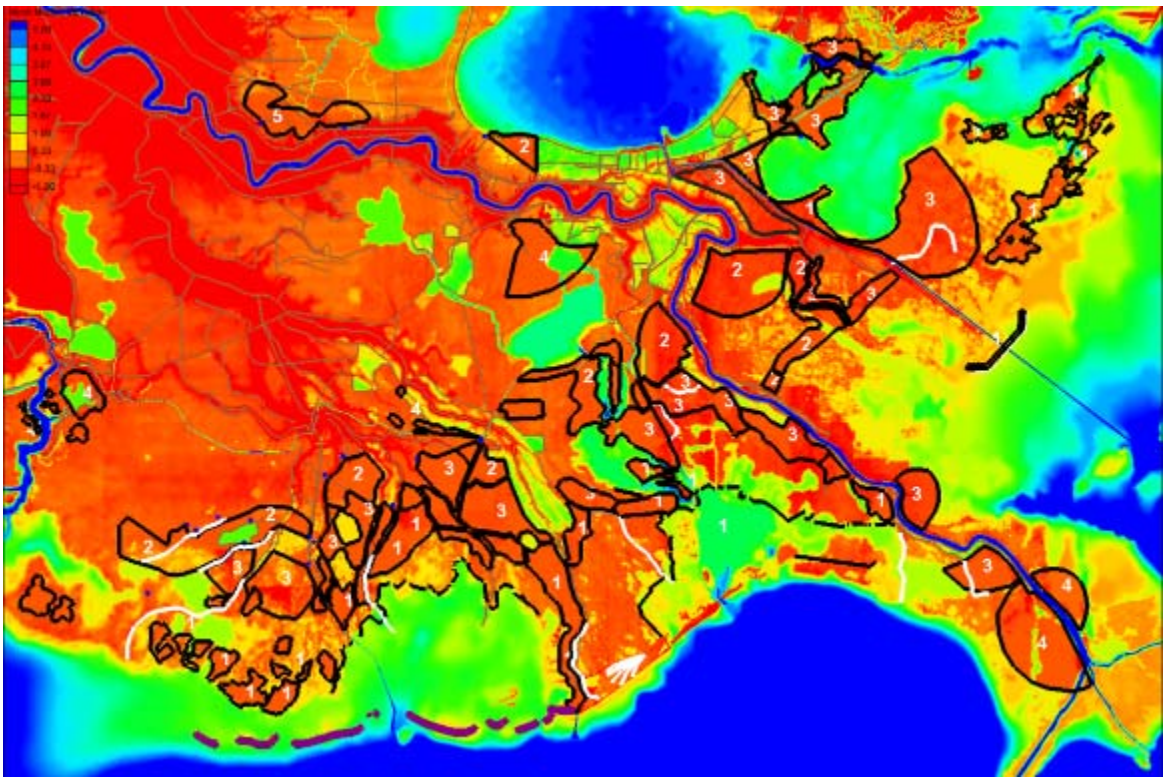


Figure 11.5.1-1. Outline of marsh restoration features. Marsh types are outlined as follows: 1 = saline, 2 = intermediate, 3 = brackish, 4 = fresh, 5 = cypress, white lines = ridges, purple = shrub/scrub for barrier islands. Colors indicate topographic/bathymetric elevation.

The restoration features outlined in Figure 11.5.1-1 were represented in the regional storm surge and wave model through modifications to the bathymetry, Manning's n values, and directional roughness lengths. A suite of 24 hypothetical storms was simulated on the restored condition and maximum water elevations were compared to maximum water elevations for the base condition.

11.5.2 Preliminary Results

Figure 11.5.2-1 presents the difference in maximum water level between the restored marsh configuration and the base case for the suite of 24 storms simulated for the immediate metropolitan New Orleans area. Note that the scale uses the color white to denote areas where changes in peak surge level are between + 1 ft and -1 ft. The wetland restoration has less than 0.5 ft impact on surge levels in both Louisiana and Mississippi. Based on these preliminary results, wetland restoration activities in Louisiana are not expected to adversely affect storm surges in the Mississippi area.

In a general sense, the influence of wetland restoration activities on storm surge and waves will be local in nature and relatively small for the types and spatial-scale of wetland restoration that are being considered and proposed in both the LaCPR and MsCIP studies. Impacts on waves may be greater than impacts on storm surge, but they are expected to be more local and are not expected to have significant regional influences outside the local area. For example, the wetland restoration proposed in the MsCIP study is local, and will not have significant storm surge or wave influences in Louisiana.

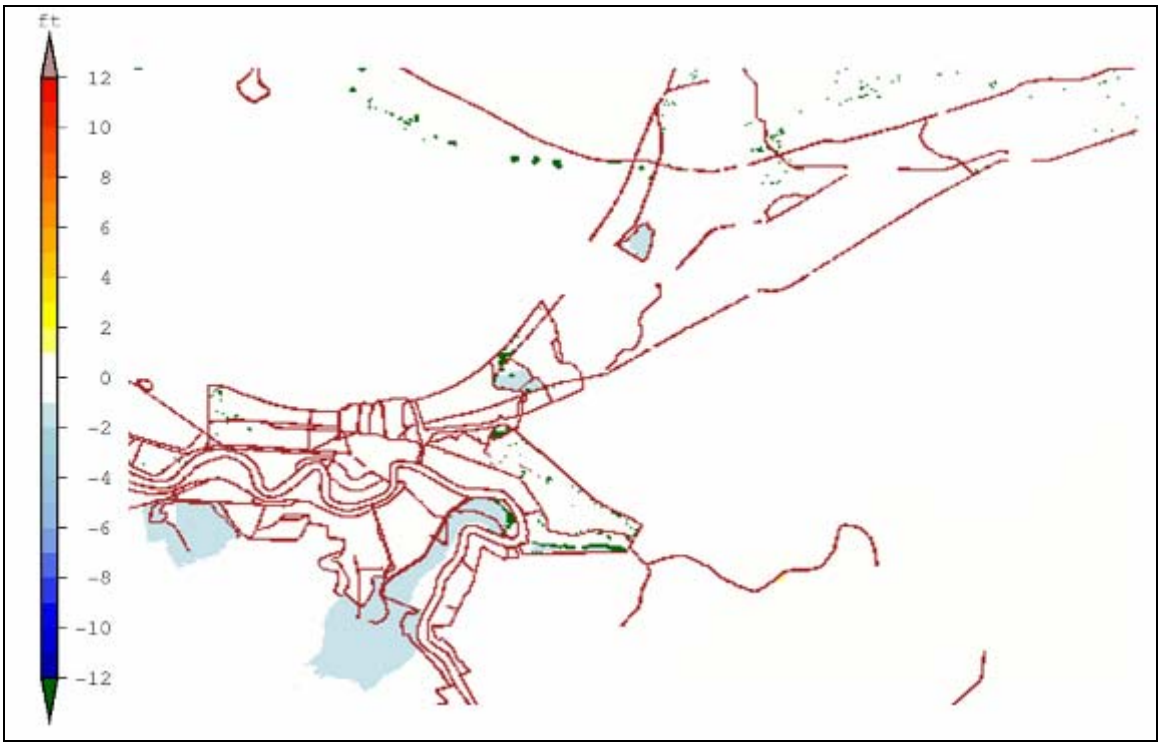


Figure 11.5.2-1. Difference in maximum surge level (ft) between the restored marsh configuration and the base case for the restored marsh storm suite

11.6 Mississippi River Diversions

The regional salinity and water quality model, WQM, has been applied to three alternative locations: (1) diversion of freshwater flow from the Mississippi River at Violet Marsh, (2) diversion of all of the Escatawpa River flow into Grand Bay, and (3) diversion of freshwater flow from the Mississippi River at Bonnet Carre' spillway. The purpose of these screening-level simulations was to examine whether or not freshwater diversions at these locations could produce reductions in salinity of a magnitude that are needed to achieve some of the objectives outlined previously for diversions.

11.6.1 Assessment Approach

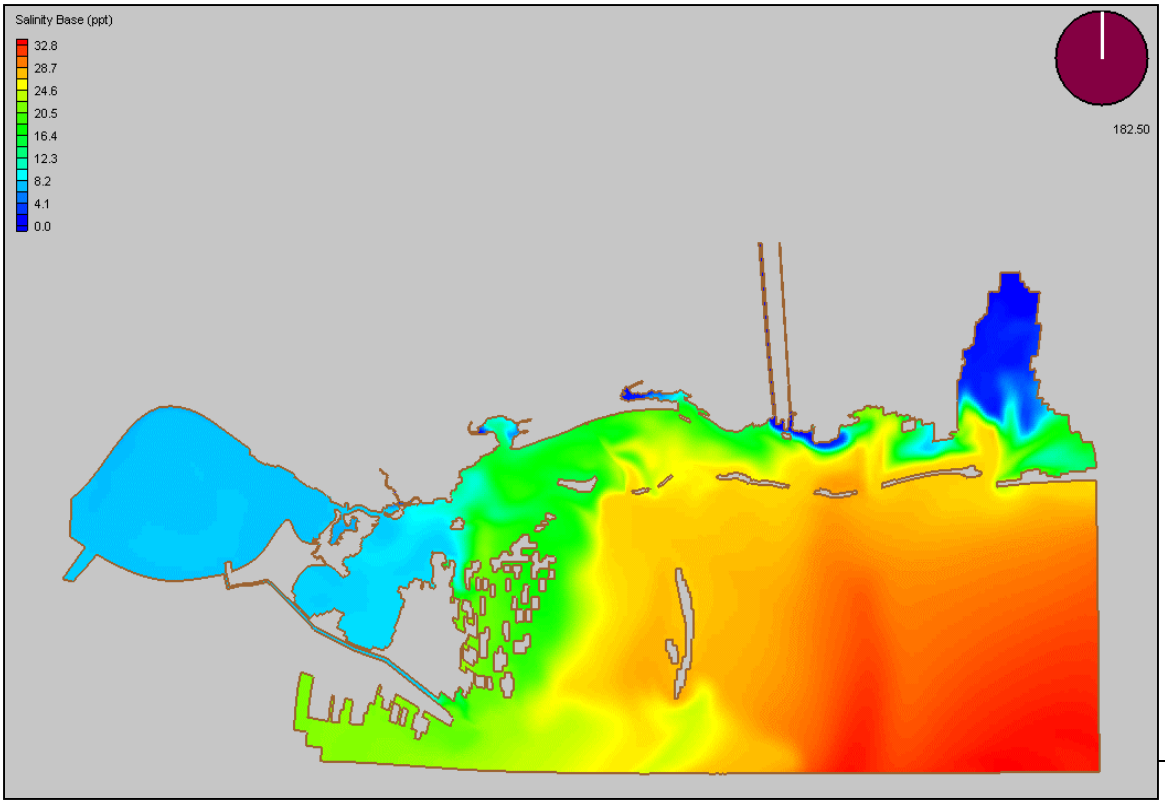
A small range of potential diversion scenarios have been run and are reported in the appendices in the MsCIP report (Dortch et al. 2007). A limited number of operational schedules were considered. For example, the discharge from the Bonnet Carre' diversion was varied by month. The Violet Marsh scenario was a diversion with a constant flow of about 210 cu m/s (7500 cubic feet per second, cfs). The Escatawpa diversion scenario was the flow that occurred in the entire Escatawpa River during 1998. The hydrodynamic model was run with the same conditions as used for the base conditions used in the WQM calibrations for 1998 except that the additional freshwater flows were introduced. The WQM was applied for the period April through September 1998 using the same inputs as the final calibration run except for different hydrodynamic input and different boundary conditions for the diverted flow and associated concentrations of the flow.

11.6.2 Preliminary Results

As an example, the results from a simulated diversion of 7,500 cfs of Mississippi River water near Violet, Louisiana, are presented in Figure 11.6.2-1. The top panel of Figure 11.6.2-1 presents salinity results after 180 days for the baseline condition without a diversion; the bottom panel shows results after 180 days for the simulated Violet diversion. The results suggest that 180 days after initiation of the diversion, salinities were lowered in western Mississippi Sound sufficiently to warrant additional examination. However, at present, absolute salinity values predicted by the regional salinity/water quality model need to be improved to match calibration data. Further refinement of the model should correct this limitation and must be made to improve its potential to quantify the potential beneficial or deleterious effects on oysters and other coastal resources.

Preliminary efforts were made to relate the WQM model results to ecological communities by utilizing oysters as a "target species." Oysters not only support a commercial fishery but interact directly with local hydrodynamic conditions, affecting currents, flow conditions, and sedimentation patterns (Lenihan 1999). They filter large amounts of phytoplankton and detritus exerting a powerful influence on water quality, phytoplankton productivity, and nutrient cycling of estuaries (Dame 1996). Oyster reefs provide habitat for a wide range of other invertebrates present either on the oyster shell itself or in the interstices between shells. Oyster reefs also support numerous resident, transient, and juvenile fish and decapod species and may provide a refuge from predation and poor water quality conditions.

Oysters are sensitive to specific ranges of salinity; therefore, freshwater diversions have the potential to either enhance or threaten the resource. For instance, where the average salinity exceeds 15 ppt oysters often experience increased predation rates by oyster drills whereas young oysters are more susceptible to certain diseases at salinities greater than 9 ppt (Cake 1983; Chatry et al. 1983). Similarly, salinities averaging below 7.5 ppt can inhibit oyster growth and sexual maturation while salinities that persist for extended periods of time below 2 ppt can result in direct mortality (Sellers and Stanley 1984, 1986). The relationship between oyster productivity and river flow is a complex one and there does not appear to be a close link between oyster harvests and freshwater inflow (Turner 2006).



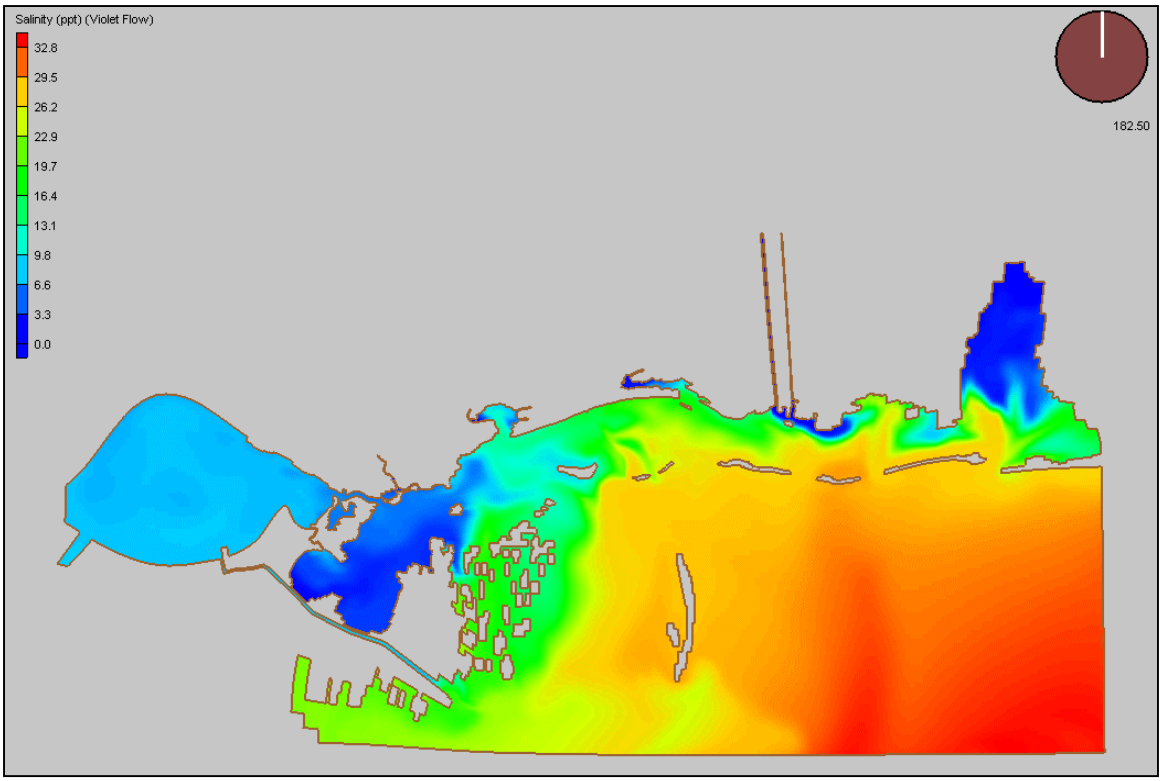


Figure 11.6.2-1. Baseline (upper panel) and projected with-diversion (lower panel) salinity values in parts per thousand (ppt) after 180 days. The royal blue color represents freshwater, while the red indicates sea water with salinity concentrations greater than 30 ppt.

To further refine the ecological concerns, during the summer and fall of 2007, MsCIP and ERDC convened a panel of representatives from the Nature Conservancy, Mississippi Department of Marine Resources, and the University of Southern Mississippi at the Gulf Coast Research Laboratory. The aim of the panel was to suggest simplistic ecological models that can be informed by results from the regional salinity/water quality model to identify diversion actions which might result in an improvement in oyster habitat quality. The panel identified several key attributes that need to be incorporated into the evaluation of freshwater diversion options. The first is that salinity averages should be as close as possible to the optimal range for oyster health and productivity. This is clearly of critical importance since the primary purpose for contemplating freshwater diversions is to improve habitat conditions for oysters. Second, a diversion should not result in extended periods of low salinity resulting in mortality or poor growth and reproduction. This consideration is particularly critical during times of high river flow or other extreme conditions. Third, a diversion should not unduly influence habitat conditions for other critical resources. Diversions that result in favorable conditions for oyster health may not be conductive to other equally important resources. For instance, most seagrasses do poorly at salinities less than 20 ppt. A diversion that results in excellent conditions over the prime commercial oyster beds but drives salinities below 20 ppt in the seagrass elsewhere would not be acceptable. Other important habitat requirements that should also be considered for seagrass health include light availability and nutrient concentrations.

During the autumn of 2007, several meetings with representatives from the States of Mississippi and Louisiana, non-governmental organizations such as the Lake Pontchartrain Foundation and the Environmental Defense Fund, various federal agencies, including US Fish and Wildlife Service, and representatives from both Mobile and New Orleans Districts have been held to discuss options, centering on details associated with a Violet Diversion. Additional work will be required to refine the

WQM regional model and apply it to examine the regional influences of proposed freshwater diversion projects on salinity, water quality and habitat.

11.7 PATH AHEAD

11.7.1 Continued LACPR-MSCIP Northern Gulf of Mexico Planning and Analysis

During the next steps in plan development in the LaCPR and MsCIP investigations beyond December 2007, the joint study teams will collaborate at a Northern Gulf of Mexico integrated systems scale. The purpose of this effort will be to identify common stakeholder agreement on the configuration, performance, and cost of alternatives with a goal of achieving no adverse impacts, levels of risk reduction, and coastal restoration in those plans. The LaCPR and MsCIP teams will hold joint meetings with stakeholders of the coastal areas in Louisiana and Mississippi during the winter-spring 2008 timeframe to accomplish this task, as follows:

- Explain the process on how the range of alternatives were initially developed in both projects for coastal restoration and risk reduction, as described in the December 2007 Technical Reports for LaCPR and MsCIP,
- Present the individual elements and integrated system configurations of the array of developed alternatives that were evaluated through these investigations,
- Describe the performance, costs, and unintended adverse consequences found through modeling simulations of these alternatives,
- Solicit the viewpoints of stakeholders for both studies in joint meeting sessions to identify consensus and differences of opinion on the makeup, performance, and costs of these alternatives,
- Interact with the stakeholders of both studies for screening, refinement, and/or re-formulation of alternatives from a Northern Gulf of Mexico integrated systems scale perspective,
- Conduct iterations of planning and analysis for identifying common agreement on the configuration, performance, and cost of alternatives for attaining no adverse impacts, risk reduction, and coastal restoration, and
- Describe requirements for further alternative plan development and analysis.

11.7.2 Regional Assessment Using Surge and Wave Modeling

In its current state, the regional storm surge and wave model is ready for use in examining regional influences and interactions that are created by MsCIP projects which are slated for construction in the near-term, and proposed LaCPR measures that remain in the final array of alternatives after the screening process. The alternatives proposed for construction in the MsCIP study and the most likely LaCPR alternatives will be evaluated using the regional storm surge and wave model to address regional influences of the proposed projects. Alternatives will be evaluated by the teams' storm surge and wave experts for the potential to produce significant regional influences. That evaluation will be reviewed and concurred upon by the external peer reviewers for both projects, and those alternatives will be assessed based upon regional storm surge and wave influences. All proposed projects/alternatives will be integrated into the regional storm surge and wave model and compared to results for the 2010 baseline case. By comparing the results to those obtained for the

baseline case, the MsCIP and LaCPR study teams can evaluate the regional influence of the proposed alternative(s).

Together, the MsCIP and LaCPR study teams, along with key stakeholder representatives, will evaluate the issue of regional storm surge and wave influences and assess whether or not there is a significant regional influence, and if so jointly decide whether any additional risk is acceptable, whether the project(s) must be modified to lessen the increased risk, or whether the project(s) need to be reformulated.

11.7.3 Regional Impact of the Lake Pontchartrain Surge Barrier

Analysis of storm surge barriers across Lake Pontchartrain indicates that a barrier can lead to significant undesirable increases in storm surge levels along the coast of Mississippi areas of southeast Louisiana. The increased surge levels are of great concern in light of the fact that coastal flood protection levees, revetments, or seawalls are not being pursued for construction in western coastal Mississippi. Therefore, any regional increase in storm surge levels induced by a Lake Pontchartrain barrier place the population at greater risk in an area that is already at relatively high risk of hurricane-induced flooding compared to other regions of the Gulf.

Lake Pontchartrain barriers provide considerable surge reduction benefits to certain communities around Lake Pontchartrain. The design of a storm surge barrier has not been optimized. Additional studies will be undertaken to assess the benefits of a lower surge barrier, which would likely also reduce adverse regional influences of the barrier. The regional influence issue will be addressed in the same manner as outlined above. Any barrier plan which induces adverse impacts must be eliminated from further consideration or its impacts satisfactorily mitigated on a regional basis.

11.7.4 Regional Assessment Using Salinity/Water Quality Modeling

All alternatives that involve barrier island restoration (specifically, those involving significant changes to island footprint or length), large-scale wetland restoration, storm surge barriers, or large-scale levee/floodwall systems will be evaluated for regional influences on salinity, water quality and habitat. The hydrodynamic, water quality, and habitat experts from the MsCIP and LaCPR study teams, plus outside peer reviewers for both projects, will make the assessment of which alternatives should be considered and integrated into the regional WQM model for this assessment. As was the case for the regional storm surge and wave model, the WQM model will be applied to examine regional influences of the alternatives (which fall into the categories outlined above) proposed for construction in the MsCIP study and the most preferable alternatives that surface in the LaCPR study.

The MsCIP study also is recommending construction of a freshwater diversion at Violet, Louisiana. Results achieved to date show that diversion at Violet has potential to achieve the salinity reduction that is sought for the Lake Borgne and Biloxi Marsh region in order to meet some of the objectives for diversions. It is expected that a freshwater diversion into this region will also be among the alternatives that surface in the LaCPR study. The issue of freshwater diversion into this region will be examined further, maintaining a regional perspective and building upon the work done to date to examine the relative benefits of freshwater diversions at Violet and the Escatawpa River, and Bonne Carre' as another possible diversion. A diversion at Violet was included in the 2007 Water Resources Development Act. In addition, a diversion at Caernarvon, Louisiana also will be examined in this same regional context.

It is proposed that a bi-state group be formed to assess freshwater diversions into this particular region, with support from the Mobile and New Orleans Districts and the Mississippi Valley and South Atlantic Divisions. One of the first activities of this group will be to fully articulate the goals of the

potential diversions and to reconcile conflicts between these goals. Subsequent to this, potential, realistic, operational plans will be developed so that they can be evaluated using the regional WQM modeling framework.

Refinements of the WQM model are required and they will be initiated immediately. The existing model will be expanded to the south and refined with additional resolution to include possible diversions at Caernarvon, and be readied for use in making event, seasonal and long-term simulations. Salinity changes at a number of time scales are of interest. The WQM model will be validated through comparisons to existing measured salinity and water quality data in Lake Pontchartrain, Lake Borgne, Biloxi Marsh, and the vicinity of Caernarvon in order to increase confidence in model predictions and to be able to withstand the close technical scrutiny of the modeling that is done to inform decision-making regarding this highly sensitive issue.

These model improvements will allow for more accurately relating the water quality results to ecological concepts and interpretation, and enable questions and issues that have been raised regarding diversions (pros and cons) to be more thoroughly and accurately addressed. The WQM model should be linked to ecological tools to be able to test the impacts of precise operational discharge plans and seasonal influences on key ecological resources. Our current collaboration with Louisiana State University on the ecological integration will be continued and expanded to more fully include representation from Mississippi.

Once recommended diversions and operational plans for those diversions are defined, they will be integrated into the regional WQM model, along with all the other features that are proposed for construction in the MsCIP study and proposed in the LaCPR study which have possible regional influences on salinity water quality and habitat. The modified regional model will be applied and results will be compared to the 2010 baseline condition. Differences will be examined to assess the regional performance of alternatives and to assess regional influences from salinity, water quality and habitat perspectives.

If alternatives emerge in LaCPR for regions west of the Mississippi River that have the potential for regional salinity, water quality and habitat influences, work will commence to expand coverage of the WQM to cover the areas where influences are of concern. This will be a significant effort.

11.7.5 Recommendations for Research to Benefit Regional Modeling

Both the regional storm/surge and WQM models, and inferences made using the results from the WQM model to infer ecological response, have a number of areas of technical uncertainty in the model formulation and knowledge base for making interpretation and analysis. This uncertainty can only be reduced through research and development that is focused on improving model capability in the areas having the greatest uncertainty. The LCA Science and Technology program will focus on these areas of technical deficiency via collaborative research conducted by USACE, State of Louisiana, other federal agencies and the academic community.

The greatest uncertainty lies in inferences made regarding ecological response to changes in hydrodynamics, sediment loading, salinity, and water quality and how they contribute to the general process of marsh creation and ecological health. This will be one area of focused research and development. Wetland and barrier island restoration will have to be undertaken accepting the fact that adaptive management will be required. Not everything will respond as originally envisioned and planned. The system is extremely fragile and complex, and knowledge and data volume/quality are poor in a number of technical areas. There are ongoing difficult-to-predict-and-quantify long-term processes like subsidence and sea level rise that complicate matters and render accurate long-term predictions to be highly uncertain and suspect. Changes to wetland restoration practices will be required, and constantly improving regional models can help better inform the adaptive management

process and more accurately assess regional influences. The goal for the research and development should be reductions in the uncertainties inherit in forecasts and predictions of ecological response.

A second area for focused research will be the area of beneficial use of wetlands for storm surge and wave reduction. Considerable scientific knowledge gaps, and lack of data volume/quantity, exist in this area. Reliable use of wetlands for surge and wave reduction benefits will require increased understanding of the friction resistance and energy dissipation characteristics provided by a wide range of vegetation species, changes of resistance and energy dissipation with increasing degree of inundation, and response of the vegetation and surrounding wetlands to the destructive forces of wind and energetic waves at varying levels of inundation. The goal for the research and development should be reductions in the uncertainties inherit in forecasts and predictions of wetland influence on storm surge and waves.

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